KENO HILL SILVER DISTRICT

DRAFT CLOSURE OPTIONS REPORT

PREPARED BY:

ALEXCO ENVIRONMENTAL GROUP



MAY 2011

Keno Hill Silver District
Existing State of Mine Draft Closure Options Report
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Appendix A Technical Summary Fact Sheets

Appendix B-1 Risk Assessment Memo

Appendix B-2 Risk Assessment Summary

1. Introduction

This document discusses options for the closure of the former United Keno Hill Mines and associated facilities within the Keno Hill Silver District (KHSD). It is intended to provide a basis for further evaluation of closure options by communities and governments, and ultimately for selection of a preferred set of closure options.

The sections of this document present:

- An overview of the Keno Hill Mines property;
- A description of the closure planning framework;
- A summary of the development of alternatives, their analysis, review, and recommendation of options for further consideration;
- An initial evaluation of short-listed options; and
- A description of the risk assessment process and preliminary outcomes that guided some of the refinement of options that are presented.

1.1 Keno Hill Silver District Knowledge Status

ERDC has developed a website, http://www.alexcoenvironmental.com/keno/ to assist in the communication and accessible storage of information related to current and historical environmental information regarding the KHSD. This website is being continuously updated to provide an up to date source of information about the work that is being completed in support of the development of the KHSD Closure Plan. Since the initiation of the closure planning process, a number of studies and investigations have been performed to assist in the understanding of the status of the district mining and environmental features, as well to develop a scientific understanding of the processes that govern environmental effects from historic operations and to determine appropriate cleanup processes and environmental quality goals.

Appendix A contains “Technical Summary Fact Sheets” that provide a brief summary of each study report developed for the KHSD. The following sections also outline the key

reports used in the development of this Draft Closure Option Report. This compilation provides a listing of the studies that have been completed on the site, both historical and contemporary, that will assist in evaluating the closure options and eventually, selection of the final closure options for the KHSD Closure Plan.

1.1.1 General and Baseline Information

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Access Consulting Group, 2009. *Keno Hill Silver District Closure Issues Report*, prepared for Elsa Reclamation and Development Company Ltd.

Access Mining Consultants Ltd., 2005. *Closure Plan for Current Conditions*, prepared for United Keno Hill Mines, Ltd.

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Komex International Ltd., 2005. *Closure Plans and Reclamation Cost Estimate for United Keno Hill Mines Ltd.*, prepared for Pricewaterhouse Coopers Inc.

Public Works and Government Services Canada, 2000. *Keno Valley/Dublin Gulch Environmental Assessment Report*, prepared for Waste Management Program, Indian and Northern Affairs Canada.

SRK Consulting, 2007. *Baseline Environmental Report, United Keno Hill Mines Property*, prepared for Elsa Reclamation and Development Company Ltd.

1.1.2 Water Quality and Receiving Environment Studies

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Access Consulting Group, 2009. *Fisheries Assessment Project, September 17-19, 2008*, prepared for Elsa Reclamation and Development Company Ltd.

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Clearwater Consultants Ltd., 2007. *Hydrological Update and Assessment*, prepared for Elsa Reclamation and Development Company.

Department of Environment, 1989. *Environmental Quality of Receiving Waters at United Keno Hill Mines Ltd, Elsa, Yukon*, Regional Program Report No. 89-04 by D Davidge and G Mackenzie-Grieve.

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Laberge Environmental Services, 2008. *Keno Valley Stream Sediment and Benthic Invertebrate Monitoring Programs*, prepared for Elsa Reclamation and Development Company Ltd.

Laberge Environmental Services, 1994. *Biological Monitoring Survey at United Keno Hill Mine Area, 1994*, prepared for United Keno Hill Mines Ltd. by B. Burns.

Minnow Environmental Inc., 2010. *Approach for Developing Water Quality Goals for United Keno Hill Mines DRAFT*, prepared for Elsa Reclamation and Development Company Ltd.

Minnow Environmental Inc., 2010. *Long-Term Aquatic Monitoring Program for United Keno Hill Mines DRAFT*, prepared for Elsa Reclamation and Development Company Ltd.

Minnow Environmental Inc., 2009. *Aquatic Resource Assessment Report for United Keno Hill Mines*, prepared for Elsa Reclamation and Development Company Ltd.

Minnow Environmental Inc., 2008. *Water Quality Assessment Report for United Keno Hill Mines*, prepared for Elsa Reclamation and Development Company Ltd.

White Mountain Environmental Consulting, 1995. *Fish and Fish Habitat Assessment Conducted near Elsa, Yukon for United Keno Hill Mines, August 1994 – September 1995*, prepared for United Keno Hill Mines Ltd. by P Sparling and M. Connor.

1.1.3 **Adit Water Quality and Water Treatment Studies**

Access Consulting Group, 2008. *Adit Discharge Survey*, prepared for Yukon Government.

Alexco Resource US Corp., 2010. *Galkeno 900 Sulfate-Reducing Bioreactor Interim Report*, prepared for Elsa Reclamation and Development Company Ltd.

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InTerralogic Inc., 2010. *Metal Attenuation Processes in the No Cash Creek Drainage*, prepared for Elsa Reclamation and Development Company Ltd.

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MERG, 2000. *Investigations into passive wetlands treatment of mine drainage to remove heavy metals at various sites at UKHM*, Mining Environmental Research Group (MERG) Report 2000-3, prepared by Laberge Environmental Services.

SENES Consultants Ltd., 2009. *Technical Review, Galkeno Waste Water Treatment Plant*, prepared for Access Consulting Group.

1.1.4 **Tailings Studies**

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Access Mining Consultants, 1995. *Elsa Tailings and Groundwater Monitoring Investigation Field Program*, prepared for United Keno Hill Mines Ltd.

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SRK Consulting, 2008. *2007 Geotechnical Closure Studies, Keno Hill, YT*, prepared for Elsa Reclamation and Development Company Ltd. Pp. 1-8; 10-13

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1.1.5 **Waste Rock Studies**

Altrua Environmental Consulting, 2008. *Review of Historic Keno Hill Static Test Data to Define ARD/ML – Controlling and Correlating Factors*, prepared for Elsa Reclamation and Development Company Ltd., by D. Lister.

Broughton, L.M., 1996. *United Keno Hill Mines Limited, Geochemical Testing Report*, prepared for United Keno Hill Mines Ltd.

SRK Consulting, 2009. *2007/08 Geochemical Studies, Keno Hill District, YT*, prepared for Elsa Reclamation and Development Company Ltd. Pp. 1; 34-49

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1.1.6 **Underground Mine and Adit Studies**

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SRK Consulting, 2008. *Outcomes from 2007/08 Keno Hill Adit Closure Studies*, Technical Memorandum prepared for Elsa Reclamation and Development Company Ltd.

1.1.7 **Vegetation and Terrestrial Studies**

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Access Consulting Group, 2009. *Keno Hill Mine, Site Investigation and Improvements, Special Projects, Hazardous Waste Assessment*, prepared for Elsa Reclamation and Development Company Ltd.

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Access Consulting Group, 2009. *Physical Hazard Assessment*, Technical Memorandum prepared for Elsa Reclamation and Development Company Ltd., by K. Neunherz

Access Consulting Group, 2010. *Keno 700 Physical Hazard Reduction*, prepared for Elsa Reclamation and Development Company Ltd.

Access Consulting Group, 2010. *Water Treatment and Capital Improvements*, Technical Memorandum prepared for Elsa Reclamation and Development Company Ltd. by K. Hanak.

1.1.9 **Other Studies**

EBA Engineering Consultants Ltd., 2009. *2009 Site Geotechnical Investigations, United Keno Hill Mines Property, Elsa, YT*, Technical Memorandum prepared for Elsa Reclamation and Development Company Ltd. by J.R. Trimble.

SRK Consulting, 2010. *2010 Bellekeno Groundwater Program*, prepared for Alexco Resource Corp.

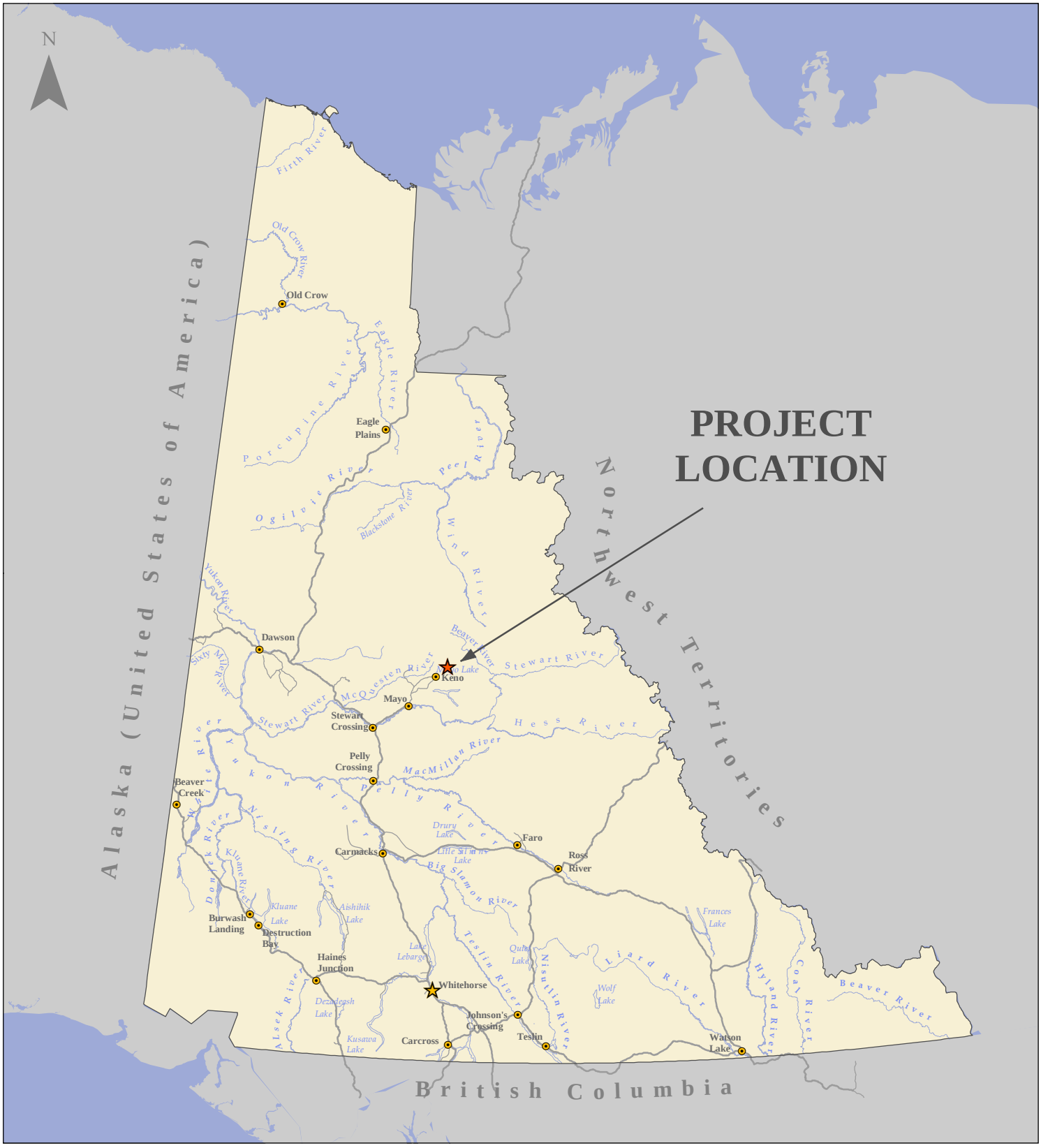
2. Site Background

2.1 Overview

The Keno Hill Silver District is located in the central Yukon Territory, 354 km (220 miles) due north of Whitehorse in the vicinity of the villages of Elsa and Keno City. A general location map is provided in Figure 2-1.

Access to the property is by a two-lane paved road from Whitehorse to Mayo and an all weather gravel road running 45 km (28 miles) northeast from Mayo; these roads together are an effective distance of 452 km (281 miles). Whitehorse, the capital of the Yukon Territory, is connected to southern Canada by the Alaska Highway.

The Keno Hill Silver District is situated on approximately 827 mineral claims, and is situated on three adjacent mountains, Keno Hill, Galena Hill, and Sourdough Hill and adjacent valleys. The area covered by claims and leases is an elongate 15,000 ha. (37,000 acres) oriented roughly east-west with dimensions about 29 km (18 miles) long and 8 km (5 miles) at its widest. Figure 2-2 illustrates the property claims. Fifteen surface leases, and several parcels of freehold property cover parts of the mineral rights.





ELSA RECLAMATION AND DEVELOPMENT COMPANY

ERDC

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FIGURE 2-1

GENERAL LOCATION

ACCESS

I:\ALEX-05-01\gis\mxd\UKHM\Overview_Maps\Project_Location_20110412.mxd
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465000 467500 470000 472500 475000 477500 480000 482500 485000 487500 490000 492500 495000

7097500 7095000 7092500 7090000 7087500 7085000 7082500

N W E S

South Ski Creek Creek River Christal Creek Shanghai South McQuesten Star Sandy Creek Creek Creek Porcupine Brefalt Gulch Flat Creek Galena Thompson Creek Creek Creek Creek Corkery

ELSA

SILVER KING ADIT
75 LEVEL ADIT
VENT RAISE
HUSKY SW SHAFT
HUSKY SHAFT
ELSA 400 LEVEL ADIT
ELSA 200 LEVEL ADIT
DIXIE ADIT
ELSA +50 LEVEL ADIT
BERMINGHAM ADIT
BREFALT SHAFT
RUBY ADIT
TOWNSITE ADIT
NO CASH 200 LEVEL ADIT
NO CASH 500 LEVEL ADIT
HECTOR ADIT
UN ADIT
GALKENO 200 LEVEL ADIT
GALKENO 100 LEVEL ADIT
GALKENO 300 ADIT

KENO CITY

VIOLA ADIT
RICO ADIT
GALKENO 900 ADIT
ONEK 400 ADIT
BELLEKENO 525 ADIT
BELLEKENO EAST PORTAL
Gambler Gulch Lightning Creek Thunder Gulch Duncan Creek Forty Rup Creek Brickson Chantry Gulch Hope Gulch McKinley Gulch McKinley Gulch

SADIE LADUE 600 ADIT
SADIE LADUE SHAFT
LUCKY QUEEN SHAFT #1
LUCKY QUEEN SHAFT #2
KLONDIKE KENO ADIT
LUCKY QUEEN ADIT
BLACK CAP ADIT
SHAMROCK
SHAMROCK "J" RAISE
BREWIS RED LAKE ADIT
FARO GULCH PORTAL
#1 ADIT
#4 LOWER ADIT
12 VEIN ADIT
200 LEVEL PORTAL
COMSTOCK ADIT
5-2 ADIT
PORCUPINE SHAFT
KENO 700 ADIT
Faro Gulch Gulch McKay Gulch Silver Basin Gulch Keno Creek Faulkner Barney Ladue

Adit
Shaft

Highway
Local Road
Haul Road
Trail

Alexco Owned Quartz Claims
Other Quartz Claims
ValleyTailings

Watercourse
Waterbody

National Topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:50,000. Cadastral data compiled by Natural Resources Canada. Reproduced underlicense from Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

Quartz claim boundaries current as of February 24th, 2011. Ownership data current as of December 20th, 2010. Data source: http://geomaticsyukon.ca.

Datum: NAD 83; Map Projection: UTM Zone 8N

1:80,000 (when printed on 11 x17 inch paper)

0 0.5 1 2 3 4 5 Kilometers

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ELSA RECLAMATION AND DEVELOPMENT COMPANY

DRAFT CLOSURE OPTIONS REPORT
FIGURE 2-2
PROPERTY OVERVIEW

DRAWN BY MD	APRIL 2011	VERIFIED BY JH

I:\ALEX-05-01\gis\mxd\UKHM\Overview_Maps\Property_Overview_20110411.mxd
(13/04/2011/10:57 AM)

Many buildings of the old Elsa townsite and old mine workshop, previously owned by Unity Keno Hill Mines Ltd, remain situated on the property. Ongoing physical hazards reduction has removed some of the higher risk sites (e.g. accessible open shafts, falling down buildings) but the majority of the buildings on site in 2006 remain. The site has been under "care and maintenance" since the cessation of production in 1989. All the silver deposits are located within a 20 km radius of Elsa, where site administration offices are located. Elsa was a company town during the active mining period and the remaining facilities include houses, school, post office, bunkhouses, mine dry offices, warehouse, transport shop, machine shop, carpentry shop and assay laboratory. A 544 ton per day concentrator and small silver refinery are also located in Elsa. The buildings and mill have deteriorated and are in varying states of disrepair. Power is supplied by the Yukon Energy Corporation from the Wareham Dam, a five megawatt hydro dam located near Mayo.

2.2 **Ecosystem Characterization**

The Keno Hill - Galena Hill area lies within the Mayo Lake-Ross River Ecoregion. The area is characterized by widespread discontinuous permafrost. The South McQuesten River valley bounds the property to the north, while the Lightning Creek watershed confines the property to the south. The climate is characterized by hot dry summers with peak stream flows mainly occurring in spring due to snowmelt. Increases in streamflow also occur with sudden rainfall events during the summer and fall. Winters are cold with minimal snowfall. The temperature range includes winter extremes of -55 ^{0} C up to 32 ^{0} C during summer with a mean annual precipitation of 285 mm. Treeline occurs near 1350 m to 1500 m.

Geographically, the property lies along the broad valley of the South McQuesten River, as well as over three prominent hills bordering the south side of the valley. The valley itself lies at about 700 m (2,300 feet) above sea level, while Galena Hill, Keno Hill and Sourdough Hill rise to elevations of 1,400 m (4,600 feet), 1,825 m (6,000 feet) and 1,370

m (4,500 feet), respectively. Each of these hills is incised by local linear valleys, commonly fault-controlled, with fast-flowing streams.

The area is underlain by mid Paleozoic meta-sedimentary rock overthrust by late pre-Cambrian meta-sedimentary rocks. The Mississippian Earn Group meta-sediments of the lower thrust panel are well documented for contributing to naturally elevated background metals and sulphate levels in soils and local waters. This characteristic is readily identified in the local background metals and sulphate levels in surface waters of this region.

The background water quality of the major stream drainages in the Keno Hill - Galena Hill area, South McQuesten River and Lightning Creek are slightly alkaline, with a moderately soft to hard water hardness. Some metals, for instance zinc, vary seasonally from near detection limits to above the guidelines established for the protection of freshwater aquatic life.

Historic mining within the South McQuesten River drainage has resulted in local drainages being impacted by mining activity. The Flat Creek and Christal Creek drainages have been most impacted as indicated by surface water quality and metal loading studies and by fisheries studies (Reference: Surface Water Quality Report, Minnow; Aquatic Resource Report, Minnow). Zinc and cadmium, in particular, appear to have impacted these streams. These smaller drainages which empty into the South McQuesten River have historically produced noticeable, but generally slight, changes in this river's water quality. Zinc and cadmium levels were noted to be particularly pronounced during low flow periods. Water quality in the South McQuesten River downstream of all mining related activities has improved over the years as management practices and interim care and maintenance activities at the Keno site have reduced the overall loading of metals into the receiving environment. For a period of time in 2007

and 2008, South McQuesten River met water quality guidelines established for the protection of freshwater aquatic life.

However, recent trends of improved water quality in Christal Creek and poorer water quality in a creek upgradient of the site, Cache Creek, has resulted in the South McQuesten River often now having worse water quality than Christal Creek with respect to zinc (EDI, 2006; InterraLogic, 2011; and Minnow, 2011). The Cache Creek drainage has had some minimal surface exploration but not substantial mining activity, making this site a limiting factor on the South McQuesten River water quality based on the natural source of elevated metals.

The local ecosystem supports a wide range of biological resources. These resources have been traditionally relied upon by the Nacho Nyak Dun First Nations and area residents. Sustaining the ecosystem to ensure viability of these resources is important to local people. The South McQuesten River has supported a wide variety of freshwater fish species including Chinook salmon. The area supports a variety of wildlife including, ungulates (moose, caribou), fur bearers, small mammals upland game birds and waterfowl. There are no rare or endangered species documented, although a local population of Thinhorn sheep on Keno Hill was historically hunted out. The most sensitive ecosystem components considered include the aquatic resources of the South McQuesten River, particularly fisheries, local country foods, and local land use including aesthetics values.

No major population centres are located near the Keno Hill Silver District. Mayo, the largest community, is located 45 kilometres west of Elsa. The unincorporated community of Keno City is located 15km east of Elsa with a resident population of around 17, and seasonal residents increasing this number especially in the summertime.

There are no communities or residents living below the Elsa valley tailings facilities. Seismicity of the area is ranked low.

2.3 Development and Ownership History

Prospecting for placer gold began in the Elsa area in 1885. The first discovery of silver was in July, 1903, when the Silver King Vein was found on Galena Creek. Silver vein discoveries on Galena Hill in 1919 led to a staking rush in the area. The Treadwell Yukon Company Limited initiated development on Keno Hill in September 1914, and in 1925 constructed a 110 tonne per day (125 ton per day) mill at Wernecke Camp. Most of the favourable ground had been staked by 1929 and was actively being explored. The Wernecke mill was shut down in 1931, and in 1936 a 136 tonne per day (150 ton per day) mill commenced operations in Elsa, supplied with ore by mines operating on Galena Hill. Most mining activity had ceased by 1942 due to declining silver prices.

Conwest Exploration Co. Limited and Frobisher Exploration Co. Limited formed Keno Hill Mining Company Limited in 1945 and acquired all former Treadwell Yukon Company Limited's interests. This company was reorganized as United Keno Hill Mines Limited (UKHM) in 1948.

The first UKHM production came from the Hector-Calumet vein system and from the Elsa mine in 1947. In 1949, the mill in Elsa was destroyed by fire and was replaced by a 225 tonne per day (250 ton per day) facility. The mill was expanded to 450 tonnes per day (500 tons per day) in 1951. The Hector-Calumet and Elsa Mines were the main producers in the 1950's. UKHM controlled most of the ground in the Keno Hill-Galena Hill area by 1958 with production coming from both Keno and Galena Hill.

The Keno Mine was brought into production in 1962 as reserves at the Hector-Calumet and Elsa Mines declined in the early 1960's. Falconbridge Nickel Mines Limited acquired control of UKHM in 1962. They initiated an aggressive exploration program between

1963 and 1965, with limited success and all underground diamond drilling ceased in 1966. The Hector-Calumet Mine, by far the largest producer in the camp, was abandoned in 1972. The newly discovered Husky Mine then became the major producer in the camp.

UKHM suspended commercial production on January 9, 1989 due to falling silver prices, high production costs, and an inability to achieve production targets. The high production costs and inability to achieve production targets can be attributed in part to high townsite costs, high labour costs, high labour turnover and costly mining practices. Control of UKHM was acquired from Falconbridge by the existing management at the time in July, 1990.

Mining in the Keno Hill-Galena Hill area from 1914 to January 9, 1989, produced 5.342 million tons of ore grading about 1,370 g/t (40 oz/ton) Ag, 6.6% Pb and 4.1% Zn from 34 different deposits for a total of about 6.6 million kg (214 million ounces) of silver.

This ore was obtained from both open pit and underground operations. Underground production, including documented small hand cobbing operations, totals 4.420 million tonnes (4.873 million tons) grading about 1,440 g/t (42 oz/ton) Ag, 7.0% Pb and 4.4% Zn. Well over half of this production has come from the Hector-Calumet and Elsa mines, which are also two of the deepest mines in the camp.

Open pit production, which commenced in 1977 with mining from the Porcupine Pit, has totalled 425,600 tonnes (469,200 tons) grading about 580 g/t (17 oz/ton) Ag, 3.0% Pb and 0.4% Zn from 14 different deposits.

Considerable effort has been made to concisely present a great deal of information about a variety of localities. The 1996 Site Characterization report (Access Consulting,

1996) presents the history, quantities of ore production, waste type, and waste rock quantity for each component or site. The Closure Issues Report (Access, 2009) summarizes the specific closure issues related to all of the individual sites across the district.

The following descriptions of the individual mines are organized in terms of these three "Hills", and thence generally in alphabetical order. The development on Galena Hill comprises:

- Bermingham Mine
- Dixie Mine
- Elsa Mine
- Elsa ("Valley") Tailings, Mill and Infrastructure
- Galkeno Mine
- Hector-Calumet Mine
- Husky and Husky SW Mines
- Miller
- No Cash Mine
- Ruby Mine
- Silver King Mine
- Sime Open Pits
- Townsite Adit
- UN Adit

These mines are all located within the South McQuesten River watershed.

Sourdough Hill has only the Bellekeno Mine. The mine is in the Lightning Creek watershed, a tributary to Duncan Creek which drains into the Mayo River.

The mines of Keno Hill comprise six main mines and two mill sites:

- Keno Summit including:
    - Keno 700 - 9 Vein Mine
    - Shamrock J - 18 Vein Mine
    - Comstock-Keno & Porcupine Mine
    - Lucky Queen/Black Cap Mine
    - Onek Mine
    - Sadie Ladue Mine
    - Wernecke Mill, Tailings, and Camp (located at Sadie Ladue)
    - Mackeno Mill and Tailings

These properties are located on drainages that go to different watersheds; Sadie Ladue to the Ladue Creek watershed, Keno 700 to Lightning Creek, and Lucky Queen and Onek to the South McQuesten River watershed via Christal Creek. Mackeno Millsite is located immediately adjacent to Christal Creek.

2.4 **Care and Maintenance History**

UKHM, the previous owner of the properties ceased operations in 1989. UKHM was subsequently convicted of several compliance issues with respect to Water Use Licence QZ96-001 in 1999. These issues were mainly due to the inability of UKHM to raise the necessary financial backing required to undertake engineering studies and to make necessary improvements to the environmental liabilities associated with the property. Further financial difficulties resulted in the company ceasing operating water treatment systems in late 2000.

In January 2001, The Minister of the Department of Indian Affairs Northern Development (DIAND) exercised his authority under the Yukon Waters Act by issuing a determination that the mine had been abandoned. Under contract to DIAND, Access Consulting Group (Access) undertook care and maintenance of the site to maintain the existing water treatment systems and tailings pond dam integrity in order to protect the

environment. DIAND retained stewardship of the mine property until it was sold through Court order by the UKHM miners' lien claimants to AMT Canada Inc. (AMT) in October of 2001. Also in October 2001, the site was declared a Type II Site under the Devolution Transfer Agreement, which meant that Yukon would manage the property, but financial responsibility for environmental liabilities would remain with the Government of Canada.

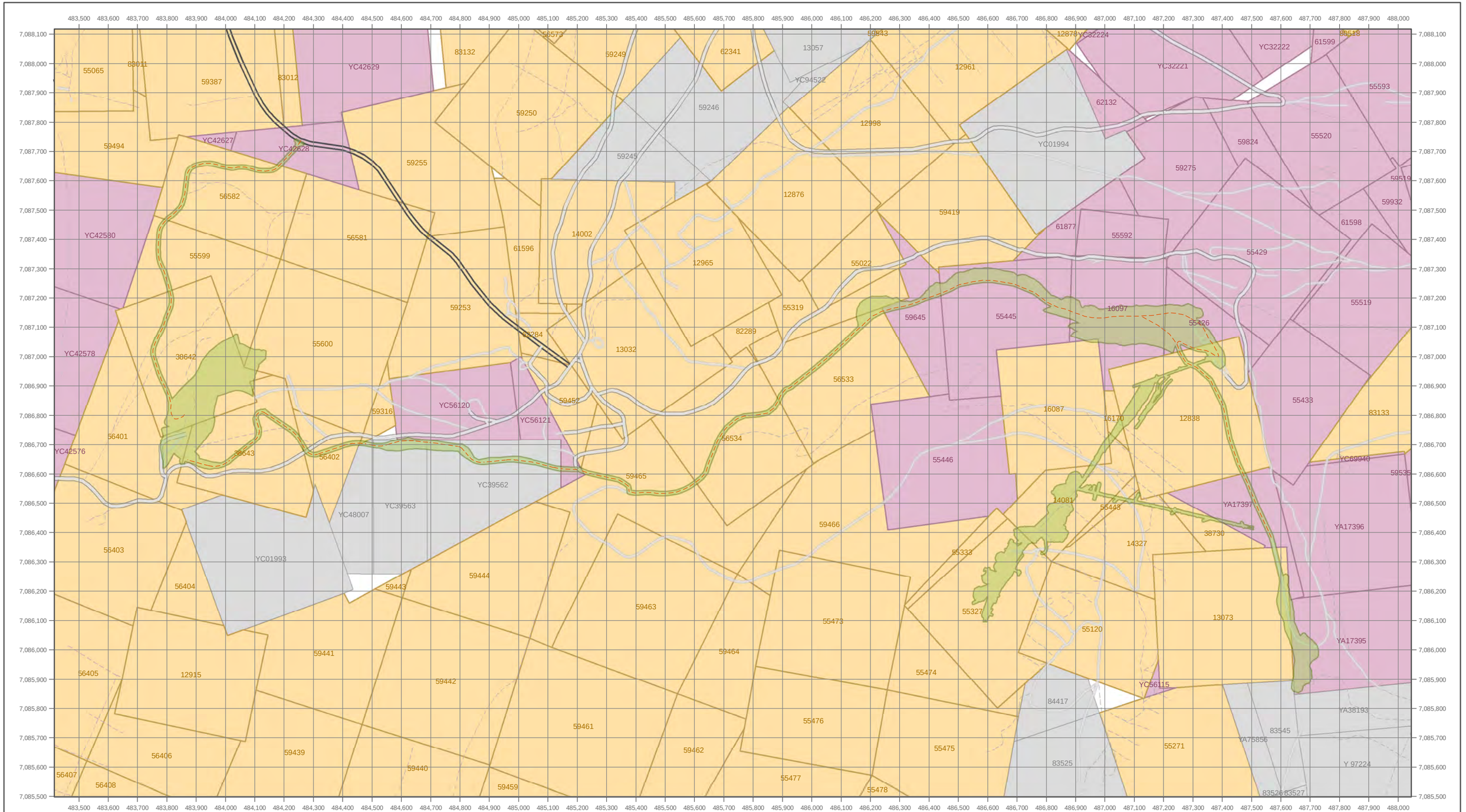
AMT operated the water treatment systems while they pursued permitting, but ultimately dropped the project in 2003. Nevada Pacific Gold Inc. operated the care & maintenance systems for a few months after AMT left in 2003, until they also ultimately ceased involvement with the property. On June 26, 2003, the Yukon Government declared the properties and the works on these sites abandoned once again. Yukon Government subsequently took over care and maintenance and water treatment activities at the site and contracted the work to Access.

The Court appointed PricewaterhouseCoopers Inc. as Interim Receiver and Receiver-Manager of United Keno Hill Mines Limited and UKH Minerals Limited (collectively known as "UKHM") on April 6, 2004, and through a selection process Alexco Resource Corp. (Alexco) became the preferred purchaser of the UKHM assets (June 24, 2005). As per the Court arranged sale, Alexco formed the Elsa Reclamation and Development Company (ERDC), as a wholly owned single purpose subsidiary of Alexco to provide a project-specific legal vehicle to undertake ownership and management of the site. Water Use Licence QZ06-074 was issued on November 14, 2007 for care and maintenance activities on the property. As the final requirement of the negotiated terms of sale between the two governments and Alexco, the issuance of the care and maintenance WUL consummates the final transfer of the property.

Separately, INAC has entered into a contractual arrangement with ERDC to perform ongoing environmental care and maintenance (provision of site security and operation of water treatment systems) at the site. The agreement further provides for ERDC to develop an Existing State of Mine Closure Plan for the site to address long term site liabilities and to implement the plan. This Draft Closure Options Report is another step towards the ultimate selection of final closure measures to be implemented at the site. After the preferred closure options have been selected with input from ERDC, INAC, YG, NND, and consultation with stakeholders, a closure and reclamation plan will be submitted for environmental assessment under YESAB and then licenced under a water use licence application process.

3. Site Closure Components

The Keno Hill mine site can be broadly broken down into mine 'components' that encompass every mine-associated development, disturbance, working and remediation activity at every site. These components include mine workings (underground and open pit), mine openings (shafts and adit portals), adit treatment areas, adit water management activities, tailings facilities (including the Valley, Mackeno and Wernecke tailings), waste rock storage areas, infrastructure, and other more minor components such as site debris and high-grade ore piles. Since the Bellekeno Mine and the Flame and Moth area are now part of the Alexco operating mine and mill, these sites are excluded from further consideration in this Draft Closure Options Report. These historic facilities are now part of the closure plan associated with the new Bellekeno mine and mill. Figure 3-1 shows the Bellekeno Production Unit which encompasses the areas of the district which are now Alexco closure responsibilities.



1:12,000 (when printed on 11 x17 inch paper)

0 250 500 750 1,000 Meters

Production unit outline may be subject to change.
Mineral claims and lease data compiled by Energy, Mines and Resources, Yukon Government.; Data current as of April 20th 2010.

Datum: NAD 83; Projection: UTM Zone 8N

- Production Unit
- Haul Road
- Highway
- Local
- Track
- Trail
- ERDC Mineral Claims and Leases
- AKHM Mineral Claims
- Third Party Mineral Claims

ERDC

BELLEKENO MINE

Figure 3-1 BELLEKENO PRODUCTION UNIT SUBSIDIARY AGREEMENT

Drawn By: MD	OCTOBER 2010	Verified by: RM

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3.1 **Mine Workings**

Mine workings are comprised of open pits and underground workings. In total, the mine workings are comprised of 19 separate open pits, (12 open pits on Galena hill, 7 on Keno Hill and none on Sourdough Hill) and 65 underground workings, including adits and shafts (23 adits and 17 shafts on Galena Hill, 15 adits and 6 shafts on Keno Hill and 4 adits and no shafts on Sourdough Hill). These mine workings were worked intermittently from 1914 to 1989 when UKHM temporarily suspended operations.

The mine workings and entry points are in various states of (dis)repair and require various degrees of remediation for closure. In general, open pits are quite small, with the most pressing concern being the issue of public access and in some instances the pits act as enhanced water catchment basins that affect outflow from related adits. All open pit excavations will continue to unravel to some degree (SRK Geotechnical Closure Studies 2007/08). Within the Bermingham, Calumet and Sime #6 pits this instability is expected to be more significant, with some larger sections of the slope walls becoming unstable over time. There are no pit lakes on the property.

3.2 **Mine Openings**

Underground workings at the Keno Hill Silver District are accessed through adits or shafts depending on mine location. As previously mentioned, there are 65 underground workings, including adits and shafts (23 adits and 17 shafts on Galena Hill, 15 adits and 6 shafts on Keno Hill and 4 adits and no shafts on Sourdough Hill).

The closure approach to adits and shafts must encompass two main aspects of closure. The first is physical stability and access at the point of entry, the second is the issue of water management and discharge.

Management of physical stability and access where there is adit drainage will depend upon the closure measure selected to deal with that drainage. SRK conducted an adit

closure study in 2007/08 (SRK 2008) which dealt with the various adit closure measures that could be employed at adit entrances from an engineering perspective. Their list was exhaustive, and provided recommendations for adit closure that ranged from a grate to prevent entry, a rock pile to close adits that occur in unstable rock faces, and low pressure hydraulic plugs that allow water management from adits without significant hydraulic head buildup caused by mine pool formation behind the plug. As a result of consultation and feedback from regulatory personnel, high pressure adit plugs/ bulkheads are not proposed as a viable closure approach for the KHSD due to perceived risks of unplanned catastrophic release of water built up behind the high pressure bulkhead, and risks of seepage of mine waters in an uncontrolled manner. While these risks are frequently engineered around in other mine closure projects, the potential benefits of implementing a high pressure hydraulic plug are not considered to be likely of a significant magnitude. All adit plugs considered in the closure planning are consequently low pressure plugs that will only allow limited accumulation of water behind the bulkhead, with cleanout features to allow for ongoing maintenance. In general, adit sites with water drainage will have upgraded portals with the ability to temporarily store water within the adit level as part of a water management strategy for the site.

EBA (2011) performed a review of shafts and recommended concrete caps be placed over 9 shafts that had the potential for recharge, and dry seals for 23 other shafts. The objective for shaft closure includes elimination of health and safety concerns for people and wildlife, and elimination to the extent possible of water ingress into mine workings, especially where it could lead to long term water treatment requirements or discharge to the environment.

3.3 **Mine Water Treatment**

Metals-laden water discharges continuously from various mine openings throughout the Keno Hill Silver District. The quality of this effluent in most cases fails to comply with

water licence effluent discharge criteria for the site. In order to reduce metals levels, water treatment is required on an ongoing basis.

The treatment system for three existing treatment sites at Keno Hill consists of the mechanical application of lime slurry ($CaO_{(s)} + H_20_{(l)}$) to the mine discharge waters. The slurry acts to raise the pH, causing zinc and other metals to precipitate out of solution, forming a metal hydroxide sludge. Precipitate retention ponds are located at each existing treatment facility to assist metals precipitation and clarification of effluent prior to release into the receiving environment. Sludge is periodically removed from the primary settling ponds and transported for storage in a cell located in the Valley Tailings, or in the case of Galkeno 300, it is pumped up into the Sime Open Pit.

Discharge samples at each treatment location are taken and analyzed on a daily basis using the on-site AA machine. Review and evaluation of these results is conducted by the ERDC project manager and discussed with the treatment system operators. These results allow the project manager to provide direction regarding the treatment process, (i.e. lime addition rates and pond clean-out activities). Monthly compliance samples are also sent to an external lab for verification and comparison with the on-site AA results. Results from the off-site certified lab have supported the daily assays of the on-site lab facilities.

3.3.1 **Existing Treatment Process General Description**

Water treatment is undertaken seasonally during the freshet at the Valley Tailings Facility and is conducted year-round at four adits (including the active Bellekeno Mine). Water treatment was initiated in 1993 at three of the adits (excluding Galkeno 300) due to concerns with metal concentration in adit discharges.

In general, the treatment processes for the care and maintenance sites currently involves continuous lime addition to mine portal effluent water at:

- The Galkeno 900 adit;
- The Galkeno 300 adit;
- The Silver King 100 adit; and
- The Valley Tailings Facility (on an as-needed basis, depending on water quality and decant situation - normally requiring treatment only during spring freshet, between May and June).

The treatment objective is to reduce zinc effluent concentrations to less than 0.50 mg/L, as required under Water Licence QZ06-074. Historic correlations between zinc concentrations and other metals (i.e. arsenic, lead and cadmium) indicate that the zinc discharge treatment objective ensures that other potential contaminants of concern are also managed.

As a result of the high levels of zinc discharging from the Galkeno 300 adit, and the difficulty associated with treating these zinc levels, ERDC completed an assessment of the performance of the Galkeno 300 adit water treatment system in 2007. This resulted in recommendations for process improvements to both the treatment plant and the sludge management systems at the site. Improvements that have been enacted are:

- A new rapid mix tank to improve lime use efficiency;
- Two new tube settler clarifiers to improve solids removal and sludge handling and sized to handle high flows associated with freshet or summertime storms;
- A new sludge storage pond to improve sludge management practice and assist in densification;
- New methods for handling and disposing of sludge from the sludge storage pond; and
- Storage of sludge in the Sime Open Pit.

Overall, these changes have been positive and have allowed the system to operate in compliance with water licence conditions with very few and short upsets since the changes were implemented in late 2007.

3.3.2 **Lime Mixing and Consumption**

Lime slurry preparation, currently conducted within the transport garage at Elsa, involves the addition of hydrated lime ($Ca(OH)_2$) via an auger conveyor into a mixing tank, where water is added to produce lime slurry. Water for lime slurry mixing is delivered to the transport garage via water tanker truck on a daily basis. In total, approximately 9,000 litres of slurry are mixed and delivered daily, via truck. The Galkeno 900 adit requires lime delivery up to two times per week, the Silver King system once per week and the Galkeno 300 system five to six times per week. Slurry concentration is roughly 37.4 grams of lime per litre of water, equating to an average consumption rate of 20 tonnes of lime per month (consumption rate rises during spring freshet in May and June, when treatment is required at the Valley Tailings). The Galkeno 300 treatment plant requires approximately 70% of the total lime consumed at the four treatment sites at Keno Hill, or approximately 14 tonnes per month.

3.3.3 **Galkeno 900 Bioreactor Cell Pilot Study**

The Galkeno 900 bioreactor is a pilot test of sulphate-reducing bacteria (SRB) technology for treating mine drainage. To create the bioreactor, a 3 m deep pond was filled with streambed gravels, and a baffle installed to direct mine water through the gravels. The mine waters are amended with a soluble organic carbon source mixture, primarily methyl and ethyl alcohols. The first few months of operation are a growth phase for naturally-occurring SRB to colonize the surface of the gravels, in time forming a microbial coating over the gravels expected to be comprised primarily of SRB. The SRB metabolize the carbon source, leading to the reduction of sulphate and the formation of aqueous sulphide within the bioreactor. The sulphide reacts with soluble metals in the

mine drainage, precipitating the metals within the bioreactor, where the metal precipitates are filtered by the gravels.

Alternative bioreactor designs often include an insoluble source of carbon, such as wood chips or peat; however, this test was performed to determine a loading rate requirement without the confounding factor of a slowly degrading carbon source such as would be present in peat or wood chips. In a full scale configuration, bioreactors would likely be constructed with locally available carbon sources such as wood chips and/or peat as part of the bioreactor solid phase, and amended with alcohols to provide treatment redundancy and to prolong the effective treatment processes.

The pilot test is a demonstration that this SRB technology, which has been successfully employed at many sites in mine pools, wetlands, and bioreactors in warmer climates, can be successfully implemented year-round in a buried pond bioreactor in the cold climate at Keno Hill, where temperatures of -40^{o}C or colder are common in the winter months. Since October 2009, the bioreactor has been successfully treating adit discharge water. The optimal flow rate through the bioreactor has been determined by operating the reactor at different flow rates and assessing the removal efficiency. With a 0.5 l/s through-flow rate, the bioreactor consistently achieved greater than 99% zinc removal, and similar results for cadmium and other metals (reference 2010 report on 2009 bioreactor). More recently, in 2010 flow rates of 0.75 and 1.0 l/s have shown that at a flow rate of 0.75 l/s treatment can be sustained, while 1.0 l/s has had insufficient treatment. The limiting factor appears to be the effective residence time in the reactor with the higher flow rates, and full scale designs will have design modifications that will limit dead zones within the bioreactor, increasing the effective hydraulic residence time. The existing configuration tested in the pilot program utilized a sub-optimal configuration for flow through the bioreactor that was necessitated by the small footprint available next to the Galkeno 900 adit, and the requirement to keep the adit

flow contained within the lime treatment system. The bioreactor technology is discussed in greater detail in the report "Galkeno 900 Bioreactor Summary Report" (Alexco Resource US, 2011).

3.3.4 **Adit Water Management**

In the fall of 1993, a hydraulic plug was installed by UKHM in the Galkeno 900 level adit, in response to concerns from Environment Canada that this adit was a major source of contaminant loading to the receiving environment. The objective of the installation was to cause flooding of the underground workings which would limit oxidation and dissolution of metals into the drainage water.

It has been recognised, given the geology of the hillside and extent of development above the 900 level, that the workings would not entirely flood and the source of soluble metals would likely continue. Moreover, as water accumulated behind the plug, the increasing hydraulic head could provide a driving head to cause mine water to seep from the rock mass beyond the plug and surrounding grout curtain, and to daylight elsewhere in the hillside. The adit plug continues to leak and produce water at a rate of several litres per second. A seep survey has been conducted on the hillside in the area around Galkeno 900, and some seeps with elevated zinc have been observed. These seeps may provide a source of zinc and other metals into the headwaters of Christal Creek and Christal Lake. It is possible that some of the natural seeps located in the headwaters of Christal Creek and Christal Lake are natural expressions of mineralized vein-associated water, and not impacted by or related to the water impounded behind the adit plug located in the Galkeno 900 adit.

Other water management facilities at the site are generally associated with treatment facilities at the adits and at the Valley Tailings. Ponds and decant structures hold and convey water to and from various sources at the site. Treated water from the Galkeno 300 system is routed down Calumet Drive via a HDPE pipeline that directs water into a

ditch and eventually becomes part of Hinton Creek. Two significant diversions on the south and east side of the tailings are maintained to limit inflows into the Valley Tailings ponds.

3.4 **Tailings**

Tailings were produced from each of the three historic mills (Elsa mill, Galkeno/Mackeno mill, and Wernecke mill).

3.4.1 **Wernecke Tailings**

The Wernecke tailings are difficult to locate as they have partially revegetated. Tailings were deposited on the hillside between 1925 and 1931. The quantity of tailings deposited here is unknown, although the maximum mill capacity was reported at 125 tons per day. There are no existing dams or tailings or water-retaining structures and tailings are known to have migrated downgradient from the site of their initial deposition. Very little information exists on these tailings. This tailings area drains north to the Keno-Ladue River. For purposes of this closure plan, the Wernecke tailings closure only includes closure of the tailings on the former UKHM claims, or approximately 1.3 km from the mill site to the property boundary on the hillside. Figure 3-2 illustrates the relative location of the Wernecke Mill Site, Sadie Ladue 600 adit, the assumed drainage pathway tailings took down to the unnamed lake, and the claim boundary.

483000 484000 485000 486000 487000

7096000 7095000 7094000 7093000 7092000 7091000

N W E S

Ladue

ALLUVIAL FAN CONTAINING WERNECKE TAILINGS

Unnamed Lake

Gambler Lake

Gambler

Gulch

Lake Site Shaft

SADIE LADUE ADIT

WERNECKE MILL

WERNECKE RAILROAD

SADIE LADUE SHAFT

Lucky

Klondike Keno Adit

Black Cap Adit

Lucky Que Adit

Brewis Red Lake Adit

483000 484000 485000 486000 487000

National topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:50,000. Reproduced under license from Her Majesty the Queen, as represented by the Minister of Natural Resources Canada. All rights reserved.

Aerial photograph obtained from Geodesy Remote Sensing Inc., Calgary Alberta. Imagery acquired September 13th and 14th 2006.

Site hydrography derived from 2006 aerial imagery obtained from Aero Geometrics, Calgary Alberta.

Datum: NAD 83; Projection: UTM Zone 8N

Drainage on Historic UKHM Claims
Drainage off Historic UKHM Claims
UKHM Claims
Watercourse
Contour 100 ft interval
Waterbody

1:18,000 *When printed on 11 by 17 Inch paper*

0 0.25 0.5 0.75 1 Kilometers

ERDC

ACCESS CONSULTING GROUP

ELSA RECLAMATION AND DEVELOPMENT COMPANY

DRAFT CLOSURE OPTIONS REPORT

FIGURE 2-3

LOCATION OF WERNECKE MILL AND OFF-CLAIM TAILINGS

DRAWN BY MD	**APRIL 2011**	VERIFIED BY JH

I:\ALEX-05-01\gis\mxd\UKHM\Closure_Options_Report_2011\Sadie_Wernecke_Site_20110415_v5.mxd
(15/04/2011/16:50 PM)

3.4.2 **Mackeno Tailings**

The Galkeno/Mackeno tailings were deposited on land near the northeast shore of Christal Lake. Mill feed was primarily from early Bellekeno and Galkeno workings. Approximately 3,000 to 5,000 tons of tailings were deposited in this area between 1953 to approximately 1959, though total production was reported to be far higher (Access 2009 report). There are unconfirmed reports that tailings were deposited in Christal Lake directly and/or by placement on ice covering the lake in the wintertime, and there are estimates of up to half of the tailings may be present in the lake as lake sediments. There are no dams retaining the on-land tailings. Historically the waters of Christal Lake and Christal Creek have inundated and eroded part of these land-based tailings. Some tailings loss to Christal Creek from the existing tailings site has occurred, and active erosion of tailings into the creek is recognized to be occurring. Tailings from this source and the tailings in the lake sediments are recognized to be a source of metals in the sediments of Christal Creek, and may act as a limiting factor to improvement of water quality in this system (Environment Canada, personal communication with Dr. John Kwong).

3.4.3 **Valley Tailings**

The Elsa Mill Tailings impoundment, also termed the Valley Tailings, is the single largest in the district and presents a host of issues to consider for closure, including physical stability of dams and diversions and long-term geochemical stability. Recent geochemical assessment by SRK (2009) suggests that the tailings are not likely to generate acidity in the future and that metal loads to surface and groundwater will continue to be generated but will remain relatively small. Considerable work has been done on re-vegetation of the tailings but with the exception of wet areas, little vegetation establishment has occurred. Wet tailings areas, on the other hand, have developed lush vegetation.

Reprocessing of tailings, perhaps with relocation, to a more secure site has been suggested as a possible economically viable project, and is under assessment by Alexco. For this report, reprocessing is not considered as a stand-alone closure option, but when reprocessing analyses are completed as a stand-alone project, combining it as a cost mitigation with the closure options will be re-considered.

The geotechnical reviews of the Valley Tailings over the years by regulatory authorities, site annual inspection consultants, and closure plan consultants indicates that there are three key issues related to physical stability of the Dam structures that need to be addressed for long term closure:

- ground thaw beneath the tailings dams resulting in settling and therefore potential for overtopping and breaching of the structure;
- presence of culverts and decant structures through the dams which may lead to blockage or piping failures around these structures; and,
- failure or slumping of the downstream face of each dam due to steep (over-steepened) slopes.

The Valley Tailings are not a significant load of metals on the property in terms of surface water pathways relative to other contaminant sources since seasonal water treatment occurs each spring. They are even less significant in terms of groundwater contaminant loading, likely due to the presence of a peat layer that appears to underlay all of the tailings area. The long-term sustainability of the peat layer to provide treatment of elevated metals in pore water is currently being assessed. The long term loading of the metals produced by the tailings to the receiving environment must be mitigated to an acceptable level using approaches that can be demonstrated to be permanent and sustainable. To achieve that objective water management issues are a primary focus to limit transport of metals in pore water and to limit erosion of tailings from the ponds to the downgradient environment.

Another consideration for closure of the Valley Tailings area is the potential for airborne contribution of metals loading to the surrounding terrestrial environment. When the tailings are dry and significant wind events occur, dust from the tailings is easily transported. This can be mitigated by keeping the tailings moist or by covering them. Where the tailings are submerged or wet, airborne transport is unlikely to occur and there is the added benefit that wet tailings are more easily revegetated.

The tailings deposited from the Elsa mill are the most recent, and by far the largest deposit. Approximately 4,128,000 tons of tailings have been deposited in this facility. Tailings were deposited from the Elsa mill during the periods 1936 to 1942, before the formation of UKHM, and 1947 to 1989, by UKHM. The Valley Tailings facility is located in the Flat Creek Valley, and consists of a series of three impoundment structures. A significant fraction of the tailings are impounded behind Dam No. 1. The No. 1 and No. 2 dams failed in the early 1970's and some tailings were lost downstream to Flat Creek. The No. 3 dam was constructed shortly thereafter. A significant fraction of the tailings are also not behind any dam structure, and thus are not contained in any way, due to the direct discharge of the tailings onto the slopes downgradient of the Elsa Mill prior to dam construction. The tailings dams are routinely inspected and monitored. There is no human habitation immediately downstream of the tailings.

3.4.4 **Existing Water Management Facilities near Valley Tailings**

Freshwater supply for domestic, fire and milling purposes in the Elsa area was obtained from a small lake connected to the South McQuesten River. A pumphouse is located near the lake and water was pumped via pipeline 5 km to the Elsa townsite and mill. There are no dams or structures located at the pumphouse. Mine water from the Husky shaft was also piped to the tailings impoundment. Tailings were piped from the Elsa mill to the Valley Tailings area, with no water recycle.

The only major surface water diversion is located on Porcupine Gulch. Porcupine Gulch originates on Galena Hill and flows by the Elsa mill. Surface waters are partially diverted around the tailings impoundment by this diversion. Maintenance work is required on the Porcupine Diversion as the diversion was constructed within the tailings itself. A smaller diversion also captures water on the eastern side of the tailings and discharges the diverted water into the No Cash bog, though this diversion was never designed and constructed using engineered controls. The entire diversion approach around the Valley Tailings will require updating and redesign during closure and reclamation implementation.

3.5 **Waste Rock**

Generally, there are waste rock storage areas (WRSAs) associated with each mine working. 68 WRSA sites have been identified within the District, and of these, there are 16 sites with pits. Note that the list does not include the Flame & Moth and Bellekeno 625 sites, which are operational facilities and not being considered for near-term reclamation under this closure and reclamation program.

There has been no mass failure of any waste rock site, although minor instabilities have been noted at some waste rock piles. The waste rock site at Keno 700 has experienced significant erosion from water surges as a result of blowouts due to failures of ice plugs, and some erosion of waste material has occurred from No Cash 500 due to the proximity of the dump toe to the creek. The WRSAs are located on hillsides generally away from major roads, water courses, and human habitation.

A major distinction between two types of WRSAs is helpful in assessing closure options. Generally WRSAs associated with adits, with the notable exception of Hector 400 Adit WRSA, are relatively small and contain a greater amount of mineralized rock that was closely associated with the vein material. Where long drainage adits were driven in country rock, such as at Sadie Ladue, Keno, and No Cash, the amount of vein-associated

mineralized rock would be expected to be less. WRSAs associated with adits also may have low grade ore material from operational periods where sphalerite-type material was uneconomic for processing and recovery, in which case it would be placed as waste at the surface or left in stopes.

In contrast, WRSAs associated with open pits would have little vein associated material, and consists primarily of country rock that did not contain significant mineralization. The assessment of closure options therefore primarily focuses on the WRSAs associated with adits from a geochemical loading perspective, and options for pit-associated WRSAs focuses on implementing reclamation standards such as minimizing erosion into creeks and removal of debris.

3.6 **Other Site Infrastructure**

Public Highways

The Silver Trail highway runs through the Elsa townsite en route to Keno City and is the primary access route for the site. This road is a public highway that will remain in use after closure which means that water diversion and other closure components must plan for highway maintenance requirements.

Electrical Transmission

Electrical power is supplied by Yukon Energy Corporation from the Wareham Dam Hydroelectric facility on Mayo Lake.

3.6.1 **Buildings and Mine Structures**

The infrastructure associated with the Keno Hill Silver District is confined to specific mine workings and the Elsa Townsite. Historically small local townsites were set-up to support major mine workings. For example, Hector Calumet and Keno 700. The Hector Calumet townsite was removed while most of the Keno 700 camp has been removed under the physical hazards reduction program. The Elsa Townsite has largely been

dismantled but considerable infrastructure at the site remains and consists of the mine offices, shops, warehouses, bunkhouses and a small number of houses. The Elsa site contains numerous remnant fuel oil and fuel storage facilities that are likely contributors to hydrocarbon contamination that will require remediation at closure.

Three mills were known to have operated within the UKHM claim boundaries. These include the existing Elsa mill which lies near the headwaters of Flat Creek, the old Galkeno or Mackeno mill near the northeast shore of Christal Lake, and the older Wernecke mill located as part of the Wernecke camp on Keno Hill. The mill building at the Galkeno mill site has been removed. Similarly, there is no visible evidence remaining of the Wernecke mill building. The Mackeno and Wernecke Mills were not UKHM operations.

The majority of houses from the Elsa town site have been removed. The ongoing physical hazard reduction continues to remove high risk structures from the district, and these efforts will continue until all buildings are either removed by demolition, stabilized for use by Alexco as part of production units, or preserved as heritage sites. A YESAA assessment was conducted on demolition of some structures in Elsa in 2010, and demolition of these sites will be completed in 2011. A project description for demolition and/or preservation of all remaining structures in the district will also be submitted to YESAA for assessment in 2011. Concurrently, a Heritage plan is also being developed for the entire district. Consequently, the completion of the disposal of buildings and related mine structures is part of a separate project and will not be discussed further in this document with the exception that for completeness of understanding of each site, the closure options summary sheets included in Section 5 document which structures are present at each site that will be part of the overall closure of each site.

3.6.2 **Keno City**

Keno City was once a thriving community housing large numbers of mine workers, but currently is a hamlet with a small resident population of about 17. The hamlet draws its drinking water from a ground water well in the center of town and operates a solid waste disposal site in the headwaters of Christal Creek. The historic impact of the Onek mine on the groundwater in the area of Keno City is an area of ongoing study. Preliminary evaluations (Access 2009) indicate at some times of the year the flow from the historic Onek 400 adit reports through surface flow and shallow subsurface flow to the Christal Creek headwaters near the Christal Lake outlet, while in the later summer/early fall 2011 an investigation in the drainage below the Onek 400 adit showed complete infiltration within 50-100 meters of the adit (InterraLogic 2011). Other issues in the Keno City area related to the Onek mine include adit waste rock scattered near the adit which exceeds soil quality guidelines.

4. Closure Planning Framework and Process

4.1 Closure Framework

The closure planning framework proposed for the Keno Hill Silver District (KHSD) is based on the recognition that sustaining ecosystem development using an ecosystem based management approach is an appropriate management philosophy. The approach to closure has been to consider the overall mining activities, both past and present, within the context of the surrounding local environment and consider and assess the relative risks associated with each mine component for closure activities on the ecosystem. Closure activities planned for each mine component considers the inter-relationships of mine components and the potential environmental hazards in order to characterize risks associated with an activity so that appropriate measures can be implemented to address environmental impacts.

Under this closure framework, the effect of closure options within the identified ecosystem (ie. Watershed or other identified spatial unit), are considered collectively with the effect of other closure options within the ecosystem. The potential performance of closure options at one site may affect the considerations of closure options at other sites as adjustments in one area impact on the overall post implementation sate of the ecosystem. In this way closure planning can address sensitive or impacted ecosystem components. Moreover, natural and other existing mechanisms interacting with mine components are evaluated and weighed in determining possible closure outcomes. The result is that decisions are not made in isolation, they consider down-gradient effects.

Examples of these are the Bermingham, Ruby, and No Cash mines. Each mine discharges (indirectly) into No Cash Creek, which discharges into the No Cash bog area, and ultimately to the subsurface. These individual mine drainages must be considered in combination when considering the closure of any one site within the No Cash Creek

watershed. Another example of this decision making process is the use of the site mass balance model to determine the relative benefits associated with treatment of particular sites, and where particular treatment approaches or mechanisms are required.

Developing a Closure Plan for the historic UHKM mining camp in the KHSD presents several unique challenges:

- Past mining activities have left the area honeycombed by small workings, open pits, and an altered drainage pattern;
- There are other historical mines within the KHSD that are not part of the Closure Plan project area since they were never owned by UHKM;
- Historical mining development and operations primarily followed the mineralized vein structures in an effort to sustain mill production;
- The concepts for closure planning and control of acidic or metal mine drainage were just being developed within the technical community as recently as the early 1980s, when UKHM was winding down its mining activities in the area.
- There is more than 20 years of placer mining activity within Lightening Creek watershed; and
- There are known to be other off claim influences on local receiving environment water quality within the South McQuesten River watershed.

As a result of these influences, the quality and quantity of water has been significantly altered from the natural environment of a hundred years ago. The lack of a clear understanding of the pre-mining conditions.

To compound this issue, there are no studies of the pre-mining natural environment. This is typically key when determining reclamation objectives, at least for new mines. However, it is recognized that traditional knowledge and FNNND history of the site does provide some basis for understanding pre-mining conditions. The knowledge that the

Keno Hill area is a mineralized area with natural elevated concentrations of some metals in some drainages near the UKHM property, and the practical limitation of rehabilitating streams with dispersed tailings mixed into natural stream sediments, will affect the potential for full restoration of water quality. It was therefore recognized that the approach to closure in an old mining district must be considerably different than for a new mine, where closure planning concepts are incorporated into designs at the onset of mining and where there is a better understanding of the pre-mining baseline environmental conditions. An integrated approach was adopted to address closure planning for past mining activities.

4.1.1 **Watershed Management**

Early on in the development of the closure plan, it was recognized that a particular focus of the closure plan would be towards managing closure activities and assessing relative impacts on a watershed management basis. Applying this to the ecosystem based framework for closure development, it became apparent that the critical ecosystem components in the area were the surrounding waters of the South McQuesten River and associated aquatic resources that it supported. This valued aquatic ecosystem component has previously been recognized by regulators, first nations and local residents for consideration in closure planning for the KHSD. There has also been recognition from parties in the closure planning process that the traditional use of the land within the South McQuesten watershed; specifically the wildlife and vegetations on which it depends, was also considered of importance.

The watershed management approach is consistent with the concept of sustainable ecosystem development. Watersheds provide natural boundaries and limits for managing ecosystem components and ultimately assessing impacts on them. The hydrologic cycle also provides a natural pathway that integrates physical, chemical, and biological processes of the ecosystem. The use of a watershed level management units

allows for the development and synthesis of closure strategies in conjunction with the assessment of associated risks and impacts of those watersheds.

Another important aspect of using a watershed management approach is that it provides a method to assess the impacts of metal leachate from the surrounding mine workings on the receiving environment. The closure plan must consider the metal leaching or acid rock drainage (ML/ARD) potential of the individual mine workings and the potential for impacts on specific watersheds. Development of mitigative measures to address these issues follows a similar watershed based management approach. The consideration of watersheds as a whole allows for the prioritization of resources to the target components that have the greatest impact/benefit to be realized for financial resources and effort being expended. Trade-offs that consider the relative benefit associated with reclamation options for a particular mine component within the watershed avoids generic prescriptive application of reclamation activities that may not appreciably improve the environment. The use of an integrated watershed approach to closure development means that economically viable closure strategies can be developed and implemented while monitoring their effect in the receiving environment.

The watersheds that were specifically considered when developing the closure plan were the South McQuesten River with particular emphasis on the Flat and Christal Creek drainages and Lightning Creek which flows into the Mayo River system. There are other minor workings which drain the north side of Keno Hill and ultimately flow to the Keno Ladue River. The Keno Ladue River was not assessed under the scope of this report because the relative loading of metals and amount of disturbance within this watershed is primarily related to tailings produced from the Wernecke Mill, which have been transported off the UKHM claim boundaries. The assessment and potential mitigation of any effects of these off claim tailings are being considered under a separate closure planning process between ERDC and INAC.

4.2 Closure Planning Process

Development of a closure plan process to address the KHSD historic environmental liabilities requires a tailor made approach given the fact there three governments (INAC, YG and FNNND) in addition to a site owner and operator (ERDC). The closure planning process considers the unique nature of this project which includes ERDC acting as the proponent, and holder of all licences and permits related to the closure project, with INAC providing a significant part of the funding and having a significant decision-making role. The three governments (INAC, YG, and FNNND) have been active closure planning participants, each providing input with respect to closure objectives, reviewing closure issues, providing feedback on monitoring and site investigation studies, and providing direction on the range of closure options considered in this report.

The method for selecting appropriate closure options for mine area components has been structured around a risk assessment process whereby potential closure options were risk assessed and then further refined to meet closure objectives or else rejected. This process resulted in the final range of closure options presented here. During the risk assessment stage, potential options and their relative risks on a number of variables were considered and then were presented to stakeholders. This option feasibility assessment process was used as an initial refining tool to elicit feedback on acceptable closure approaches and how they might interplay. The draft closure option list presented in this document, and the options considered but not advanced, are largely the result of this feasibility assessment process.

Given the large number of individual sites (adits, shafts, waste dumps, buildings/infrastructure, etc.) conducting a risk assessment on all of the multiple closure combinations that are possible at each site would become unworkable and not effective. The option feasibility assessment approach was used to develop the range of closure options proposed in this report, and to inform the range of options that were

considered, but not advanced for closure of Keno Hill historical mine components. The feasibility assessment exercise was designed to assess the most significant mine area components in the district from a scale of disturbance and relative complexity perspective, and present a range of viable closure options for these components. Based on the risks identified for this select group of components, it is reasonable that the salient high level risks will be identified that can then be applied to all components across the district.

Further prioritization and focussing of closure planning of resources and closure planning focus was done by selecting mines with more significant impacts to the environment that also have complex environmental or physical issues. The selection criteria were primarily based on those sites with mine drainage above a threshold of 100 kg/yr zinc. This process led to the identification of 14 “complex site components” and 31 relatively “simple sites”. The complex site components can be summarized as adits with point source drainage above 100 kg/yr zinc, waste rock dumps with potential for similarly large zinc loading, and the tailings facilities (Valley Tailings, Wernecke, and Mackeno). Based on this screening, the complex site components for which greater closure planning focus has been prioritized are:

- Silver King Mine (100 level adit)
- Husky SW Mine (shaft)
- No Cash Mine (500 level adit)
- Bermingham Mine (200 level 3adit)
- Ruby Mine (400 level adit)
- Galkeno Mine (300 level adit)
- Galkeno Mine (900 level adit)
- Sadie Ladue Mine (600 level adit)
- Onek Mine (400 level adit)
- Keno Mine (700 level adit)

- Hector WRSA
- Wernecke Tailings
- Valley Tailings
- Mackeno Tailings

The remaining sites are classified as relatively simple, in that the closure options selected for the complex sites will be used to inform the approach to be taken for the other sites, or in many cases conventional accepted reclamation approaches will be taken.

4.3 **Closure Objectives**

Closure Plan Objectives are being developed through a consultative process with INAC, YG and FNNND. The following are the closure objectives that are intended to guide the development of the Existing State of Mine Closure Plan for the Keno Hill Mines property. The current closure objectives have been developed and continue to be refined in conjunction with INAC, YG, NND and ERDC, and will be used to assist with selection of preferred closure options and implementation of the final plan. These objectives have been refined and restated as project needs have developed, and will be finalized prior to the preferred option selection process. A current version of the Closure Plan Objectives is:

- Protect Public and Worker Health and Safety
- Protect and Restore the Environment
- Restore Mine Site to a State that Reflects Community Desires and Traditional Land Uses
- Maximize First Nation, Local, and Yukon Socio-economic Benefits
- Manage Current and Future Long-term Liabilities and Risk in a Cost Effective Manner

These Closure Objectives will be used to assess and rank closure options using an evaluation process that has yet to be determined. More detailed discussion of the Closure Plan Objectives will be circulated as a memorandum for discussion concurrently with this document.

4.4 Mine Component Closure Option Risk Assessment Process

For the purposes of risk assessment of the short listed closure options, the components of mine areas that represent the majority of contaminant loading and present the most challenging issues within the district were selected. A working group of stakeholders and project leaders were gathered including INAC, ERDC, FNNND and YG. The process covered all closure components presently existing at the site, including waste rock storage areas, pits, adits and their associated water management and the valley tailings area. Risks identified for these sites provide the most conservative risk scenarios and can therefore be applied to other sites in an effort to select acceptable closure options for further review. The following mine sites were assessed and are representative of the major contaminant loads, risks and challenges across the district:

- Galkeno 900
- Onek 400
- Hector Calumet
- Galkeno 300
- Valley Tailings Area
- No Cash 500
- Keno 700
- Elsa Village

The risk assessment was recorded in a standard risk matrix which logged both the probability and severity of a potential risk, and in turn identified the resulting risk rating. Risk identification and rating was based on the premise that each scenario was an unmitigated measure for closure. Following the formal group risk assessment ERDC provided mitigative measures for each closure scenario and performed an internal

residual risk assessment, which ERDC used in further refining the viability of some of the closure scenarios, and in designing technical field studies. The results of the both the initial group risk assessments and the residual risk assessment are presented in Appendix B, along with the original technical memorandum to the working group outlining the process and results. In the future, a residual risk assessment will need to be carried out among the larger working group given the advanced stage of the technical studies, and preferred options for closure will be selected. Preferred options and residual risks will be taken to the public to undergo a stakeholder and peer review. With the feedback from this process in mind, final options for each mine site component will be selected and used to develop a final closure option for each site. Outstanding items for closure planning include a further global risk assessment, working group mitigation and residual risk assessment, stakeholder and peer review and selection of a preferred, and later, final option for each site.

4.5 **Preferred Closure Option Process**

After this report has received review and input from INAC, FNNND, YTG and the Independent Peer Review Panel (IPRP), the preferred options selection process will be implemented. Following the selection of the preferred option for each site, preferred options and residual risks will be submitted for a similar stakeholder and IPRP review process. With the feedback from this process in mind, final options for each mine site component will be selected and used to develop a final closure approach for each site.

As the last step in the preferred option selection process it is planned to conduct a global risk assessment that considers mitigation and residual risks. This will ensure that the proposed options will remediate the site and only leave acceptable risks, and that appropriate mitigations are planned for each preferred option selected and that the preferred options will remediate the site and only leave acceptable residual risks.

5. Draft Closure Options

5.1 Summary Tables and Figures

An extensive review of relevant materials has been conducted from previous investigations, along with site visits and inspections during the last 5 years. This has led to the identification of the major closure issues at each site on the property. The following tables and figures provide a summary, broken down by component, of the various issues that the closure plan will necessarily need to address. The key issues that will drive closure planning at Keno Hill relate to human and wildlife health and safety, contamination of the environment (including water, air and land), community concerns, and risks from extreme events that may affect the ability to effectively manage water or the structural integrity of site works.

Tables 5-1 to 5-7 summarize the possible closure options identified for the complex mine components at the Keno Hill Property. Tables 5-8 through 5-40 present a summary of closure issues and options for each site. Associated with each closure option site table is a summary figure (Figures 5-1 to 5-48) that illustrates the site from a recent aerial photograph, and the location of each closure option for the following sites:

- Silver King Site
- Husky SW Site
- Husky Site
- No Cash 500 Site
- Bermingham and Ruby Sites
- Galkeno 300 Site
- Galkeno 900 Site
- Galkeno Site
- Sadie Ladue 600 Site
- Onek Site

- Keno 700 Site
- Mackeno Site
- Valley Tailings Site
- Husky Site
- Elsa Mine Site
- Dixie Site
- No Cash 100 Site
- Townsite Site
- Hector Calumet Site
- UN and Miller Sites
- Bluebird Site
- Galena Hill Other Sites
- Duncan Creek Site
- Klondike Keno Site
- Sadie Ladue/Wernecke Sites
- Lucky Queen and Blackcap Sites
- Lucky Queen Shafts
- Shamrock Site
- Highlander Site
- Cub and Bunny Site
- Keno 200 Site
- 5-2 Site
- Keno #9 Site
- Keno Hill Other Sites

Component Description	Component Type	Closure Activitiy No. (map reference)	Closure Issue Categories: Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest	Min Flow: Top figure 1994 - 2010; bottom figure 2004 - 2010	Average Flow: Top figure 1994 - 2010; bottom figure 2004 - 2010	Max Flow: Top figure 1994 - 2010; bottom figure 2004 - 2010	Alternatives	Major Cost Elements
Silver King 100 Level Adit	*adit*	*SK1*	- Potential ecological risk to flora/fauna in all areas downgradient of adits discharging to the environment through plant uptake of metals - potential for public access to workings	Adit discharge is slightly elevated for contaminants of concern (i.e. 1.0ppmZn). The effect of this on Flat Creek is difficult to discern as a result of the combined contamination from Silver King, Husky SW and the VTF	Adit discharge decants over the toe of the 100 level adit dump directly into Galena Creek; discharges at an average of 4.8L/s	Adit portal is susceptible to degradation and collapse	This is the first mine in the district, and therefore has historical significance. Aside from the 100 level adit, there is potential for heritage restoration.	**1**	**4.84**	**12**	**(1) Managed natural attenuation:** a) engineered water management structure passively aerates water at adit, settles precipitates, and disperses water onto hillside; b) study program to confirm NA is performing adequately; c) ongoing monitoring at adit and within Flat Creek to demonstrate treatment; d) define thresholds for source and receiving environment that define acceptable treatment e) note: engineered water management structure could be used as an injection point for carbon source for in situ bioreactor	1) engineered water management structure would be passive aeration tumbling device concrete bunker buried in hillside (CapEx); 2) buried concrete tank settling structure for any Fe/Mn/Al precipitates with sorbed trace metals (CapEx and annual O&M); 3) buried injection trench to distribute adit drainage across hillside (CapEx and annual O&M); 4) study program to confirm NA mechanisms and long term stability (CapEx); 5) monitoring program quarterly at adit and Flat Creek for 5 years, transition to annual for 5 years, transition to every 5 years to closure (O&M)
								1.0	**5.6**	**8.8**	**(2) Mine pool treatment:** a) alkaline and/or carbon source injection and mixing into pool that creates clean discharge; b) ongoing monitoring at adit to demonstrate treatment c) note: could be used to pretreat for MNA alternative	1) low pressure hydraulic plug in 100 level 2) Reagent storage, mixing, and injection facility located above mine pool at mine shaft (CapEx and O&M); 3) monitoring program monthly at adit for first 2 years, transition to quarterly for 8 years, then annual for 20 years (O&M) 4) aeration at adit drainage point, allow to drain toward Galena/Flat Creek (CapEx) 5) monthly checks of treatment system (1 hour per visit) for first 2 years, transition to quarterly checks for 8 years, then annual for 20 years (O&M)
											(3) Bioreactor treatment a) use existing lined facility in existing settling ponds; b) carbon source addition in both solid phase and dissolved phase; c) ongoing monitoring at bioreactor discharge to demonstrate treatment d) note: could be used to pretreat for MNA alternative	1) Fill existing ponds with layered media primarily coarse gravels, some wood chips and peat (CapEx) 2) Reagent storage, mixing and injection facility to add carbon source to bioreactor (CapEx and O&M) 3) Monitoring program monthly at adit and bioreactor discharge monthly for 2 years; transition to quarterly for 8 years, then annual for 20 years (O&M) 4) Monthly checks of treatment system (1 hour per visit) for first 2 years, transition to quarterly checks for 8 years, then annual for 20 years (O&M)
											(4) Mechanical Plant a) treatment plant using active water mixing with reagents and recovery of treatment sludge (range of treatment substrates include lime, sodium hydroxide, sodium hydrosulfide) b) note: could be stand alone small plant, or combined with common plant for instance in Elsa	1) Adit collection structure consisting of low pressure hydraulic adit plug with a few days storage in mine (CapEx) 2) Reagent storage, mixing, and injection facility (enhance existing system) (CapEx) 3) Reagent addition using automated pH control (O&M) 4) Sludge settling in existing ponds, infrequent cleanout (O&M) 5) Monitoring program weekly for first year, transition to monthly for next 29 years (O&M) 6) Daily checks and maintenance of treatment system (1 hour per day) years 1-2, years 3-5 weekly, monthly for next 25 years (O&M)
Husky SW Shaft	*shaft*	*HSW1*	- Potential ecological risk to flora/fauna in all areas downgradient of adits discharging to the environment through plant uptake of metals - Potential for public access to workings	shaft discharges roughly 1.0mg/L Zn; visible staining at discharge path below dump where adit decants to environment; however, loadings from the shaft are not significant	produces water; <0.5L/sec; discharge is piped through the dump to a discharge point beyond the dump	Shaft will require cap and water management structure during closure.	There is an old cabin that supposedly was a homestead for a woman and her kids (NND anecdotal information)	**0.1 (2010)**	**0.42 (2004 - present)**	**25.3 (1995)**	**(1) Managed natural attenuation:** a) engineered water management structure as part of shaft closure passively aerates water, settles precipitates, and disperses water onto hillside; b) study program to confirm NA is performing adequately; c) ongoing monitoring at shaft and within Flat Creek to demonstrate treatment; d) define thresholds for source and receiving environment that define acceptable treatment e) note: engineered water management structure could be used as an injection point for carbon source for in situ bioreactor f) note MNA may allow for reclamation-only alternative	1) engineered water management structure would be passive aeration tumbling device concrete bunker buried in hillside (CapEx); 2) buried concrete tank settling structure for any Fe/Mn/Al precipitates with sorbed trace metals (CapEx and annual O&M); 3) buried injection trench to distribute adit drainage across hillside (CapEx and annual O&M); 4) study program to confirm NA mechanisms and long term stability (CapEx); 5) monitoring program quarterly at shaft and Flat Creek for 5 years, transition to annual for 5 years, transition to every 5 years to closure (O&M); may include groundwater monitoring
								0.1	**0.4**	**1.6**	**(2) Mine pool treatment:** a) alkaline and/or carbon source injection and mixing into shaft mine pool that creates clean discharge; b) ongoing monitoring at shaft to demonstrate treatment c) note: could be used to pretreat for MNA alternative	1) engineered shaft cap with water management structure to allow injection deep in shaft. 2) Reagent storage, mixing, and injection facility located above shaft mine pool (CapEx and O&M); 3) monitoring program monthly at adit for first 2 years, transition to quarterly for 8 years, then annual for 20 years (O&M) 4) aeration at adit drainage point, allow to drain toward Galena/Flat Creek (CapEx) 5) monthly checks of treatment system (1 hour per visit) for first 2 years, transition to quarterly checks for 8 years, then annual for 20 years (O&M)
											(3) Bioreactor treatment a) could be a lined facility or an injection gravel-filled trench; b) carbon source addition in both solid phase and dissolved phase; c) ongoing monitoring at bioreactor discharge to demonstrate treatment d) note: could be used to pretreat for MNA alternative	1) Create filled pond/trench downgradient of shaft with layered media primarily coarse gravels, some wood chips and peat (CapEx) 2) Reagent storage, mixing and injection facility to add carbon source to bioreactor (CapEx and O&M) 3) Monitoring program monthly at adit and bioreactor discharge monthly for 2 years; transition to quarterly for 8 years, then annual for 20 years (O&M) 4) Monthly checks of treatment system (1 hour per visit) for first 2 years, transition to quarterly checks for 8 years, then annual for 20 years (O&M); may include groundwater monitoring
											(4) Mechanical Plant (only as a contingency measure if adit characteristics substantially change) a) treatment plant using active water mixing with reagents and recovery of treatment sludge (range of treatment substrates include lime, sodium hydroxide, sodium hydrosulfide) b) note: could be stand alone small plant, or combined with common plant for instance in Elsa	
											(5) Reclamation-only a) minimal reclamation aimed at reducing shaft discharge contact with mineralized waste rock downgradient of the shaft.	1) Excavation to remove waste rock from flowpath of adit discharge 2) Monitoring program monthly during active flow period for for first 2 years with quarterly monitoring for 8 years, then annual for 20 years (O&M)

Component Description	Component Type	Closure Activitiy No. (map reference)	Closure Issue Categories: Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest	Min Flow: Top figure 1994 - 2010; bottom figure 2004 - 2010	Average Flow: Top figure 1994 - 2010; bottom figure 2004 - 2010	Max Flow: Top figure 1994 - 2010; bottom figure 2004 - 2010	Alternatives	Major Cost Elements
No Cash 500 Level Adit	*adit*	*NC500-1*	receiving waters and vegetation may be adversely impacted by high levels of contamination in drainage; unknown capacity for No Cash bog to absorb zinc	No Cash 500 drainage has the highest untreated zinc concentration in the district at roughly 15ppm Zn (and 0.15ppm Cd)	drainage spills from a pipe over dump crest and into No Cash Creek bog at ~4.0L/s	adit is susceptible to winter freezing and ice plug formation; adit structure is significantly collapsed; surface air circulates within workings	drainage contamination is significant enough to generate public concern	**2.5**	**4.7**	**8.5**	**(1) Managed natural attenuation:** a) aeration of water along No Cash as it flows down Galena Hill, settling basin at edge of Silver Trail highway, polishing treatment in No Cash Bog, periodic maintenance to remove precipitates in settling basin; b) study program to confirm NA is performing adequately; c) ongoing monitoring at adit and within surface pond in No Cash Bog and South McQueston River to demonstrate treatment; d) define thresholds for source and receiving environment that define acceptable treatment	Note, this alternative is entirely overlapping with Bermingham/Ruby natural attenuation, with the exception of No Cash adit monitoring and adit water control system 1) settling pond for No Cash Creek to remove any Fe/Mn/Al precipitates with sorbed trace metals (CapEx and annual O&M) and limit them moving into No Cash Bog; 2) injection/distribution surface trench to distribute No Cash Creek drainage across hillside (CapEx), optional carbon source addition at distribution system; 3) study program to confirm NA mechanisms and long term stability (CapEx); 4) monitoring program quarterly at adit and No Cash Bog terminal pond and selected wells, transition to annual for 5 years, transition to every 5 years to closure (O&M)
								2.5	**5.5**	**8.0**	**(2) Mine pool treatment:** a) create mine pool using low pressure hydraulic adit plug, alkaline and/or carbon source injection and mixing into mine pool that creates clean discharge; b) ongoing monitoring at adit to demonstrate treatment c) note: could be used to pretreat for MNA alternative	1) Hydraulic low pressure adit plug 2) Reagent storage, mixing, and injection facility located at adit, injection through adit hydraulic plug into the mine pool (CapEx and O&M); 3) monitoring program monthly at adit for first 2 years, transition to quarterly for 8 years, then annual for 20 years (O&M) 4) passive aeration at adit drainage point, allow to drain into No Cash Creek (CapEx) 5) monthly checks of treatment system (1 hour per visit) for first 2 years, transition to quarterly checks for 8 years, then annual for 20 years (O&M)
											(3) Bioreactor treatment a) lined facility at No Cash 500 adit on waste dump; b) carbon source addition in both solid phase and dissolved phase; c) ongoing monitoring at bioreactor discharge to demonstrate treatment d) note: could be used to pretreat for MNA alternative	1) Create filled lined pond/trench downgradient of adit drainage with layered media primarily coarse gravels, some wood chips and peat (CapEx) 2) Reagent storage, mixing and injection facility to add carbon source to bioreactor (CapEx and O&M) 3) Monitoring program monthly at adit and bioreactor discharge monthly for 2 years; transition to quarterly for 8 years, then annual for 20 years (O&M) 4) Monthly checks of treatment system (1 hour per visit) for first 2 years, transition to quarterly checks for 8 years, then annual for 20 years (O&M)
											(4) Mechanical Plant a) treatment plant using active water mixing with reagents and recovery of treatment sludge (range of treatment substrates include lime, sodium hydroxide, sodium hydrosulfide) b) note: could be stand alone small plant, or combined with common plant for instance in Elsa. Could utilize one of the existing clarifiers at Galkeno 300.	1) mine water storage--in adit, or in pond/tank, pipeline to plant 2) reagent storage 3) rapid mix tank 4) solids separation--clarifier 5) sludge filtering and handling/disposal 6) discharge system 7) operations and maintenance of plant daily operator 1 hour 8) monitoring adit and discharge, daily years 1&2, weekly years 3-5, monthly years 6-30
Bermingham Adit	*adit*	*BR1*		produces water (4.5ppm Zn, 0.2ppm Cd)	water discharges to ground, reporting to No Cash Creek and ultimately to the No Cash bog	Adit is supported by original wooden cribbing. The cribbing is rotting and warped; will eventually fail.		**0.2**	**2.01**	**12**	**(1) Managed natural attenuation:** a) aeration of water along No Cash as it flows down Galena Hill, settling basin at edge of Silver Trail highway, polishing treatment in No Cash Bog, periodic maintenance to remove precipitates in settling basin; b) study program to confirm NA is performing adequately; c) ongoing monitoring at adit and within surface pond in No Cash Bog and South McQueston River to demonstrate treatment; d) define thresholds for source and receiving environment that define acceptable treatment	Note, this alternative is entirely overlapping with No Cash/Ruby natural attenuation, with the exception of Bermingham adit monitoring and adit water control system 1) settling pond for No Cash Creek to remove any Fe/Mn/Al precipitates with sorbed trace metals (CapEx and annual O&M) and limit them moving into No Cash Bog; 2) injection/distribution surface trench to distribute No Cash Creek drainage across hillside (CapEx); 3) study program to confirm NA mechanisms and long term stability (CapEx); 4) monitoring program quarterly at adit and No Cash Bog terminal pond and selected wells, transition to annual for 5 years, transition to every 5 years to closure (O&M)
								0.3	**2.0**	**5.0**	**(2) Mine pool treatment:** a) alkaline and/or carbon source injection and mixing into pit pond and mine pool that creates clean discharge; b) ongoing monitoring at adit to demonstrate treatment c) note: could be used to pretreat for MNA alternative	1) Hydraulic low pressure adit plug 2) Reagent storage, mixing, and injection facility located at adit, injection through adit hydraulic plug into the mine pool (CapEx and O&M); 3) monitoring program monthly at adit for first 2 years, transition to quarterly for 8 years, then annual for 20 years (O&M) 4) passive aeration at adit drainage point, allow to drain into No Cash Creek (CapEx) 5) monthly checks of treatment system (1 hour per visit) for first 2 years, transition to quarterly checks for 8 years, then annual for 20 years (O&M)
											(3) Bioreactor treatment a) could be a lined facility or an injection gravel-filled trench; b) carbon source addition in both solid phase and dissolved phase; c) ongoing monitoring at bioreactor discharge to demonstrate treatment d) note: could be used to pretreat for MNA alternative	1) Create filled pond/trench downgradient of adit drainage with layered media primarily coarse gravels, some wood chips and peat (CapEx) 2) Reagent storage, mixing and injection facility to add carbon source to bioreactor (CapEx and O&M) 3) Monitoring program monthly at adit and bioreactor discharge monthly for 2 years; transition to quarterly for 8 years, then annual for 20 years (O&M) 4) Monthly checks of treatment system (1 hour per visit) for first 2 years, transition to quarterly checks for 8 years, then annual for 20 years (O&M)
											(4) Mechanical Plant a) treatment plant using active water mixing with reagents and recovery of treatment sludge (range of treatment substrates include lime, sodium hydroxide, sodium hydrosulfide) b) note: could be stand alone small plant, or combined with common plant for instance in Elsa	1) mine water storage--in adit, or in pond/tank, pipeline to plant 2) reagent storage 3) rapid mix tank 4) solids separation--clarifier 5) sludge filtering and handling/disposal 6) discharge system 7) operations and maintenance of plant daily operator 1 hour 8) monitoring adit and discharge, daily years 1&2, weekly years 3-5, monthly years 6-30

Component Description	Component Type	Closure Activitiy No. (map reference)	Closure Issue Categories: Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest	Min Flow: Top figure 1994 - 2010; bottom figure 2004 - 2010	Average Flow: Top figure 1994 - 2010; bottom figure 2004 - 2010	Max Flow: Top figure 1994 - 2010; bottom figure 2004 - 2010	Alternatives	Major Cost Elements
Ruby Adit			- Potential ecological risk to flora/fauna in all areas downgradient of adits discharging to the environment through plant uptake of metals - potential for public access to workings		- Adit drainage pools in the area around the adit and loadout structure - Adit drainage path to west has no controls	Adit is supported by original wooden cribbing. The cribbing is rotting and warped; will eventually fail.		**0.1**	**1.4**	**5.0**	**(1) Managed natural attenuation:** a) aeration of water along No Cash as it flows down Galena Hill, settling basin at edge of Silver Trail highway, polishing treatment in No Cash Bog, periodic maintenance to remove precipitates in settling basin; b) study program to confirm NA is performing adequately; c) ongoing monitoring at adit and within surface pond in No Cash Bog and South McQueston River to demonstrate treatment; d) define thresholds for source and receiving environment that define acceptable treatment	Note, this alternative is entirely overlapping with No Cash/Bermingham natural attenuation, with the exception of Ruby adit monitoring and adit water control system 1) settling pond for No Cash Creek to remove any Fe/Mn/Al precipitates with sorbed trace metals (CapEx and annual O&M) and limit them moving into No Cash Bog; 2) injection/distribution surface trench to distribute No Cash Creek drainage across hillside (CapEx); 3) study program to confirm NA mechanisms and long term stability (CapEx); 4) monitoring program quarterly at adit and No Cash Bog terminal pond and selected wells, transition to annual for 5 years, transition to every 5 years to closure (O&M)
								0.3	**1.0**	**3.0**	**(2) Mine pool treatment:** a) alkaline and/or carbon source injection and mixing into mine pool that creates clean discharge; b) ongoing monitoring at adit to demonstrate treatment c) note: could be used to pretreat for MNA alternative	1) Hydraulic low pressure adit plug 2) Reagent storage, mixing, and injection facility located at adit, injection through adit hydraulic plug into the mine pool (CapEx and O&M); 3) monitoring program monthly at adit for first 2 years, transition to quarterly for 8 years, then annual for 20 years (O&M) 4) passive aeration at adit drainage point, allow to drain into No Cash Creek (CapEx) 5) monthly checks of treatment system (1 hour per visit) for first 2 years, transition to quarterly checks for 8 years, then annual for 20 years (O&M)
											(3) Bioreactor treatment a) could be a lined facility or an injection gravel-filled trench; b) carbon source addition in both solid phase and dissolved phase; c) ongoing monitoring at bioreactor discharge to demonstrate treatment d) note: could be used to pretreat for MNA alternative	1) Create filled pond/trench downgradient of adit drainage with layered media primarily coarse gravels, some wood chips and peat (CapEx) 2) Reagent storage, mixing and injection facility to add carbon source to bioreactor (CapEx and O&M) 3) Monitoring program monthly at adit and bioreactor discharge monthly for 2 years; transition to quarterly for 8 years, then annual for 20 years (O&M) 4) Monthly checks of treatment system (1 hour per visit) for first 2 years, transition to quarterly checks for 8 years, then annual for 20 years (O&M)
											(4) Mechanical Plant a) treatment plant using active water mixing with reagents and recovery of treatment sludge (range of treatment substrates include lime, sodium hydroxide, sodium hydrosulfide) b) note: could be stand alone small plant, or combined with common plant for instance in Elsa	1) mine water storage--in adit, or in pond/tank, pipeline to plant 2) reagent storage 3) rapid mix tank 4) solids separation--clarifier 5) sludge filtering and handling/disposal 6) discharge system 7) operations and maintenance of plant daily operator 1 hour 8) monitoring adit and discharge, daily years 1&2, weekly years 3-5, monthly years 6-30
Galkeno 300 Level Adit	*adit*	*GK300-1*	accessible to public	Water exiting the Galkeno 300 portal drains the Hector-Calumet mine, with the highest amount of pre-treatment contamination in the district (86ppmZn [↓Q4 2010]; 0.355ppm Cd [1994 - present])	consistently produces water at ~12L/s (historical range from 0.1L/s to 30L/s) collapse in adit could lead to rerouting flow from Hector Calumet	adit timbers are old, although there is no imminent concern over the condition of the adit; inspections conducted weekly		**0.1**	**9.21 (historical average; has been higher 2008 - 2010)**	**30.0+ (at freshet)**	**1) Existing facility at Galkeno 300, upgraded:** a) to enhance sludge management b) improved adit water collection management; redundant water recovery from Hector Calumet (?) c) improved winter access d) improved reagent handling facilities	1) sludge thickening, filtration and pressing 2) adit storage or ponds 3) road O&M 4) reagent storage and mixing 5) larger building 6) sludge disposal
											2) New treatment facility at Elsa: a) pipeline from G300 or well into Hector Calumet to Elsa, capacity for other mine discharges b) new water treatment plant including reagent handling and mixing, treatment plant, sludge handling facilities c) capacity of treatment plant sufficient to handle No Cash additional flow (adaptive management alternative)	1) mine water storage--in adit, or in pond/tank, pipeline to plant 2) reagent storage 3) rapid mix tank 4) solids separation--clarifier 5) sludge filtering and handling/disposal 6) discharge system 7) operations and maintenance of plant daily operator 2 hour 8) monitoring adit and discharge, daily years 1&2, weekly years 3-30 9) large building 10) sludge disposal
											3) New treatment facility at Silver Trail Highway near Galkeno 900: a) pipeline from G300 or well into Hector Calumet to Silver Trail area b) new water treatment plant including reagent handling and mixing, treatment plant, sludge handling facilities c) capacity of treatment plant sufficient to handle Onek and Galkeno 900 additional flow (adaptive management alternative)	1) mine water storage--in adit, or in pond/tank, pipeline to plant 2) reagent storage 3) rapid mix tank 4) solids separation--clarifier 5) sludge filtering and handling/disposal 6) discharge system 7) operations and maintenance of plant daily operator 2 hour 8) monitoring adit and discharge, daily years 1&2, weekly years 3-30 9) large building 10) sludge disposal

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Galkeno 900 Level Adit (Treatment)	*adit*	*GK900-1a*		produces ~3.5L/s water at 6.0ppm Zn (historical range from 0.005 to 27.6mg/L; 2009 range from 4.7 to 6.54mg/L)	produces ~3.5L/s water at 6.0ppm Zn (historical range from 0.9 to 24L/s; 2009 range from 2.36 to 3.15L/s)	Adit plug located 1200 feet into adit. Portal located on hillside with many seeps above adit opening; adit is severely degraded near portal requiring maintenance in 2011 winter; long term maintenance will be required		**2.1**	**5.22**	**9.8**	**(1) Bioreactor treatment** a) lined facility at Galkeno 900 adit built into hillside on contour b) carbon source addition in both solid phase and dissolved phase; c) ongoing monitoring at bioreactor discharge to demonstrate treatment	1) Create filled pond/trench downgradient of adit drainage with layered media primarily coarse gravels, some wood chips and peat (CapEx) 2) Reagent storage, mixing and injection facility to add carbon source to bioreactor (CapEx and O&M) 3) Monitoring program monthly at adit and bioreactor discharge monthly for 2 years; transition to quarterly for 8 years, then annual for 20 years (O&M) 4) Monthly checks of treatment system (1 hour per visit) for first 2 years, transition to quarterly checks for 8 years, then annual for 20 years (O&M)
								2.1	**3.1**	**9.8**	**(2) Stand-alone small mechanical plant** a) similar to G300 plant, clarifier, option of reagents b) new sludge management facilities c) discharge to bog at edge of Christal Lake	1) mine water storage--in adit, or in pond/tank, pipeline to plant 2) reagent storage 3) rapid mix tank 4) solids separation--clarifier 5) sludge filtering and handling/disposal 6) discharge system 7) operations and maintenance of plant daily operator 1 hour 8) monitoring adit and discharge, daily years 1&2, weekly years 3-5, monthly years 6-30
											3) Treat in new treatment facility at Silver Trail Highway near Galkeno 900: a) pipeline from G900 to Silver Trail area b) new water treatment plant including reagent handling and mixing, treatment plant, sludge handling facilities c) capacity of treatment plant designed initially to handle Galkeno 300, Onek and Galkeno 900 flow (adaptive management alternative)	see Alternative 3, Galkeno 300
Sadie Ladue Adit	*adit*	*SL1*	- Potential ecological risk to flora/fauna in all areas downgradient of adits discharging to the environment through plant uptake of metals	0.7ppm Zn (~112Kg/yr Zn); does not report directly to any watercourse	discharge from Sadie Ladue Adit is high (4.95L/s 2004-2010 average) despite adit collapse	- Adit is collapsed for some length; tunnelled into fissile, schistose rock (ACG 2009 site inspection) - Some adit water is currently flowing through a pipe through the dump that daylights in an adit-like structure at the toe. This will eventually fail. It may already have leaks that enter the dump and affect dump stability					**(1) Reclamation-only; water treatment not required** a) grade pits to be free draining under reclamation alternatives b) natural attenuation study to demonstrate no treatment required and stable chemistry c) adaptive management	1) enhanced reclamation at pit areas 2) study program to confirm NA mechanisms and long term stability (CapEx)
								0.5	**11.27**	**20**	**(2) Managed natural attenuation:** a) aeration of water along channel as it flows down Keno hill, settling basin in valley bottom, distribution within peat in valley bottom b) study program to confirm NA is performing adequately; c) ongoing monitoring at adit and within surface pond in headwaters of Ladue River to demonstrate treatment; d) define thresholds for source and receiving environment that define acceptable treatment	1) collection system and adit rehabilitation 2) engineered water management structure would be passive aeration tumbling device in hillside (CapEx); 3) settling pond or similar structure for any Fe/Mn/Al precipitates with sorbed trace metals (CapEx and annual O&M); 4) injection/distribution surface trench to distribute Sadie Ladue creek drainage across hillside (CapEx); 5) study program to confirm NA mechanisms and long term stability (CapEx); 6) monitoring program quarterly at adit and un-named lake outlet for 5 years, transition to annual for 5 years, transition to every 5 years to closure (O&M)
								0.5	**7.6**	**15.0**	**(3) Bioreactor treatment** a) lined facility at Sadie Ladue 600 adit on waste dump; b) carbon source addition in both solid phase and dissolved phase; c) ongoing monitoring at bioreactor discharge to demonstrate treatment d) note: could be used to pretreat for MNA alternative	1) collection system and adit rehabilitation 2) Create filled pond/trench downgradient of adit drainage with layered media primarily coarse gravels, some wood chips and peat (CapEx) 3) Reagent storage, mixing and injection facility to add carbon source to bioreactor (CapEx and O&M) 4) Monitoring program monthly at adit and bioreactor discharge monthly for 2 years; transition to quarterly for 8 years, then annual for 20 years (O&M) 5) Monthly checks of treatment system (1 hour per visit) for first 2 years, transition to quarterly checks for 8 years, then annual for 20 years (O&M)

Component Description	Component Type	Closure Activitiy No. (map reference)	Closure Issue Categories					Min Flow	Average Flow	Max Flow	Alternatives	Major Cost Elements
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest	Top figure 1994 - 2010; bottom figure 2004 - 2010	Top figure 1994 - 2010; bottom figure 2004 - 2010	Top figure 1994 - 2010; bottom figure 2004 - 2010		
Onek 400 Level Adit	*adit*	*O5*	ice plugging occurs in the adit portal, with very close proximity to homes in Keno City; water from the portal that enters the groundwater supply may impact Keno City water supply	low flows and high concentrations (2.3L/sec, 80ppm Zn and 1.4ppm Cd); loading to Christal creek unknown due to infiltration to ground and attenuation	outflow flows in gully developed from blowouts; low flows and high concentrations (2.3L/sec, 80ppm Zn and 1.4ppm Cd) goes to ground within 100 m of the adit, during freshet flow continues toward Christal creek along power line road; unknown loading to Christal creek	ice blockage in portal; timber bracing in poor condition		**0.1**	**1.85**	**7.3**	**(1) Bioreactor treatment with natural attenuation** a) lined facility at Onek 400 adit area b) carbon source addition in both solid phase and dissolved phase; c) ongoing monitoring at bioreactor discharge to demonstrate sufficient pre-treatment for MNA d) MNA by aeration after bioreactor, settling pond, distribution on N side of Christal creek in peat beds e) MNA monitoring at settling pond, and in Christal creek upstream and downstream of NA area	1) Create filled pond/trench downgradient of adit drainage with layered media primarily coarse gravels, some wood chips and peat (CapEx) 2) Reagent storage, mixing and injection facility to add carbon source to bioreactor (CapEx and O&M) 3) passive aeration system at bioreactor discharge, settling structure for any precipitates, and distribution network for drainage from bioreactor to peat beds downgradient of Keno City 4) study program to confirm NA mechanisms and long term stability (CapEx); 5) Monitoring program monthly at adit and bioreactor discharge monthly and in Christal Creek upgradient and downgradient for 2 years; transition to quarterly for 8 years, then annual for 20 years (O&M) 6) Monthly checks of treatment system (1 hour per visit) for first 2 years, transition to quarterly checks for 8 years, then annual for 20 years (O&M)
								0.5	**2.3**	**7.3**	**(2) Stand-alone small mechanical plant** a) similar to G300 plant, clarifier, option of reagents b) new sludge management facilities c) discharge to peat beds on N side of Christal creek	1) mine water storage--in adit, or in pond/tank, pipeline to plant 2) reagent storage 3) rapid mix tank 4) solids separation--clarifier 5) sludge filtering and handling/disposal 6) discharge system downgradient of Keno City 7) operations and maintenance of plant daily operator 1 hour 8) monitoring adit and discharge, daily years 1&2, monthly years 3-5
											3) Treat in new treatment facility at Silver Trail Highway near Galkeno 900: --pipeline from Onek to Silver Trail area --new water treatment plant including reagent handling and mixing, treatment plant, sludge handling facilities --capacity of treatment plant designed initially to handle Galkeno 300, Onek and Galkeno 900 flow (adaptive management alternative)	see Alternative 3, Galkeno 300
											4) Reclamation with natural attenuation a) source control to reduce metal loadings b) route flows to point downgradient of Keno City c) discharge flows to ground in exfiltration channel d) monitoring program downgradient of discharge point	
Keno 700 Level Adit	*adit*	*K700-1*	adit portal is located along a popular tourist route and is easily accessible to public if access is not adequately controlled	Keno 700 Adit discharges the largest load from the Keno Hill property to the Lightning Creek watershed; in 2009 130Kg zinc entered the watershed from Keno 700 discharge (the average rate of discharge was 3.3L/sec at 1.24mg/L zinc)	discharge from Keno 700 travels a short path along ground before entering Hope Gulch, a tributary to the Lightning Creek watershed; waste rock wastes downslope with adit discharge (adit discharge passes through waste rock material)	adit opening is physically stable		**1.3**	**3.8**	**7**	**(1) Bioreactor treatment** a) lined facility at Keno 700 adit on waste dump or down valley; b) carbon source addition in both solid phase and dissolved phase; c) ongoing monitoring at bioreactor discharge to demonstrate treatment d) option of chemical reactive media such as ZVI will be considered in the design phase	1) Create filled pond/trench downgradient of adit drainage with layered media primarily coarse gravels, some wood chips and peat (CapEx) 2) Reagent storage, mixing and injection facility to add carbon source to bioreactor (CapEx and O&M) 3) Monitoring program monthly at adit and bioreactor discharge monthly for 2 years; transition to quarterly for 8 years, then annual for 20 years (O&M) 4) Monthly checks of treatment system (1 hour per visit) for first 2 years, transition to quarterly checks for 8 years, then annual for 20 years (O&M)
								1.3	**3.4**	**5.5**	**(2) Mine pool treatment:** a) create mine pool using low pressure hydraulic adit plug, alkaline and/or carbon source injection and mixing into mine pool that creates clean discharge; b) ongoing monitoring at adit to demonstrate treatment c) note: could be used to pretreat for MNA alternative	1) Hydraulic low pressure adit plug 2) Reagent storage, mixing, and injection facility located at adit, injection through adit hydraulic plug into the mine pool (CapEx and O&M); 3) monitoring program monthly at adit for first 2 years, transition to quarterly for 8 years, then annual for 20 years (O&M) 4) passive aeration at adit drainage point, allow to drain into Lightning (CapEx) 5) monthly checks of treatment system (1 hour per visit) for first 2 years, transition to quarterly checks for 8 years, then annual for 20 years (O&M)
											(3) Managed natural attenuation: a) pipeline carries water to drainage at headwaters of Christal Creek b) aeration of water at discharge location and as it flows down Keno Hill, settling basin at slope break where flow becomes slower, polishing treatment in peat beds on Keno Hill south-facing slope, periodic maintenance to remove precipitates in settling basin; c) study program to confirm NA is performing adequately; d) ongoing monitoring at adit, settling basin, and Christal Creek upstream and downstream to demonstrate treatment; e) define thresholds for source and receiving environment that define acceptable treatment	1) engineered adit plug to capture water into pipeline, pipeline route to Christal Creek watershed, and passive aeration tumbling device buried in hillside (CapEx); 2) settling pond or similar structure for any Fe/Mn/Al precipitates with sorbed trace metals in new drainage (CapEx and annual O&M); 3) injection/distribution surface trench to distribute creek drainage across hillside (CapEx); 4) study program to confirm NA mechanisms and long term stability (CapEx); 5) monitoring program quarterly at Keno 700 adit and Christal Creek for 5 years, transition to annual for 5 years, transition to every 5 years to closure (O&M)
											4) Water Treatment Plant a) pipeline carries water to treatment site. b) new water treatment plant including reagent handling and mixing, treatment plant, sludge handling facilities	

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			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest	Top figure 1994 - 2010; bottom figure 2004 - 2010	Top figure 1994 - 2010; bottom figure 2004 - 2010	Top figure 1994 - 2010; bottom figure 2004 - 2010		
Hector Adit Dump	*dump*	*HC8*	there is a zone of impacted vegetation beneath the dump (PWGSC 2000; ACG 2009 field investigation) - anecdotal evidence implies that this may be the result of silt deposition from mine water released during operation	sulphur, zinc, and lead concentrations are elevated relative to most other dumps, and classification of ARD potential ranged from PAG to Uncertain (1995) to Uncertain to Non-PAG (2007); dump is large (198,000 tons; PWGSC 2000) and has the potential for significant loading to the environment - the suggestion is that porewater may reach up to 100mg/L zinc (SRK 2008 geochem study)	Sandy creek drainage may show the effects of drainage from the Hector-Calumet mine waste rock, as well as the Townsite dump; unmonitored drainages to the east of Sandy creek may have received a significant portion of Hector adit loading from past dewatering and therefore the full extent of contamination may not be known					**1) Cover for revegetation** a) regrade for stability b) add stable soil layer with nutrients and seeds c) monitor for revegetation success	1) grade dump 2) transport of cover material 3) thickness of cover material 4) amount of nutrient and organic amendments 5) seed 6) revegetation monitoring
											2) Cover for reduced infiltration and source control a) regrade for stability b) add fine grain layer for water storage c) capillary break option d) stable soil layer with nutrients and seeds e) monitor for reduced flux of metals, and vegetative success f) cover system optimization	1) grade dump 2) transport of cover material layers, soil, fine grain, capillary break layers 3) synthetic liner option 4) thickness of cover material layers 5) amount of nutrient and organic amendments 6) seed 7) revegetation monitoring 8) downgradient groundwater monitoring
											3) Reclaim with No Cover a) regrade dump for stability as required b) address any potential issues associated with public access and dump drainage	
Wernecke Tailings (on UKHM claims)	*tailings*	*SLW4*			visible gullying						**(1) Close in place** a) create stable water channels through and around b) cover un-vegetated tailings with growth media c) monitor for % cover objectives d) cover system optimization	1) add growth media, seed, nutrients, organics, lime 2) water channel construction and maintenance 3) monitor vegetation and stability
											(2) Combine with Wernecke Millsite tailings a) remove unvegetated tailings in drainage and transport to Wernecke tailings at millsite b) scarify and seed existing millsite tailings areas c) cover with growth media d) monitor for revegetation and geochemical loading reduction e) cover system optimization	1) remove tailings from water courses 2) transport tailings to Wernecke millsite 3) add growth media 4) water channel construction and maintenance 5) monitor vegetation and stability
Mackeno Tailings	*tailings*	-	moose graze on the tailings at the edge of Christal Lake throughout the year; the tailings may pose a threat to the health of moose and other wildlife	loading of zinc and metals to creek from erosion is currently poorly characterized; no recent data. History of deposition in Christal lake and creek have created pore water issues (Environment Canada data)	Mackeno tailings eroding into Christal creek	tailings erosion and slumping may occur; dry tailings may be dispersed by wind					**(1) Close in place** a) create stable water channel through and around tailings, remove tailings from watercourse if required b) cover un-vegetated tailings with growth media c) monitor for % cover objectives d) cover system optimization	1) add growth media, seed, nutrients, organics, lime 2) water channel construction and maintenance 3) monitor vegetation and stability
											(2) Consolidate and cover a) isolate work site from stream b) excavate tailings from shoreline c) install new shoreline with barrier/riprap d) grade tailings and cover e) cover system optimization	1) cut off trench or sheet pile wall 2) grading 3) cover material 4) option of synthetic cover material
											(3) Combine with Valley Tailings a) remove unvegetated tailings and transport to Valley Tailings b) scarify and seed existing tailings areas c) closure combined with Valley tailings	1) remove tailings from Christal Creek and Christal Lake, costs for working in stream and lake 2) transport tailings to Valley tailings site 3) add growth media 4) water channel and lake shore re-construction and maintenance 5) monitor vegetation and stability

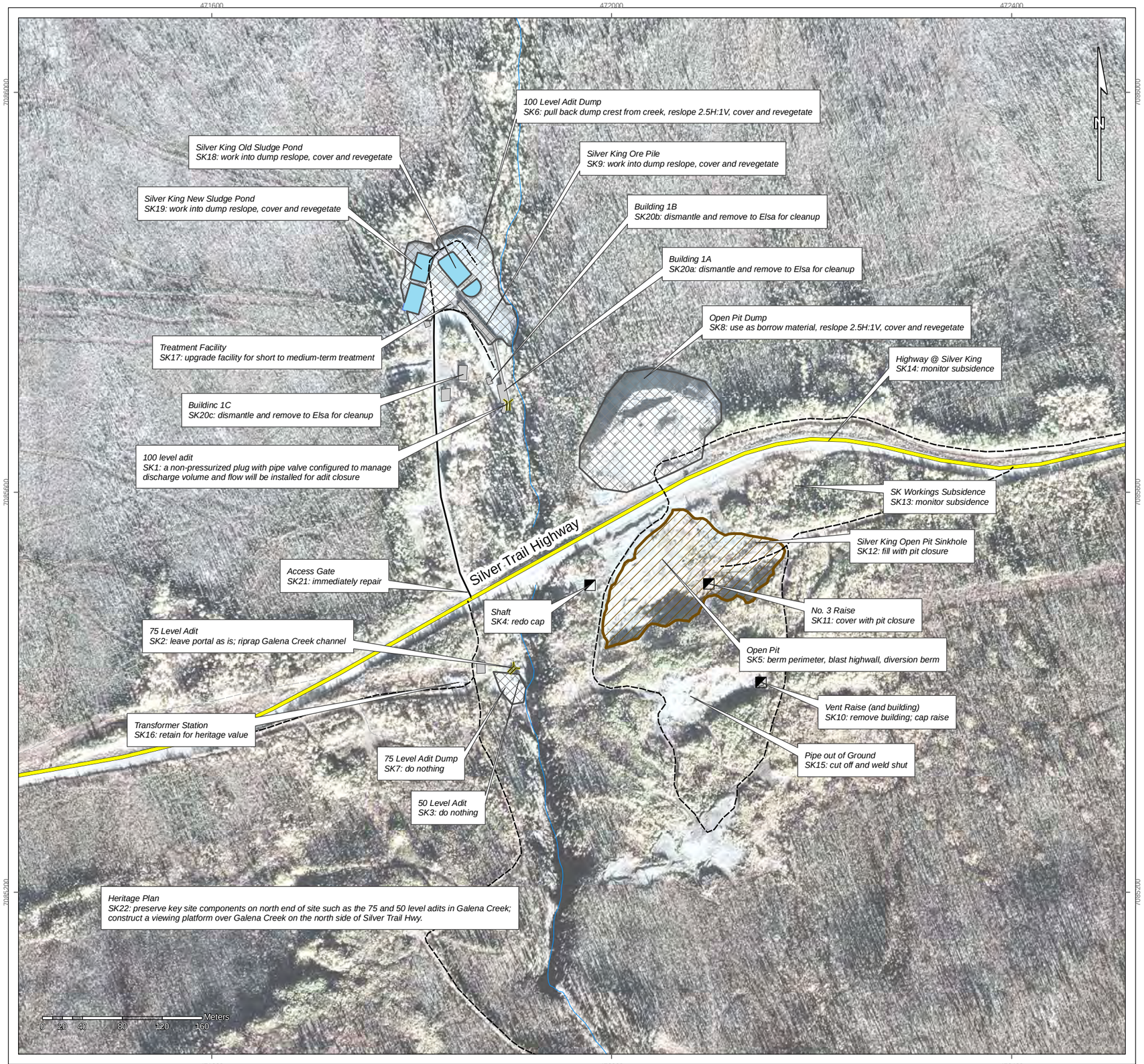
Component Description	Component Type	Closure Activitiy No. (map reference)	Closure Issue Categories					Min Flow	Average Flow	Max Flow	Alternatives	Major Cost Elements
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest	Top figure 1994 - 2010; bottom figure 2004 - 2010	Top figure 1994 - 2010; bottom figure 2004 - 2010	Top figure 1994 - 2010; bottom figure 2004 - 2010		
Valley Tailings	*tailings*	-	Exposed tailings may pose threat to wildlife grazing in the ponds	- Suspended solids in freshet flows also have concentrations of zinc - Windblown tailings have affected vegetation and soils around tailings impoundment area - High zinc in tails pore water and subsurface peat layers - Potential for zinc remobilization during winter freeze period	- Diversions around tailings require frequent maintenance - Ponds are dewatered in the fall to provide treatment and storage capacity in the springa - Water balance of the VTF is not well understood	Dam stability has improved as permafrost has progressively degraded; at current time there is no permafrost in the dam area. Dam maintenance has also consequently become minimal.	Major facility with obvious visual impacts leading to speculation that all issues/problems in the valley are due to VTF. Talking to NND, they think that the dying trees in the valley are due to the VTF				**(1) Close in place** a) create stable water channels through and around tailings b) cover unvegetated tailings with growth media c) monitor for % cover objectives d) cover system optimization and evaluation	1) add growth media, seed, nutrients, organics, lime 2) water channel/diversion construction and maintenance 3) monitor vegetation and stability 4) groundwater and Flat Creek monitoring biannual for first 5 years, annual for 5 years, every 5 thereafter until closure 5) annual dam maintenance
											(2) Combine exposed tailings (partial consolidation) a) create stable water channels through and around tailings b) move exposed tailings on hillside to valley bottom, place behind dams to minimize ponded water and limit phreatic surface buildup c) cover combined tailings to meet revegetation objectives d) combination of consolidation based on existing tailings characteristics e) cover system optimization and evaluation	1) consolidate tailings to minimize cover and exposure 2) option of synthetic cover 3) add growth media, seed, nutrients, organics, lime 4) scarify and seed areas from which tailings were removed 5) water channel/diversion construction and maintenance, sediment ponds management 6) monitor vegetation and stability 7) groundwater and Flat Creek monitoring biannual for first 5 years, annual for 5 years, every 5 thereafter until closure 8) annual dam maintenance 9) option of partial relocation of tailings into other disposal location (local open pits, u/g workings) based on characteristics
											(3) Combine tailings into lined facility a) move tailings into lined facility capable of maintaining saturated tailings with appropriate cover system b) scarify and seed existing tailings footprint c) re-establish native drainages d) re-processing as a mechanism for closure cost offset e) cover system optimization and evaluation f) potential for some residual tailings deposits to be left after consolidation	1) create acceptable lined facility to receive tailings 2) add growth media, seed, nutrients, organics, lime to create cover 3) option of synthetic cover 4) scarify and seed areas from which tailings were removed 5) water channel/diversion construction and maintenance, sediment ponds management 6) monitor vegetation and stability 7) groundwater and Flat Creek monitoring biannual for first 5 years, annual for 5 years, every 5 thereafter until closure 8) annual lined facility inspection 9) optional water treatment 10) option of partial relocation of tailings into other disposal location (local open pits, u/g workings) based on characteristics

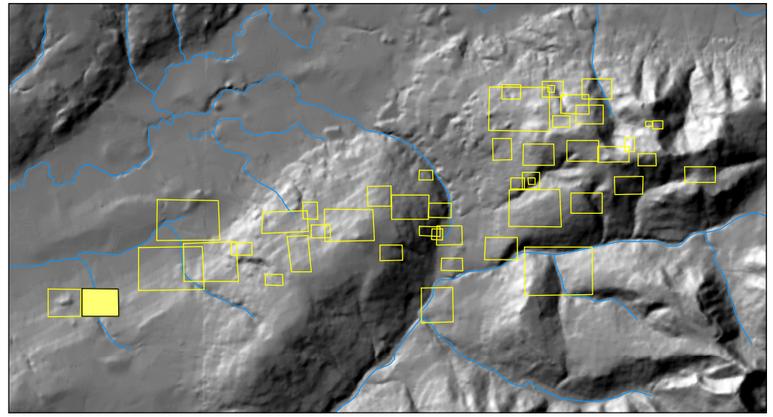
Common Site Name: **Silver King**

	easting	northing	
Site coordinates:	471871.69	7085658.17	*coordinates are UTM zone 8N NAD83

Component Description	Component Type	Closure Activity No. (map reference)	Closure Issue Categories					Proposed Component Measure	Closure Rationale	Estimated Costs
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest			
Silver King 100 Level Adit	*adit*	*SK1*	- Potential ecological risk to flora/fauna in all areas downgradient of adits discharging to the environment through plant uptake of metals - potential for public access to workings	Adit discharge is elevated for contaminants of concern (1.0 ppm Zn)[1]	Adit discharge decants over the toe of the 100 level adit dump directly into Galena Creek; discharges at an average of 6.0L/s[1]	Adit portal is susceptible to degradation and collapse	This is the first mine in the district, and therefore has historical significance. Aside from the 100 level adit, there is potential for heritage restoration.	*See "Complex Sites" sheet*		
Silver King 75 Level Adit	*adit*	*SK2*			The adit area is stable and sealed with a welded screen and black geofabric. During high flows, Galena Cr floods the adit entrance as it is not a watertight seal (ACG 2009 field investigation)			*install waterproof seal in adit to prevent flooding, rip-rap channel; signage for heritage*	*sealing adit would result in less metal loading.*	
Silver King 50 Level Adit	*adit*	*SK3*						*do nothing*	*adits are sealed off entirely and stable*	
Shaft	*shaft*	*SK4*				cement cap is dilapidated and poorly placed		*redo cap*	*eliminates access to workings*	
Open Pit	*open pit*	*SK5*	highwall not bermed; easy public access			open pit highwall has potential for weathering, not dissimilar from that of Galena Creek Canyon		*berm perimeter; blast highwall; diversion berm, grade pit to be free draining.*	*permanently removes need for safety bermand diverts water away from pit*	
Silver King 100 Level Adit Dump	*dump*	*SK6*		characterized as acid-generating (SRK 2008 geochem study); dump appears to be actively leaching contaminants into creek bed; visible sludge in creek bed (ACG field investigation)	scouring of waste dump in Galena Creek	scouring of waste dump in Galena Creek; some creep & dessication cracks noted at crest near new ponds		*pull back dump crest from creek, reslope 2.5H:1V, rip-rap toe, cover and revegetate*	*cover and vegetation will reduce infiltration and associated contamination; pulling back crest will eliminate raveling into Galena Creek. Armouring toe will reduce potential for scour by Galena Creek.*	
Silver King 75 Level Adit Dump	*dump*	*SK7*		unknown acid-generation potential (not covered in SRK 2008 geochemical study), though not large enough to produce significant loadings	precipitation erosion and movement of waste rock into Galena Creek	creep & dessication cracks on top		*do nothing*	*dump is chemically inert and naturally revegetating*	
Open Pit Dump	*dump*	*SK8*		characterized as acid-generating (SRK 2008 geochem study), though not large enough to produce significant loadings and does not discharge directly to a watercourse	drainage channel erosion @ dump face	drainage channel erosion @ dump face		*use as borrow material, reslope 2.5H:1V, cover and revegetate*	*cover and vegetation will reduce infiltration and stabilize*	
Ore Piles	*low-grade ore pile (4)*	*SK9*		localized chemical issues associated with high grade ore leaching				*bury within dump, reslope, cover and revegetate*	*cover and vegetation will reduce leaching potential of piles*	
Vent Raise (and Building)	*shaft*	*SK10*	intrigue risk; close proximity to tourist area					*remove building; cap raise*	*covering the raise will eliminate intrigue risk and access to workings*	
No. 3 Raise	*shaft*	*SK11*	intrigue risk; close proximity to tourist area			`		*cover with pit closure*	*covering the raise will eliminate intrigue risk and access to workings.*	
Sinkhole	*pit*	*SK12*	accessible to public					*fill with pit closure*	*the ground will become level with pit infill*	
Subsidence over workings	*workings*	*SK13*	accessible to public					*monitor subsidence*	*any observed areas of subsidence to be filled as necessary*	
Highway @ Silver King	*workings*	*SK14*						*monitor subsidence*	*any observed areas of subsidence to be filled as necessary*	
Pipe to workings	*misc.*	*SK15*	accessible to public					*cut off and weld shut*		
Transformer Station	*infrastructure*	*SK16*	intrigue risk; close proximity to tourist area					*retain for heritage value; stabilize to remove fluids if necessary*	*Silver King heritage plan*	
Treatment Facility	*infrastructure*	*SK17*	intrigue risk; close proximity to tourist area					*upgrade facility for short to medium-term treatment while site transitions to preferred treatment option*	*the facility will be required for water treatment until final treatment method can be installed*	
Old Sludge Ponds	*settling pond*	*SK18*		sludge is inert at meteoric pH				*infill ponds, cover and revegetate*	*the sludge will be isolated from meteoric runoff*	
New Sludge Ponds	*settling pond*	*SK19*		sludge is inert at meteoric pH				*after transition to permanent treatment is complete, infill ponds, cover and revegetate*	*the sludge will be isolated from meteoric runoff*	
Buildings 1A, 1B, and 1C	*infrastructure*	*SK20a through SK20c*	intrigue risk; close proximity to tourist area					*dismantle and remove to Elsa for cleanup*	*eliminates safety issues*	
Access Gate	*infrastructure*	*SK21*						*upgrade and retain access gate*	*the access gate restricts access to the treatment facility and the 100 level adit*	

1. See attached water quality information





Silver King Mine Components

#1 *100 Level Adit*
See "Complex Sites" sheet

#2 *75 Level Adit*
The portal is sealed with a geotextile fabric and welded screen; however, during high flows, adit entrance is flooded. Riprap will reduce the amount of water that will contact the opening.

#3 *50 Level Adits (west and east portals)*
The adits are sealed off entirely and stable.

#4 *Shaft*
Capping the shaft will eliminate access to workings.

#5 *Open Pit*
Resloping is a permanent safety solution. Additional berms will prevent access.

#6 *100 Level Adit Dump*
Cover and vegetation will reduce infiltration and associated contamination; pulling back crest will eliminate contact with Galena Creek.

#7 *75 Level Adit Dump*
The dump is chemically inert and naturally revegetating; no activity is necessary

#8 *Pit Dump*
Cover and vegetation will reduce infiltration and stabilize.

#9 *Low-grade Ore Piles*
Cover and vegetation will reduce leaching potential of piles.

#10 *Vent Raise (and building)*
Covering the raise will eliminate intrigue risk and access to workings.

#11 *No 3 Raise*
Covering the raise will prohibit access.

#12 *Sinkhole*
The ground will become level with pit in-fill.

#13 *Subsidence over workings*
Any additional subsidence will be observed and filled if necessary.

#14 *Highway @ Silver King*
Monitoring will allow perventative maintenance if necessary.

#15 *Pipe to workings*
Removing the pipe will effectively eliminate any hazards.

#16 *Transformer Station*
Maintaining the Transformer Station will add heritage value.

#17 *Treatment Facility*
The treatment facility will be required to continue to treat adit water.

#18 *Old Sludge Ponds*
By working the ponds into closure with the dump, the sludge is isolated from surface runoff (although the sludge tends to be inert at meteoric pHs).

#19 *New Sludge Ponds*
By working the ponds into closure with the dump, the sludge is isolated from surface runoff (although the sludge tends to be inert at meteoric pHs).

#20a thru c *Buildings 1A, 1B and 1C*
Demolishing the buildings eliminates safety issues.

#21 *Access Gate*
The access gate restricts access to the treatment facility and the 100 level adit area.

Legend

- Preferred Options
- Shaft
- Structures
- Open Pit
- Settling Pond
- Waste Rock Dump
- Adit
- Highway
- Local
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:4,000

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Closure Options Report

Figure 5.1

Silver King

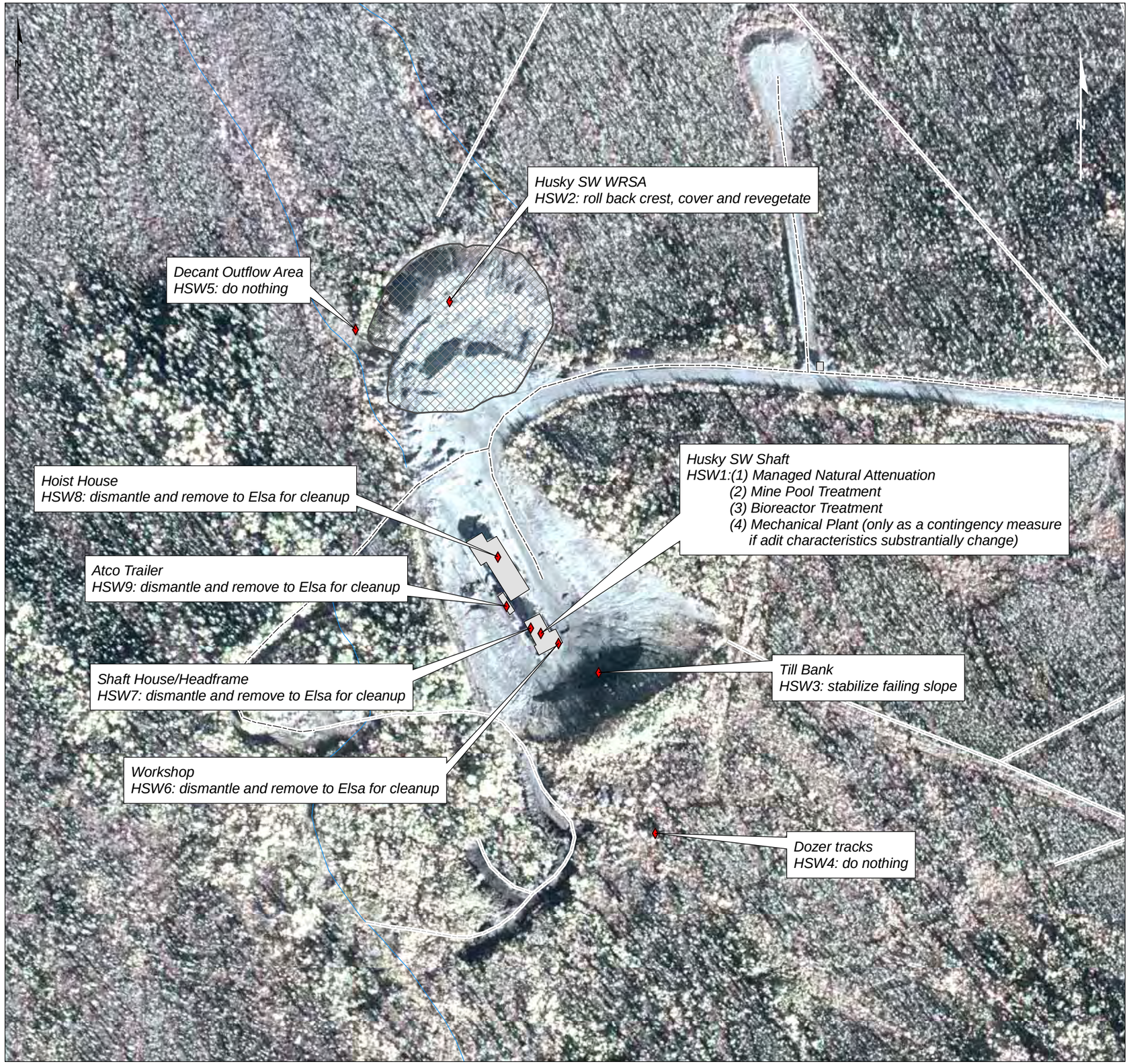
Drawn By: TL/JP

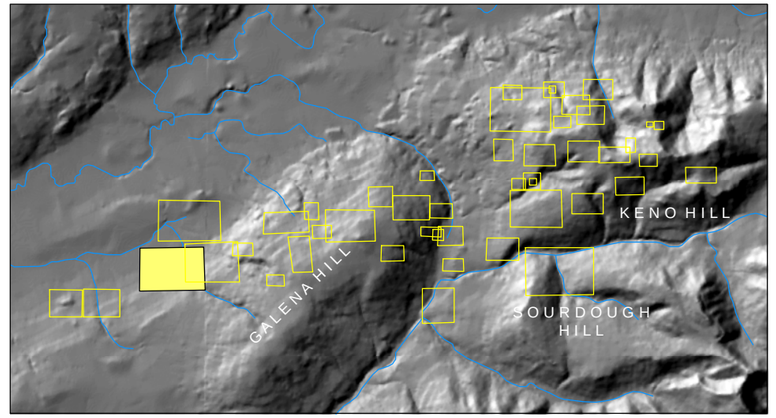
APRIL 2011

Common Site Name: **Husky SW**

	easting	northing	
Site coordinates:	474740	708677	*coordinates are UTM zone 8N NAD83

Component Description	Component Type	Closure Activity No. (map reference)	Closure Issue Categories					Proposed Component Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Shaft	*shaft*	*HSW1*	- Potential ecological risk to flora/fauna in all areas downgradient of adits discharging to the environment through plant uptake of metals - Potential for public access to workings	shaft discharges elevated metals (approximately 1.0mg/L Zn[1)]; visible staining at discharge path below dump where adit decants to environment. Loadings from the shaft are not significant	produces water; <0.5L/sec[1]; discharge is piped through the dump to a discharge point beyond the dump		There is an old cabin that supposedly was a homestead for a woman and her kids (NND anecdotal information)	*See "Complex Sites" sheet*	
Waste Dump	*dump*	*HSW2*		orange surface staining; potentially acid-generating (SRK 2008 geochem study), although dump not large enough to produce significant chemical loads		tension cracks; potential permafrost (SRK 2007 Baseline Study)		*reslope 2.5H:1V, cover and revegetate*	*eliminates potential physical stability and chemical contamination issues*
Till bank (behind Husky SW shaft)	*till bank*	*HSW3*				actively failing; rivulets; unconsolidated seds (SRK 2007 Baseline Study)		*reslope and stabilize as required*	*eliminates potential physical stability issues. Excasvated materials can be used as cover material*
Dozer Tracks behind till bank (south of Husky SW shaft)	*misc*	*HSW4*			water seeping in; flow diffuses			*naturally revegetate (do nothing)*	*no activity required*
Out-flow area for buried drain pipeline	*misc*	*HSW5*		orange staining and precipitation along flow path (ACG 2009 field investigation)					
Workshop	*infrastructure*	*HSW6*	accessible to public				possible heritage value	*remove to Elsa for cleanup*	*removing eliminates safety and stability issues*
Shaft house and headframe	*infrastructure*	*HSW7*	accessible to public				possible heritage value	*remove to Elsa for cleanup*	*removing eliminates safety and stability issues*
Hoist house	*infrastructure*	*HSW8*	accessible to public					*remove to Elsa for cleanup*	*eliminates safety and stability issues*
ATCO trailer	*infrastructure*	*HSW9*	accessible to public					*remove to Elsa for cleanup*	*eliminates safety and stability issues*





Activity Number	Husky SW Adit Mine Components and Closure Activities Rationale
HSW1	*Shaft* *See "Complex Sites" Sheet*
HSW2	*Waste Dump* *Eliminates potential physical stability and chemical contamination issues*
HSW3	*Till bank (behind Husky SW shaft)* *Eliminates potential physical stability issues. Excavated materials can be used as cover material*
HSW4	*Dozer Tracks behind till bank (south of Husky SW shaft)* *No further remediation required.*
HSW5	*Out-flow area for buried drain pipeline* *No further remediation required.*
HSW6	*Workshop* *Removing eliminates safety and stability issues.*
HSW7	*Shaft house and headframe* *Removing eliminates safety and stability issues.*
HSW8	*Hoist house* *Removing eliminates safety and stability issues.*
HSW9	*ATCO trailer* *Removing eliminates safety and stability issues.*

Legend

- Preferred Options
- Waste Rock Dump
- Structures
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:2,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.2

Husky SW

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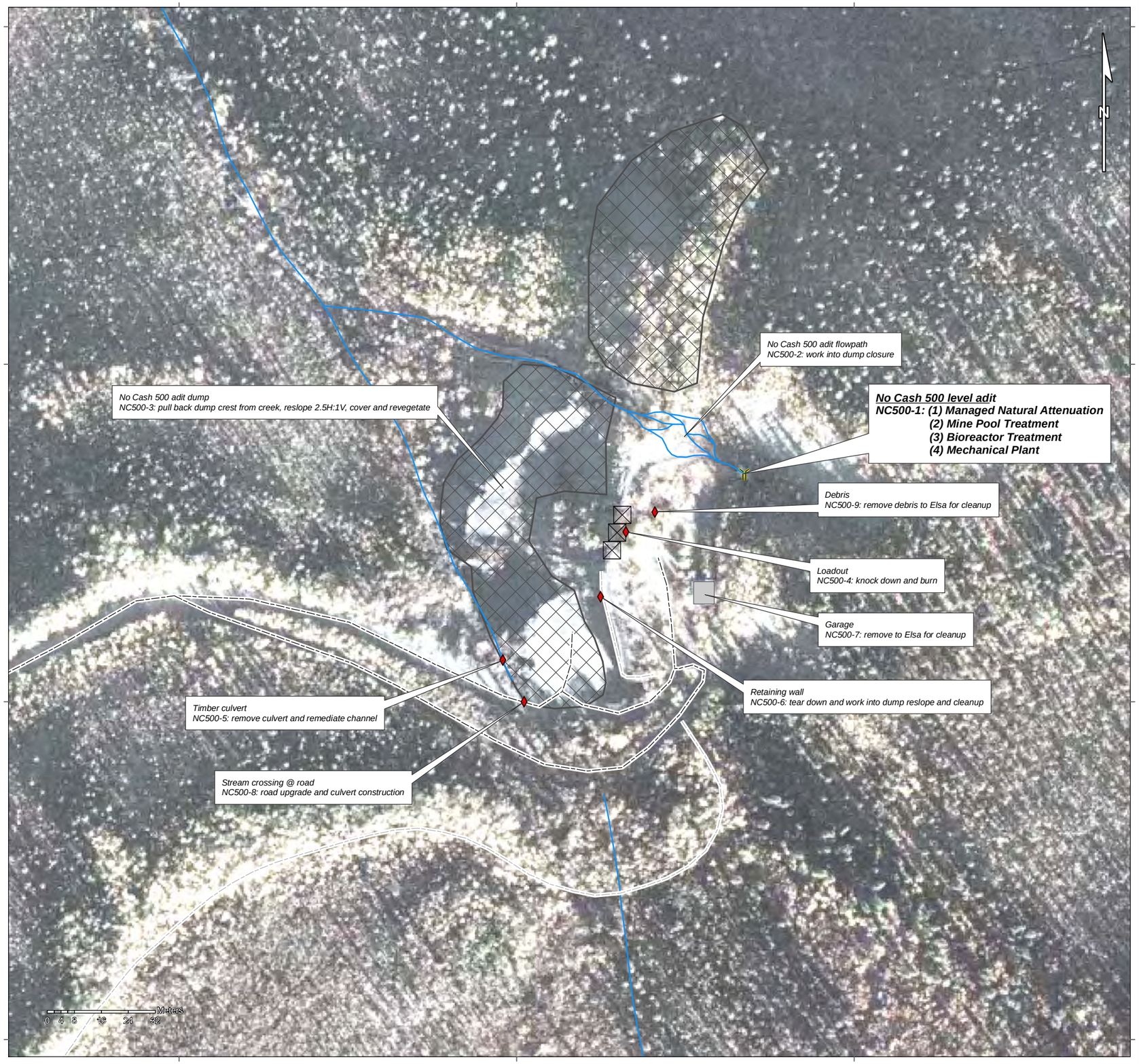
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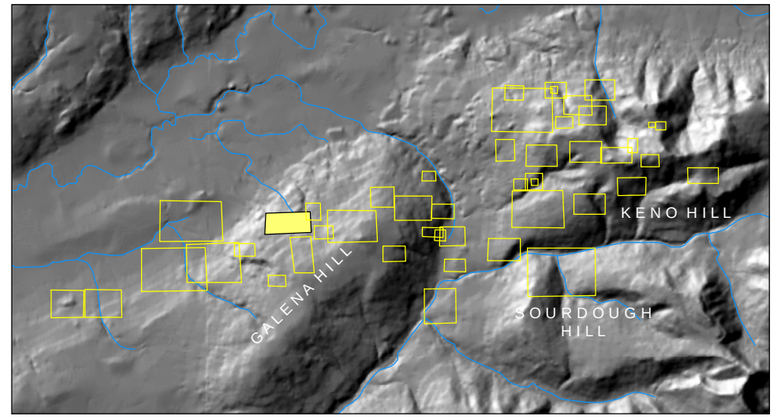
Common Site Name: **No Cash 500**

Site coordinates:	easting	northing	*coordinates are UTM zone 8N NAD83
	477230	7088058	

Component Description	Component Type	Closure Activity No. (map reference)	Closure Issue Categories					Proposed Component Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
No Cash 500 Level Adit	*adit*	*NC500-1*	receiving waters and vegetation may be adversely impacted by high levels of contamination in drainage; unknown capacity for No Cash bog to absorb zinc	No Cash 500 drainage has the highest untreated zinc concentration in the district at roughly 15ppm Zn (and 0.15ppm Cd)[1]	drainage spills from a pipe over dump crest and into No Cash Creek bog at ~4.0L/s[1]	adit is susceptible to winter freezing; adit structure is significantly collapsed; surface air circulates within workings	drainage contamination is significant enough to generate public concern	*See "Complex Sites" sheet*	
No Cash 500 Adit discharge flowpath	*adit*	*NC500-2*		significant sludge deposition along flowpath of adit discharge (ACG 2009 field inspection)				*Excavate and bury in dump during component closure*	*Including the area currently contaminated by adit drainage into dump closure will prevent remobilization of precipitated metals*
No Cash 500 Level Adit Dump	*dump*	*NC500-3*	significant amount of debris in dump	waste rock shows little to no surface staining; unknown acid-generation potential (not covered in SRK 2008 geochemical study); however, dump is known to be composed principally of overburden material	adit drainage spills from a pipe over dump crest; creek passes along dump toe (ACG 2009 field inspection)	dump contains a large wooden cribbing structure which may fail if rotten; drainage causing erosion; creek passes dump toe		*pull back dump crest from creek, rip-rap toe as required, reslope 2.5H:1V, cover and revegetate*	*Pulling back the crest, armouring toe and resloping the dump will prevent physical stability issues and contamination to the creek. Revegetating the dump surface will similarly prevent potential contamination of drainage.*
Loadout	*dump*	*NC500-4*	contains debris, including rail lines and cars		adit drainage passes by loadout structure	rail lines unstable at crest of dump		*knock down and burn wooden debris. Reslope and bury metal debris within dump*	*Knocking down the loadout will eliminate potential physical stability issues*
Square timber culvert in creek	*infrastructure*	*NC500-5*	failure may pose a hazard to travel along road	passes into waste rock	passes into waste rock	wood may rot		*Remove culvert*	*Removing the culvert will facilitate stream rehabilitation*
Cribbed log retaining wall along East side of overburden dump	*infrastructure*	*NC500-6*				cribbing is rotten and failing; holds back a significant amount of waste rock		*remove cribbing and reslope area*	*Removing cribbed wall during dump resloping will stabilize area*
Stream crossing @ road	*infrastructure*	*NC500-7*	creek crossing is not stable					*road upgrade and install armoured ford*	*A road upgrade will allow access to adit and will stabilize the stream crossing for heavier traffic*
Garage	*infrastructure*	*NC500-8*	accessible to public; asbestos	asbestos		structure is unstable		*remove to Elsa for cleanup*	*Removing the building debris to Elsa will safely deal with asbestos*
Site Debris	*misc*	*NC500-9*	rail lines, rail cars, wire, timber and piping are all found at the site					*site cleanup*	*Site cleanup will eliminate trip and fall hazards*

1. See attached water quality information





Activity Number	No Cash 500 Components and Closure Activities Rationale
NC500-1	No Cash 500 level adit See "Complex Sites" Sheet
NC500-2	No Cash 500 adit discharge flowpath Working the area currently contaminated by adit drainage into dump closure will prevent infiltration of water and dissolution of metals.
NC500-3	No Cash 500 adit dump Pulling back the crest and resloping the dump will prevent physical stability issues and contamination to the creek. Revegetating the dump surface will similarly prevent potential contamination of WRSA drainage.
NC500-4	Loadout Knocking down the loadout will eliminate potential physical stabilty issues.
NC500-5	Square timber culvert in creek Removing the culvert will help in stream rehabilitation.
NC500-6	Cribbed log retaining wall Tearing down the cribbed wall during dump reslope will prevent dump failure in the future.
NC500-7	Stream crossing @ road A road upgrade will allow access to adit and will stabilize the stream crossing for heavier traffic.
NC500-8	Garage Removing the building debris to Elsa will safely deal with asbestos problems.
NC500-9	Debris Site cleanup will eliminate trip and fall hazards.

Legend

- Preferred Options
- Loadout
- Waste Rock Dump
- Structures
- Adit
- WaterCourses
- Track
- Trail

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:1,200

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.3

No Cash 500

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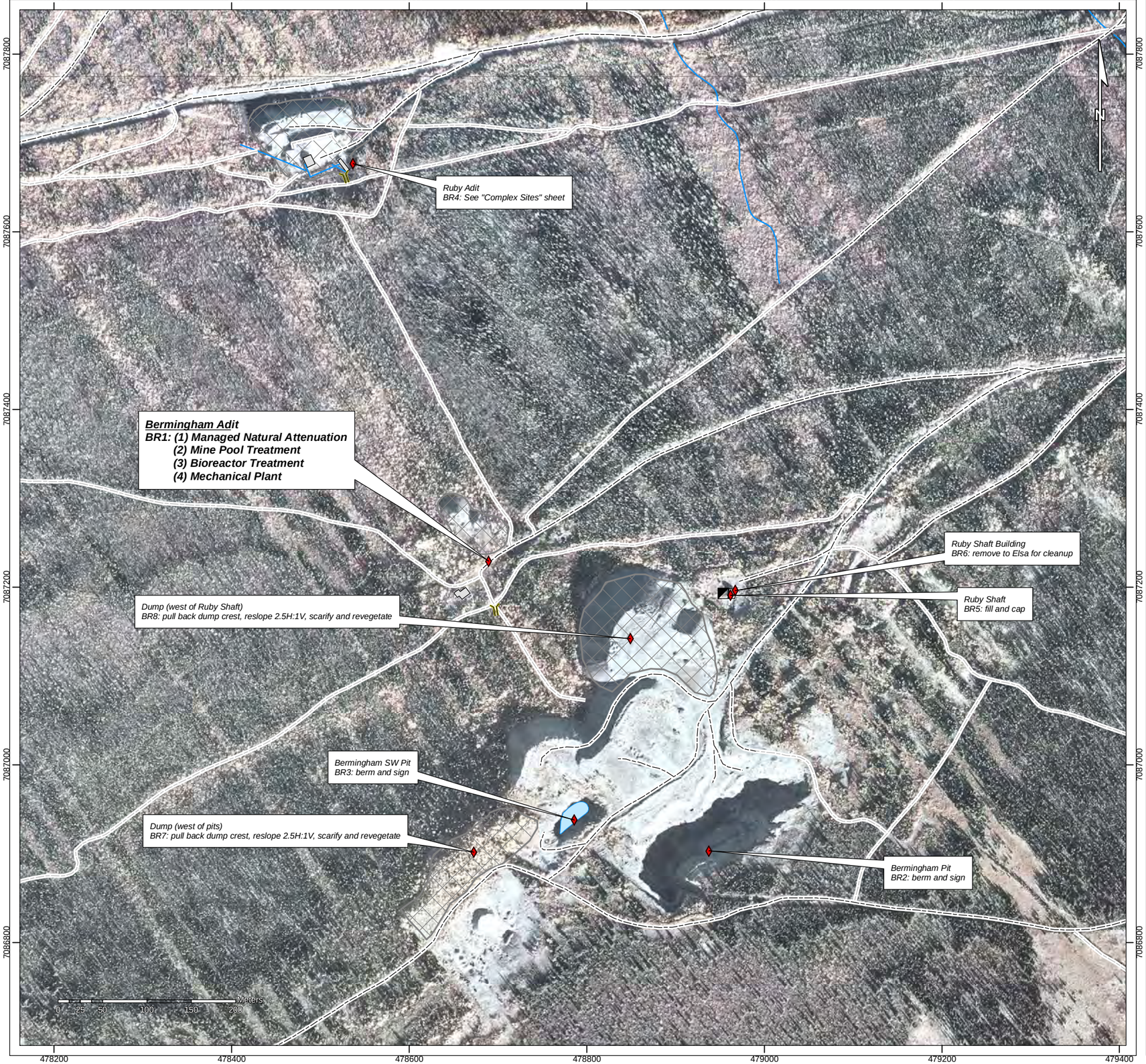
APRIL 2011

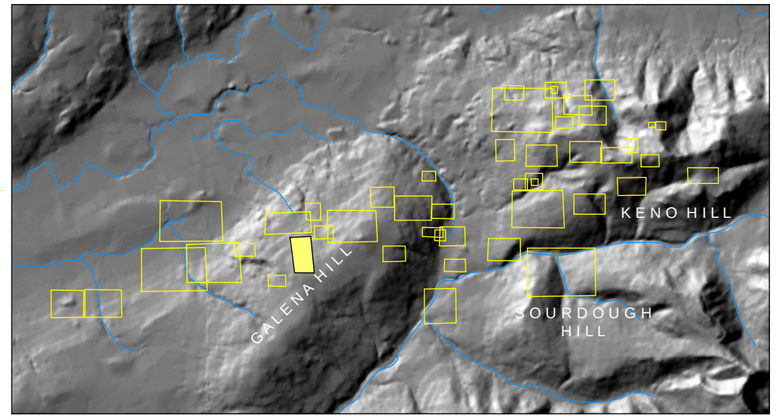
Common Site Name: **Bermingham**

	easting	northing	
Site coordinates:	474740	708677	*coordinates are UTM zone 8N NAD83

Component Description	Component Type	Closure Activity No. (map reference)	Closure Issue Categories					Proposed Component Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Bermingham Pit Area									
Bermingham Adit	*adit*	*BR1*		produces water (4.5ppm Zn, 0.2ppm Cd)[1]	water discharges to ground, reporting to No Cash Creek bog[1]			*See "Complex Sites" sheet*	
Bermingham Pit	*open pit*	*BR2*	no berms	pit wall rock is non-potentially acid generating (SRK 2008)	no water was noted in the bottom of the pit; water is draining in at a slow rate from the southwest corner; a small creek drains into the pit in the northeast corner	pre-split blasting techniques were used, the faces look good in the southeast corner, but less so in other pit areas; the southeast slope area shows definite weaker rock mass conditions, the slope in this area is unravelling extensively; tension cracks exist in several areas, indicating failure over the medium to long term; pit creep is observed at perimeters cracks (SRK 2007 Baseline Study)		*berm and sign*	*eliminates public safety and access issues*
Bermingham SW Pit	*open pit*	*BR3*	no berms	pit wall rock is non-potentially acid generating (SRK 2008)	water collects at pit bottom	weaker phyllitic material is cracking and creeping; walls expected to break back in the weaker material (SRK 2007 Baseline Study)		*berm and sign*	*eliminates public safety and access issues*
Ruby									
Ruby Adit								*See "Complex Sites" sheet*	
Ruby Shaft	*shaft*	*BR4*	accessible to public		does not produce water	shaft is open		*fill and cap*	*eliminates public safety and access issues*
Ruby Shaft (subsidence)	*shaft*	*BR5*	accessible to public			ground subsidence occurring near shaft		*fill*	*eliminates public safety and access issues*
Ruby Shaft Building	*infrastructure*	*BR6*	accessible to public			ground slumping occurring under structure, building is partially collapsed		*remove to Elsa for cleanup*	*eliminates public safety and access issues*
Dump (west of pits)	*dump*	*BR7*	no berms	pit wall rock is non-potentially acid generating (SRK 2008)	water collected on the dump drains into the Bermingham SW pit bottom	tension crack on top of the dump (SRK 2007 Baseline Study)		*pull back dump crest, reslope 2.5H:1V, scarify and revegetate*	*eliminates potential physical stability and chemical contamination issues*
Dump (west of Ruby Shaft)	*dump*	*BR8*	no berms	pit wall rock is non-potentially acid generating (SRK 2008)	no seeps at toe	tension crack on top of the dump (SRK 2007 Baseline Study)		*pull back dump crest, reslope 2.5H:1V, scarify and revegetate*	*eliminates potential physical stability and chemical contamination issues*

1. See attached water quality information





Activity Number	Bermingham and Ruby Mine Components and Closure Activities Rationale
BR1	*Bermingham Adit* *See "Complex Sites" Sheet*
BR2	*Bermingham Pit* *Eliminates public safety and access issues*
BR3	*Bermingham SW Pit* *Eliminates public safety and access issues*
BR4	*Ruby Shaft* *Eliminates public safety and access issues*
BR5	*Ruby Shaft (subsidence)* *Eliminates public safety and access issues*
BR6	*Ruby Shaft Building* *Eliminates public safety and access issues*
BR7	*Dump (west of pits)* *Eliminates potential physical stability and chemical contamination issues*
BR8	*Dump (west of Ruby Shaft)* *Eliminates potential physical stability and chemical contamination issues*

Legend

- Preferred Options
- Shaft
- Structures
- WaterBodies
- Waste Rock Dump
- Adit
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:4,500

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.4

Bermingham and Ruby

Drawn By: TL/JP

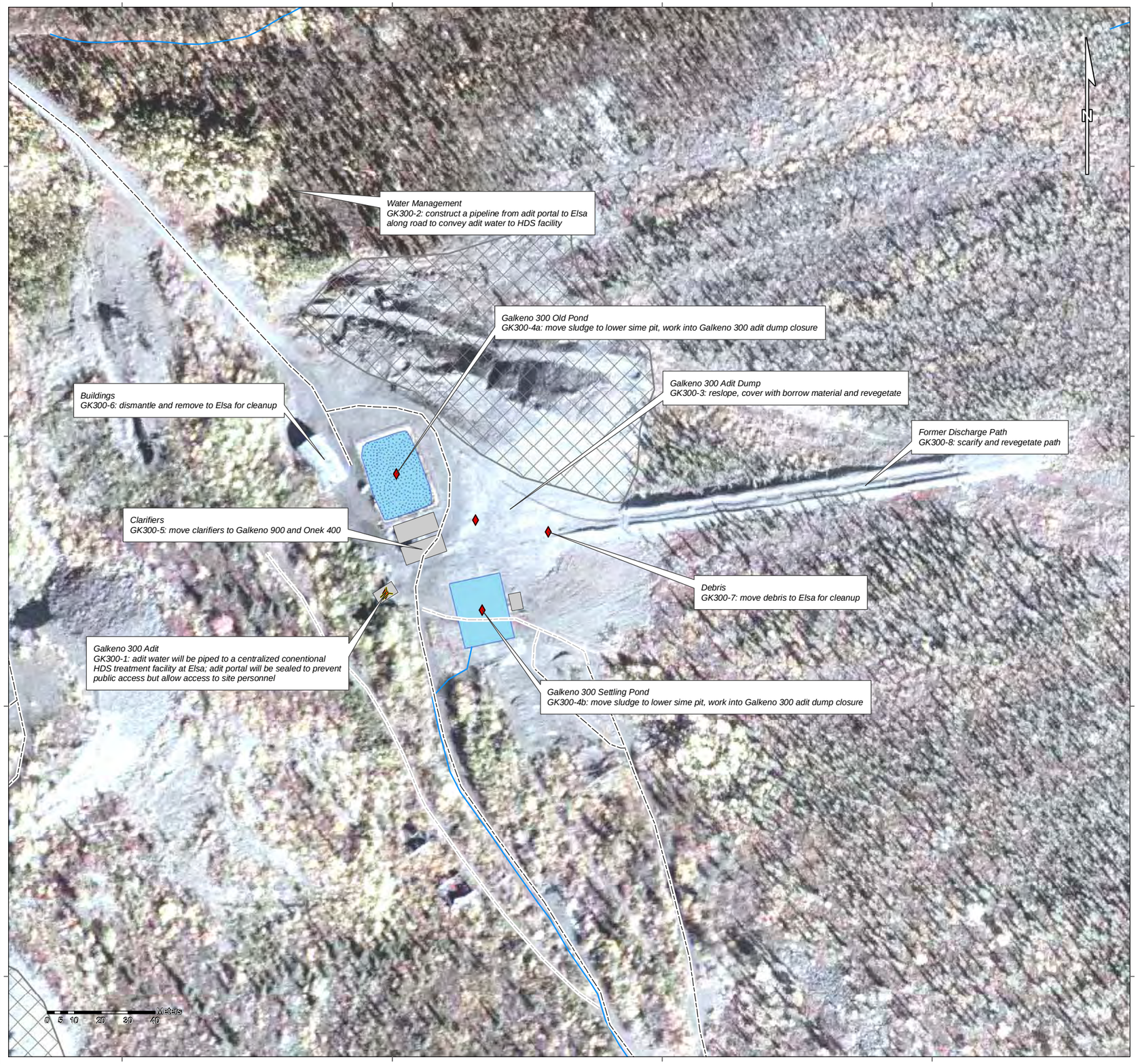
APRIL 2011

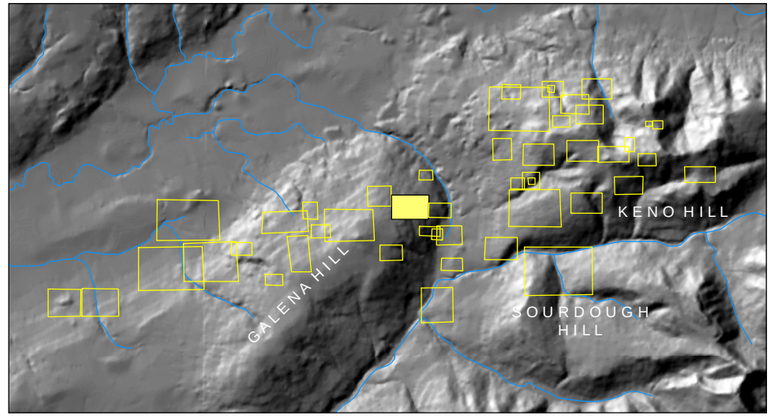
Common Site Name: **Galkeno 300**

	easting	northing		
Site coordinates:	482600	7088600	*coordinates are UTM zone 8N NAD83	473040 52034.4

Component Description	Component Type	Closure Activity No. (map reference)	Closure Issue Categories					Proposed Component Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Galkeno 300 Level Adit	*adit*	*GK300-1*	accessible to public	water exiting the Galkeno 300 portal drains the Hector-Calumet mine, with the highest amount of pre-treatment contamination in the district[1]	consistently produces water at ~12L/s (historical range from 0.1L/s to 30L/s)[1]	adit timbers are old, although there is no imminent concern over the condition of the adit; inspections conducted weekly		*See "Complex Sites" sheet*	
Galkeno 300 Adit Water Management	*adit*	*GK300-2*		water exiting the Galkeno 300 portal drains the Hector-Calumet mine, with the highest amount of pre-treatment contamination in the district[1]	consistently produces water at roughly 12L/s (historical range from 0.1L/s to 30L/s)[1]			*See "Complex Sites" sheet*	
Galkeno 300 Adit Dump	*dump*	*GK300-3*	accessible to public	low reactivity in nearby Sime pit walls and dumps (SRK 2008 geochem study); GK300 adit dump not specifically characterized	well-developed erosion gully observed in dump face	waste rock has been dispersed downslope with scattered wood and metal debris; dump stability is fair; east side of dump has been recontoured		*reslope at least 2.5H:1V, cover with borrow material and revegetate; bury wood and metal debris in dump*	*eliminates potential physical stability and chemical contamination issues*
Sludge Storage Ponds	*sludge pond*	*GK300-4a and GK300-4b*	accessible to public, contains actively settling sludge	contains sludge	contain actively settling sludge; currently used as water storage for treatment facility	built into Galkeno 300 adit dump		*move sludge to lower Sime pit, work into Galkeno 300 adit dump closure; potentially retain GK300 old pond as a holding pond*	*eliminates potential physical stability and chemical contamination issues*
Clarifiers	*infrastructure*	*GK300-5*	clarifiers are locked inside clarifier sheds (inaccessible to the public)					*remove clarifiers for potential usage elsewhere in the District; if upgraded plant remains at G300, these clarifiers may stay*	*Sites with significant loads in the Keno Hill District may warrant active treatment; these clarifiers would be useful for standalone mechanical plants or possible use in final G300 water treatment plant*
Buildings	*infrastructure*	*GK300-6*	accessible to public					*dismantle and remove to Elsa for cleanup*	*will eliminate access and safety issues*
General site debris	*misc*	*GK300-7*	site debris					*move debris to Elsa for cleanup*	*eliminates safety issues associated with debris*
Former discharge path	*misc*	*GK300-8*						*the ground will be restored to its former vegetated state with the closure of the dump*	

1. See attached water quality information





Activity Number	Galkeno 300 Treatment Area Components and Closure Activities Rationale
GK300-1	Galkeno 300 Level Adit See "Complex Sites" Sheet
GK300-2	Galkeno 300 Adit Water Management A pipeline will effectively convey water to Elsa for treatment.
GK300-3	Galkeno 300 Adit Dump Although the Galkeno 300 dump does not pose any geochemical concerns, to prevent any potential unforseen contamination associated with the waste rock and in the interest of conservative closure, the dump will be resloped, covered and revegetated.
GK300-4a and 4b	Sludge Storage Ponds The ponds will be emptied and sludge removed to eliminate sludge waste concerns.
GK300-5	Clarifiers Adits with discharges containing >0.5mg/L Zn will be treated with lime treatment; the two clarifiers currently at Galkeno 300 will be removed to the Galkeno 900 and Onek 400 sites to treat discharges there.
GK300-6	Buildings Any hazards associcated with the storage building will be eliminated when the buildings are removed.
GK300-7	Debris Any hazards associcated with site debris will be eliminated when the debris is removed.
GK300-8	Former Discharge Path The ground will be restored to its former vegetated state with the closure of the dump.

Legend

- Preferred Options
- Structures
- Old Pond
- Settling Pond
- Waste Rock Dump
- Adit
- Pipeline
- Track
- Trail
- WasterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:1,500

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.5

Galkeno 300 Treatment Area

Drawn By: TL/JP

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Common Site Name: **Galkeno 900**

	easting	northing		
Site coordinates:	483600	7087700	*coordinates are UTM zone 8N NAD83	110376 607.068

Component Description	Component Type	Closure Activity No. (map reference)	Closure Issue Categories					Proposed Component Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Galkeno 900 Level Adit	*adit*	*GK900-1a*		adit discharges elevated concentrations of contaminants of concern (6.0ppm Zn) (historical range from 0.005 to 27.6mg/L; 2009 range from 4.7 to 6.54mg/L)[1]	produces ~3.5L/s (historical range from 0.9 to 24L/s; 2009 range from 2.36 to 3.15L/s)[1]			*See "Complex Sites" sheet*	
Galkeno 900 Level Adit (Portal)	*adit*	*GK900-1b*		adit discharges elevated concentrations of contaminants of concern (6.0ppm Zn) (historical range from 0.005 to 27.6mg/L; 2009 range from 4.7 to 6.54mg/L)[1]	produces ~3.5L/s (historical range from 0.9 to 24L/s; 2009 range from 2.36 to 3.15L/s)[1]			*a non-pressurized plug with pipe valve configured to manage discharge volume and flow will be installed for adit closure*	*allows management of discharge volumes to the treatment facility*
Galkeno 900 Level Adit Dump	*dump*	*GK900-2*		characterized as acid-generating; not large enough to produce significant loading to the environment (SRK 2008 geochem study)	location not proximal to surface waters	ponds are built atop dump surface; tension cracks and slumping at dump toe		*reslope at least 2.5H:1V, cover with borrow material and revegetate*	*eliminates potential physical stability and chemical contamination issues*
Galkeno 900 Settling Pond	*settling pond*	*GK900-3*				ponds are built atop dump surface; tension cracks and slumping at dump toe		*remove sludge to storage cell at Valley Tailings and decommission ponds with dump closure*	*eliminates contamination associated with residual sludge waste*
Current Discharge Area (upper)	*treatment site*	*GK900-4*	corrugated metal located at decant point		flow escapes along path			*remove metal and dispose of at Elsa*	*prevents further contamination and eliminates safety issues associated with debris*
Current Discharge Area (lower)	*treatment site*	*GK900-5*		white precipitates and heavy iron staining		permafrost degradation and erosion		*scarify precipitates and revegetate; remove discharge to stable rip rap lined channel into wetland*	*returns environment to natural state*
Former Discharge Area	*misc*	*GK900-6*				permafrost degradation and soil settling; area has been partially mitigated		*do nothing*	*no activity required; partly mitigated*
Old Settling Pond	*settling pond*	*GK900-7*				decommissioned and recontoured		*cover and revegetate*	*eliminates potential physical stability and chemical contamination issues*
Constructed Wetland	*misc*	*GK900-8*	constructed wetland is coming in successfully					*do nothing*	*no activity required*

1. See attached water quality information

483300 483400 483500 483600 483700 483800

7982900 7982800 7982700 7982600

Galkeno 900 Level Adit
GK900-1a: Install active treatement system; move one clarifier from Galkeno 300 to the Galkeno 900 Adit site and commission with lime treatment, later transitioning to bioreactor technology

Pilot Bioreactor
GK900-9: remove liner, backfill with original material, cover and revegetate; new bioreactor for transition treatment technology

Galkeno 900 Level Adit
GK900-1b: a non-pressurized plug with pipe valve configured to manage discharge volume and flow will be installed for adit closure

Constructed Wetland
GK900-8: do nothing

Current Treatment Building
GK900-10: do nothing

Galkeno 900 Level Adit Dump
GK900-2: reslope at least 2.5H:1V, cover with borrow material and revegetate

Settling Pond
GK900-3: remove sludge to storage cell at Valley Tailings and decommission ponds with dump closure

Current discharge area (upper)
GK900-4: remove metal and dispose of at Elsa

Current discharge area (lower)
GK900-5: scarify precipitates and revegetate; remove discharge to stable rip rap lined channel into wetland

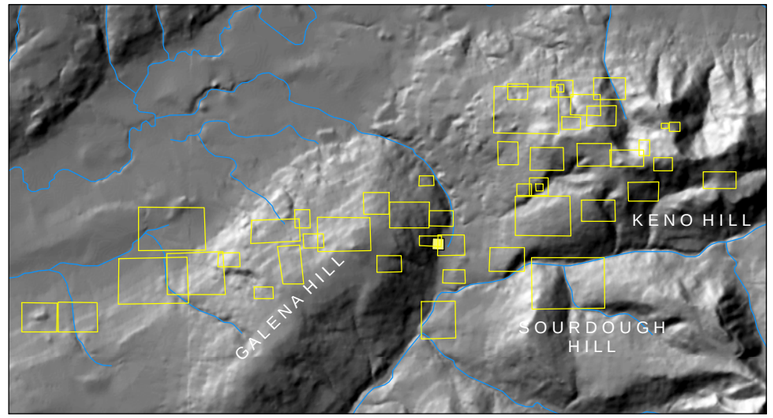
Old Settling Pond
GK900-7: cover and revegetate

Former discharge area
GK900-6: do nothing

Christal Lake

N

0 5 10 20 30 40 Meters



Activity Number	Galkeno 900 Treatment Area Components and Closure Activities Rationale
GK900-1a	*Galkeno 900 level adit* *See "Complex Sites" Sheet*
GK900-1b	*Galkeno 900 adit closure* *A non-pressurized plug with pipe valve will allow management of discharge volumes to the treatment facility.*
GK900-2	*Galkeno 900 level adit dump* *Resloping, covering and revegetating the dump will eliminate any potential physical stability and chemical contamination issues.*
GK900-3	*Galkeno 900 Settling Pond* *The pond will be emptied and sludge removed to eliminate contamination associated with residual sludge waste.*
GK900-4	*Current Discharge Area (upper)* *Removing the metal debris will prevent contamination and eliminate safety issues associated with debris.*
GK900-5	*Current Discharge Area (lower)* *Scarifying precipitates and revegetating the discharge area will allow the current flowpath to return to a natural state.*
GK900-6	*Former Discharge Area* *No activity is required; partly mitigated.*
GK900-7	*Old Settling Pond* *Covering and revegetating the pond in the waste rock dump closure will eliminate potential physical stability and chemical contamination issues.*
GK900-8	*Constructed Wetland* *No activity required.*
GK900-9	*Pilot Bioreactor* *By removing the liner, backfilling, covering and revegetating, chemical concerns will be eliminated.*
GK900-10	*Current Treatment Building* *No activity required.*

Legend

- Preferred Options
- Pilot Bioreactor
- Waste Rock Dump
- Settling Pond
- Structures
- Adit
- Showing
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:2,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.6

Galkeno 900 Treatment Area

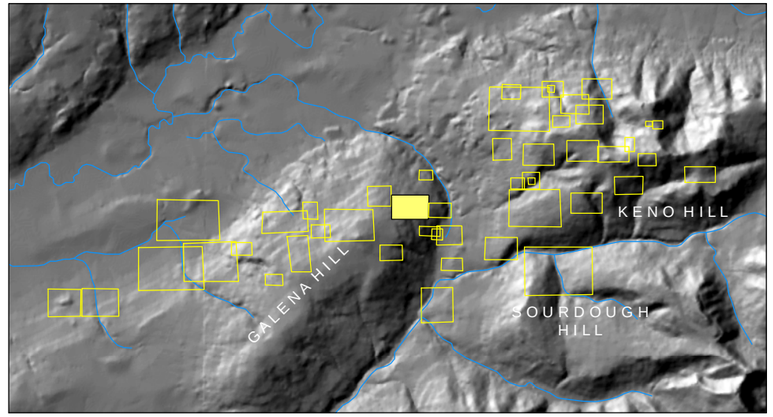
Drawn By: TL/JP APRIL 2011

Common Site Name: **Galkeno**

	easting	northing	
Site coordinates:	482600	7088600	*coordinates are UTM zone 8N NAD83

Component Description	Component Type	Closure Activity No. (map reference)	Closure Issue Categories					Proposed Component Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Galkeno 100 level adit	*adit*	*GK1*	the timbers of the collapsed adit make access difficult, but not impossible (ACG 2009 field inspection)		no discharge	adit partially collapsed (ACG 2009 field inspection)		*rock pile*	*The adit does not produce water; access is not required*
Galkeno 200 level adit	*adit*	*GK2*	accessible to public		no discharge	adit partially collapsed (ACG 2009 field inspection)		*rock pile*	*The adit does not produce water; access is not required*
Sime #6 pit	*open pit*	*GK3*		non-potentially acid-generating (SRK 2008 geochem study)		the pit walls show a high level of ravelling which is expected to continue (2007 SRK Baseline Study)		*berm and sign*	*eliminates public safety and access issues*
Sime #4 pit - NE side	*open pit*	*GK4*		non-potentially acid-generating - low reactivity (SRK 2008 geochem study)		limited ravelling of the slopes on the NE side; pit is considered stable (2007 SRK Baseline Study)		*berm and sign*	*eliminates public safety and access issues*
Upper Sime pit (aka #35 vein pit)	*open pit*	*GK5*	accessible to public	non-potentially acid-generating - low reactivity (SRK 2008 geochem study)	no water noted in pit	stable with no tension cracks observed; some ravelling of slope face is occurring (2007 SRK Baseline Study)		*berm and sign*	*eliminates public safety and access issues*
Lower Sime pit (aka #35 vein pit)	*open pit*	*GK6*	filled with sludge; accessible to public	non-potentially acid-generating (SRK 2008 geochem study); filled with Galkeno 300 sludge	unknown if, or to what degree sludge may be re-entering hydrological cycle; water does not pool at pit bottom	stable with no tension cracks observed; some ravelling of slope face is occurring (2007 SRK Baseline Study)		*consolidate Galkeno 300 sludge production, dry, cap and vegetate sludge deposit; berm and sign*	*eliminates public safety and access issues*
McLeod shaft	*shaft*	*GK7*	accessible to public		no water	subsidence around shaft, open holes (2007 SRK Baseline Study)		*fill holes and cap*	*prevents access and further subsidence*
Sime #6 pit dump NE	*dump*	*GK8*	accessible to public	non-potentially acid-generating - low reactivity (SRK 2008 geochem study)		no indication of instability (2007 SRK Baseline Study)		*pull back dump crest as required, allow to naturally revegetate*	*enhances physical stability; dump is not geochemical issue so cover not required*
Sime #6 pit dump NW	*dump*	*GK9*	accessible to public	non-potentially acid-generating - low reactivity (SRK 2008 geochem study)		no indication of instability (2007 SRK Baseline Study)		*pull back dump crest as required, allow to naturally revegetate*	*enhances physical stability; dump is not geochemical issue so cover not required*





Activity Number	Galkeno 300 Treatment Area Components and Closure Activities Rationale
GK1	The Galkeno 100 level adit does not produce water, therefore no access is required for maintenance. A rock pile will prohibit entry and ensure public safety physical stability.
GK2	The Galkeno 200 level adit does not produce water, therefore no access is required for maintenance. A rock pile will prohibit entry and ensure public safety and physical stability.
GK3 through 5	Berming and signing the Sime pits will prevent public access and ensure safety.
GK6	The Lower Sime pit contains sludge from the treatment process at the Galkeno 300 adit and it poses a chemical and health and safety hazard. Berms and signs will prevent access and allow the sludge to dry. A cap and vegetated cover will prevent dispersion and associated chemical issues.
GK7	Filling the McCleod Shaft will prevent access and further subsidence.
GK8 through 14	Resloping, covering and revegetating all of the dump surfaces will eliminate potential physical stability and chemical contamination issues.
GK15	Site cleanup is necessary to return the site to a condition commensurate with the natural surrounding and ensure public safety.
GK16	Filling the sinkhole at the south bench of the Lower Sime pit will reduce the possibility of further subsidence.

Legend

- Preferred Options
- Waste Rock Dump
- Structure
- WaterBodies
- Settling Pond
- Shaft
- Adit
- Pipeline
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:5,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Keno Hill Silver District
Closure Options Report

Figure 5.7

Galkeno Site

Drawn By: TL/JP

APRIL 2011

Common Site Name: **Sadie Ladue**

Site coordinates:	easting	northing
	486400	7092000

General Location Description	Component Type	Closure Activity No.	Closure Issue Categories: Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest	Proposed Measure	Closure Rationale
Sadie Ladue Adit	*adit*	*SL1*	- Potential ecological risk to flora/fauna in all areas downgradient of adits discharging to the environment through plant uptake of metals	0.7ppm Zn (~112Kg/yr Zn); does not report directly to any watercourse[1]	discharge from Sadie Ladue Adit is high (4.95L/s) despite adit collapse[1]	adit is collapsed for some length; tunnelled into fissile, schistose rock (ACG 2009 site inspection)		*See "Complex Sites" sheet*	
Sadie Ladue Adit Dump	*dump*	*SL2*		characterized as non-potentially acid-generating (SRK 2008 geochem study); dump toe is scoured by stream and may pose some degree of chemical hazard as a result of proximity to water (ACG 2009 field investigation)	dump toe is scoured by stream (SRK 2007 Baseline Study)	- Dump toe is scoured by stream; no large-scale erosion (SRK 2007 Baseline Study) - Some adit water is currently flowing through a pipe through the dump that daylights in an adit-like structure at the toe. It may have leaks that enter the dump and affect dump stability.		*pull back toe of dump from stream edge, reslope and revegetate. Route flow away from dump and seal pipe through dump.*	*Resloping, covering and revegetating the dump will prevent contamination of water by waste rock. It will also prevent contamination of precipitation and other surface runoff*
Loadout	*dump*	*SL3*				structure is deteriorating and is a hazard; timbers are giving way and rails and portions of the structure are at elevated heights above the underlying waste rock foundation (SRK 2007 Baseline Study)		*knock down and burn wood, reslope waste rock*	*Knocking down and burning the loadout will eliminate physical safety issues*
Wernecke Tailings	*tailings*	*SL4*				significant tailings have been transported from this area downstream into small lake (ACG field investigation)		*See "Complex Sites" sheet*	
Water Management	*water management*	*SL5*		dump toe is scoured by stream and may pose a chemical hazard	discharge from Sadie Ladue Adit is high despite adit collapse	a collection box was installed to channel adit flow to an underground culvert; a significant amount of flow bypasses this culvert and scours the toe of the waste dump; no large-scale erosion (ACG 2009 site investigation)		*Construct engineered channel to keep water from tow of dump*	*An engineered channel would avoid the dump toe and ensure long term stability*
Cabin	*infrastructure*	*SL6*	intrigue risk			cabin is partially collapsed	possible heritage value	*leave as is and post sign*	*Post signage indicating no one should enter cabin but otherwise do nothing*
Debris (wooden)	*misc*	*SL7*	much of the debris has been removed by Keno City residents					*consolidate and bury in dump*	*Eliminates safety hazards*
Debris (asbestos)	*misc*	*SL7*						*consolidate and bury in dump*	*Eliminates safety hazards*

1. See attached water quality information

485900

486000

7092700

7092600

Sadie Ladue 600 Adit Dump
SL2 pull back toe of dump from adit discharge channel

Sadie Ladue 600 Adit Dump
SL2: reslope and revegetate

Access Trail

Water Management
SL5: bypass dump toe enroute to lake with engineered riprap channel

Adit Discharge

Cabin
SL6: consolidate cabin with site debris and bury or burn

Loadout
SL3: knock down and burn

Sadie Ladue 600 Adit
SL1 Option #1: in-mine pool treatment
SL1 Option #2: bioreactor (although flows may be too high)

Seasonal discharge channel through tailings

Debris
SL7: consolidate and bury in dump

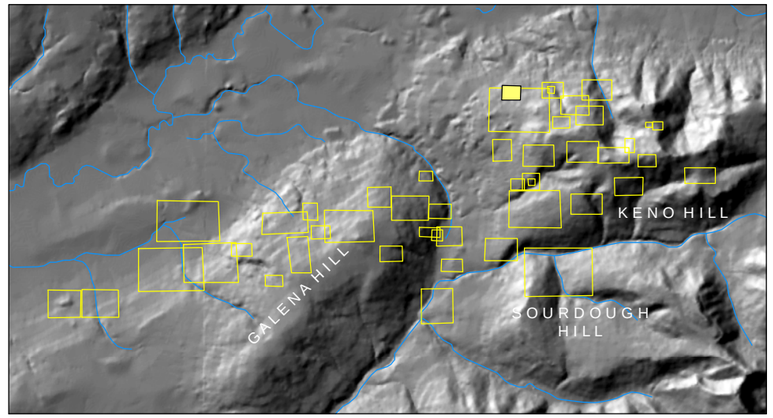
Building foundations and scattered debris
SL7: consolidate and bury in dump

Venecke Tailings
SL4: prevent further downslope movement with upgraded ditch diversion; possible stack pad and cover if flows are too great and material continues to wash out

Extent of Wernecke Tailings downslope movement

N

0 5 10 20 30 40 Meters



Activity Number	Sadie Ladue 600 Adit Mine Components and Closure Activities Rationale
SL1	600 Level Adit See "Complex Sites" Sheet
SL2	Sadie Ladue 600 Adit Dump The dump toe is scoured by water discharging from the adit. No physical instability is noted. Resloping, covering and revegetating the dump will prevent contamination of treated water from dump waste. It will also prevent contamination of precipitation and other surface runoff.
SL3	Loadout The loadout structure is deteriorating and is a hazard. Knocking down and burning the loadout will eliminate physical safety issues.
SL4	Wernecke Tailings Tailings are creeping downslope from the Wernecke camp. By upgrading the existing diversion ditch to circumvent the tails, seasonal flows will not be impacted by the deposit. Where creep is excessive, tailings can be removed to a stack pad.
SL5	Water Management Discharge from the adit is currently free-flowing and scours the dump. An engineered riprap channel is required to avoid the dump toe and manage drainage pathway.
SL6	Cabin A collapsed cabin presents and intrigue risk. Removing debris to the dump and covering it will prevent safety hazards.
SL7	Debris and Building Foundations Site debris will be consolidated in dump to prevent safety hazards.

Legend

- Preferred Options
- Adit
- Loadout Structure
- Track
- Building (foundation only)
- Tailings
- Waste Rock Dump
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:1,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Keno Hill Silver District
Closure Options Report

Figure 5.8

Sadie Ladue 600

Drawn By: TL/JP

APRIL 2011

Common Site Name: **Onek**

Site coordinates:	easting	northing	*coordinates are UTM zone 8N NAD83
	487406	7087196	

General Location Description	Component Type	Closure Activity No.	Closure Issue Categories: Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest	Proposed Measure	Closure Rationale
Onek 400 Portal									
Onek 400 Level Adit	*adit*	*O5*	ice plugging occurs in the adit portal, with very close proximity to homes in Keno City; water from the adit reports to groundwater and may impact Keno City water supply	low flows and high concentrations (2.3L/sec, 80ppm Zn and 1.4ppm Cd)[1]	outflow is not in discharge pipe, but flows along base; low flows and high concentrations (2.3L/sec, 80ppm Zn and 1.4ppm Cd)[1]; Adit discharge is adjacent to Keno City residential dwellings	ice blockage in portal; timber bracing in poor condition		*See "Complex Sites" sheet*	
Ore Pile	*ore pile*	*O6*		possible oxidation and leaching into adit discharge				*move to WRSAs and bury with dump closure*	*eliminates contamination issues associated with metals leaching from low-grade ore*
Onek 400 Level Adit Area	*water management*	*O7*			drainage from portal flows along ditch and infiltrates about 10m above culvert, does not re-emerge downstream of road			*See "Complex Sites" sheet*	
Buildings	*infrastructure*	*O8*	accessible to public	minor hydrocarbon staining near buildings, one lead/acid battery noted				*demolish and remove to Elsa*	*eliminates physical hazards and safety concerns*
Debris	*misc*	*O9*	site debris around adit portal			`		*remove with site cleanup*	*eliminates safety concerns*
Onek Pit and Waste Dumps									
Open Pit	*open pit*	*O1*	no berms; very close proximity to Keno City and easily accessible (used as a shooting range for Keno residents)	pit wall rock is non-potentially acid generating (SRK 2008)	Water drains into the pit and flows into shaft	pit walls and benches potentially unstable		*Because of size of pit and proximity to Keno, employ large double safety berms; erect signage. Partial filling of pit to make free draining*	*Double safety berms coupled with signage will significantly decrease accessibility and ensure public safety. The town of Keno uses the pit as a shooting range from time to time. Making the pit free draining would reduce water entering the underground workings.*
Lone Star and Fisher Shafts	*shaft*	*O2a and O2b*	shafts have been filled and covered			shafts have been filled; no subsidence		*shafts have been filled; do nothing*	*Shafts are not a public safety hazard and therefore no activity is necessary.*
Waste Rock Dumps	*dump*	*O3a through O3f*	only occasional berming; some steep areas; accessible to public	waste rock is non-potentially acid generating (SRK 2008); some local oxidation and orange-black staining		some dump areas are very steep		*pull back crests, reslope dump slopes, scarify and revegetate top surface to cover stained rock*	*In accordance with the overall property closure plan for waste rock, Onek dumps will be resloped and crests rolled back. Dump surfaces will be scarified. Although the waste rock is not a geochemical concern, the surfaces will also be covered with growth media to promote revegetation and cover any stained rock.*
Buildings - north of Lone Star Shaft	*infrastructure*	*O4*	buildings in poor repair; accessible to public and near to town					*demolish and remove to Elsa*	*Removing any buildings will eliminate any current safety and access issues associated with them. This is particularly important considering the site's close proximity to Keno City.*

1. See attached water quality information

485000 485100 485200 485300 485400

7087500 7087400 7087300 7087200 7087100

N

Onek Water Management
O7: construct a pipeline to convey water from the decant at the treatment facility

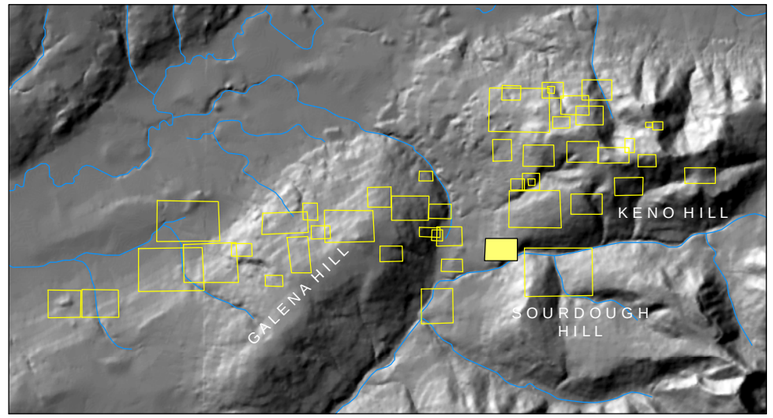
Onek 400 Adit
O5: (1) Bioreactor Treatment with Natural Attenuation
(2) Stand-Alone Small Mechanical Plant
(3) Treat in New Treatment Facility at Silver Trail Highway Near Galkeno 900

Building
O8: dismantle and remove to Elsa

Debris
O9: remove with site cleanup

Onek 400 Ore Pile
O6: move to WRSAs and bury with dump closure

Meters
0 5 10 20 30 40



Activity Number	*Onek Mine Components and Closure Activities Rationale*
O5	*Onek 400 Level Adit* *See "Complex Sites" Sheet*
O6	*Ore Pile* *Moving and burying the ore will eliminate contamination issues associated with metals leaching from low-grade ore.*
O7	*Onek 400 Level Adit Area* *Water will need to be conveyed across the highway to Christal Creek watershed from the treatment facility, a pipeline will achieve this.*
O8	*Buildings* *Demolishing and removing the buildings will eliminate physical hazards and safety concerns. This is especially important due to Onek's close proximity to Keno City*
O9	*Debris* *Removal of debris will eliminate safety concerns.*

Legend

- Preferred Options
- Keno City Buildings
- Onek
- Waste Rock Dump
- Adit
- Highway
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:1,750

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.9a

Onek 400 Adit Area

Drawn By: TL/JP

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485400
485600
485800
486000
7087600
7087400
7087200
7087000

Building
O5: dismantle and remove to Elsa

Onek WRSA
O4d: pull back crests, reslope dump slopes, scarify and revegetate top surface to cover stained rock

Onek WRSA
O4f: pull back crests, reslope dump slopes, scarify and revegetate top surface to cover stained rock

Onek WRSA
O4b: pull back crests, reslope dump slopes, scarify and revegetate top surface to cover stained rock

Fisher Shaft
O2b: shafts have been filled; do nothing

Onek Open Pit
O1: because of size of pit and proximity to Keno, employ large double safety berms; erect signage

Onek WRSA
O4e: pull back crests, reslope dump slopes, scarify and revegetate top surface to cover stained rock

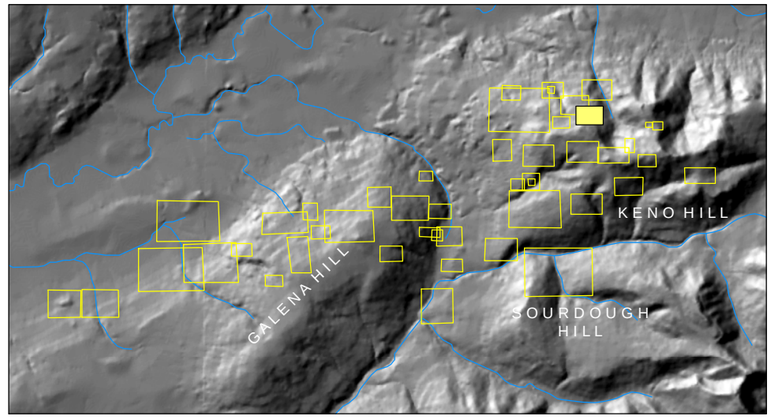
Lone Star Shaft
O2a: shafts have been filled; do nothing

Onek WRSA
O4c: pull back crests, reslope dump slopes, scarify and revegetate top surface to cover stained rock

Onek WRSA
O4a: pull back crests, reslope dump slopes, scarify and revegetate top surface to cover stained rock

N

0 15 30 60 90 120 Meters



Activity Number	*Onek Mine Components and Closure Activities Rationale*
O1	*Onek Open Pit* *Double safety berms coupled with signage will significantly decrease accessibility and ensure public safety.*
O2	*Lone Star and Fisher Shafts* *Shafts are not a public safety hazard and therefore no activity is necessary.*
O3	*Waste Rock Dumps* *In accordance with the overall property closure plan for waste rock, Onek dumps will be resloped and crests rolled back. Dump surfaces will be scarified. Although the waste rock is not a geochemical concern, the surfaces will also be covered with growth media to promote revegetation and cover any stained rock.*
O4	*Buildings* *Removing any buildings will eliminate any current safety and access issues associated with them.*

Legend

- Preferred Options
- Shaft
- Structures
- Waste Rock Dump
- Open Pit
- Local
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:3,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Keno Hill Silver District
Closure Options Report

Figure 5.9b

Onek Waste Rock Area

Drawn By: TL/JP

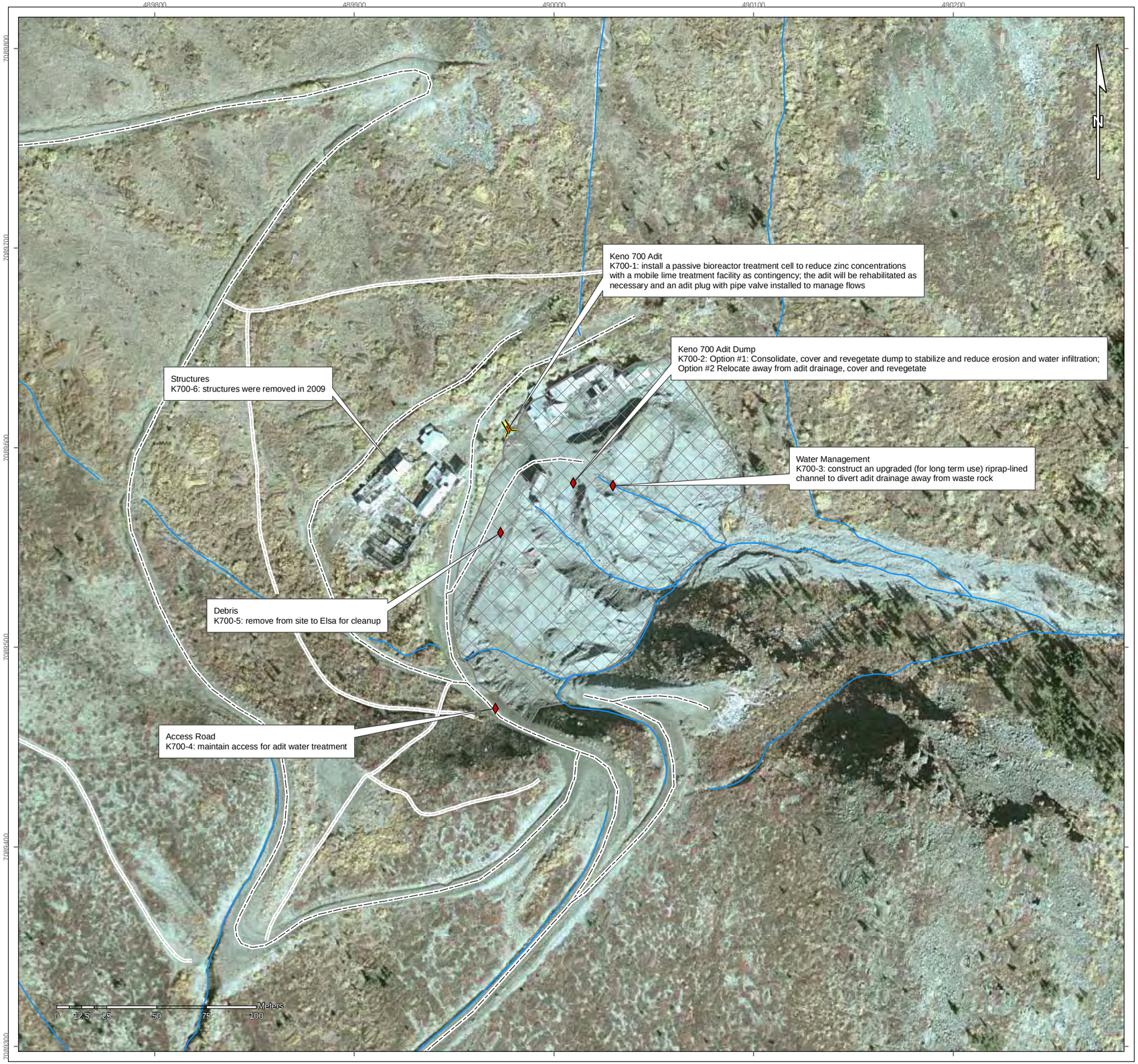
APRIL 2011

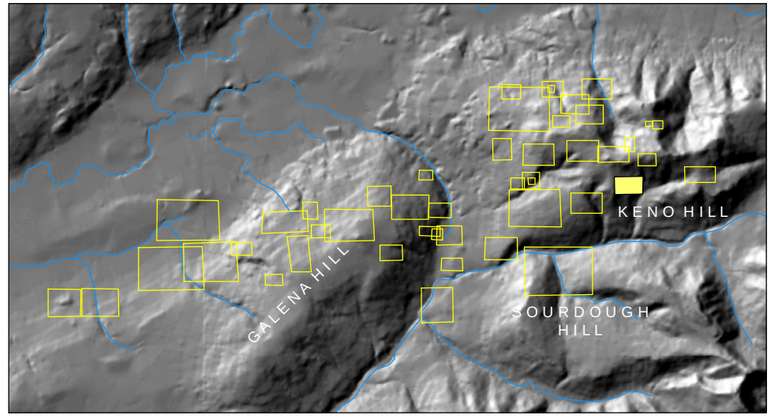
Common Site Name: **Keno 700**

	easting	northing
Site coordinates:	489969.49	7089596.39

General Location Description	Component Type	Closure Activity No.	Closure Issue Categories					Proposed Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Keno 700 Level Adit	*adit*	*K700-1*	adit portal is located along a popular tourist route and is easily accessible to public if access is not adequately prohibited	Keno 700 Adit discharges the largest load from the Keno Hill property to the Lightning Creek watershed; in 2009 130Kg zinc entered the watershed from Keno 700 discharge (the average rate of discharge was 3.3L/sec at 1.24mg/L zinc)[1]	discharge from Keno 700 travels a short path along ground before entering Hope Gulch, a tributary to the Lightning Creek watershed; waste rock erosion from adit discharge (adit discharge passes through waste rock material)[1]	adit opening is physically stable		*See "Complex Sites" sheet*	
Keno 700 Level Adit Dump	*dump*	*K700-2*		characterized as non-potentially acid-generating (SRK 2008 geochem study); size of dump is ~25,000 tons with much of the material eroded downslope (PWGSC 2000)	dumps are mass wasting downslope into Hope Gulch; a diversion ditch has been constructed to prevent adit water from travelling through dump; however, adit discharge still passes through dump material. Discharge pipe is gunbarreled	dumps have eroded downslope into Hope Gulch (PWGSC 2000); a diversion ditch has been constructed to prevent adit water from travelling through dump; however, adit discharge still passes through dump material		*Option #1: Consolidate, cover and revegetate dump to stabilize and reduce erosion and water infiltration; Option #2 Relocate away from adit drainage, cover and revegetate*	
Water Management	*water management*	*K700-3*			discharge from Keno 700 travels a short path along ground before entering Hope Gulch, a tributary to the Lightning Creek watershed; waste rock wastes downslope with adit discharge (adit discharge passes through waste rock)			*construct an upgraded (for long term use) riprap-lined channel to divert adit drainage away from waste rock*	
Keno 700 Access Road	*infrastructure*	*K700-4*					used for access to top of Keno Hill	*maintain access for adit water treatment*	
Site Debris	*miscellaneous*	*K700-5*					most site debris was removed in 2009; some tanks and heavy equipment remain	*remove from site to Elsa for cleanup*	

1. See attached water quality information





Activity Number	Keno 700 Mine Components and Closure Activities Rationale
K700-1	*Keno 700 Level Adit* *See "Complex Sites" Sheet*
K700-2	*Keno 700 Level Adit Dump* *Isolating the dump from treated adit drainage will reduce the potential for infiltration of contaminants from the dump to the treated water. Consolidating and stabilizing the dump will prevent mass wasting.*
K700-3	*Water Management* *Isolating the dump from treated adit drainage will reduce the potential for infiltration of contaminants from the dump to the treated water.*
K700-4	*Keno 700 Access Road* *The road must be maintained for access to the treatment facilities.*
K700-5	*Site Debirs* *Removeing site debris will eliminate associated safety hazards to the public.*
K700-6	*Structures* *Buildings at Keno 700 were removed from the site in a manner congruent with best practices in 2009.*

Legend

- Preferred Options
- WaterBodies
- Waste Rock Dump
- Adit
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:2,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.10

Keno 700

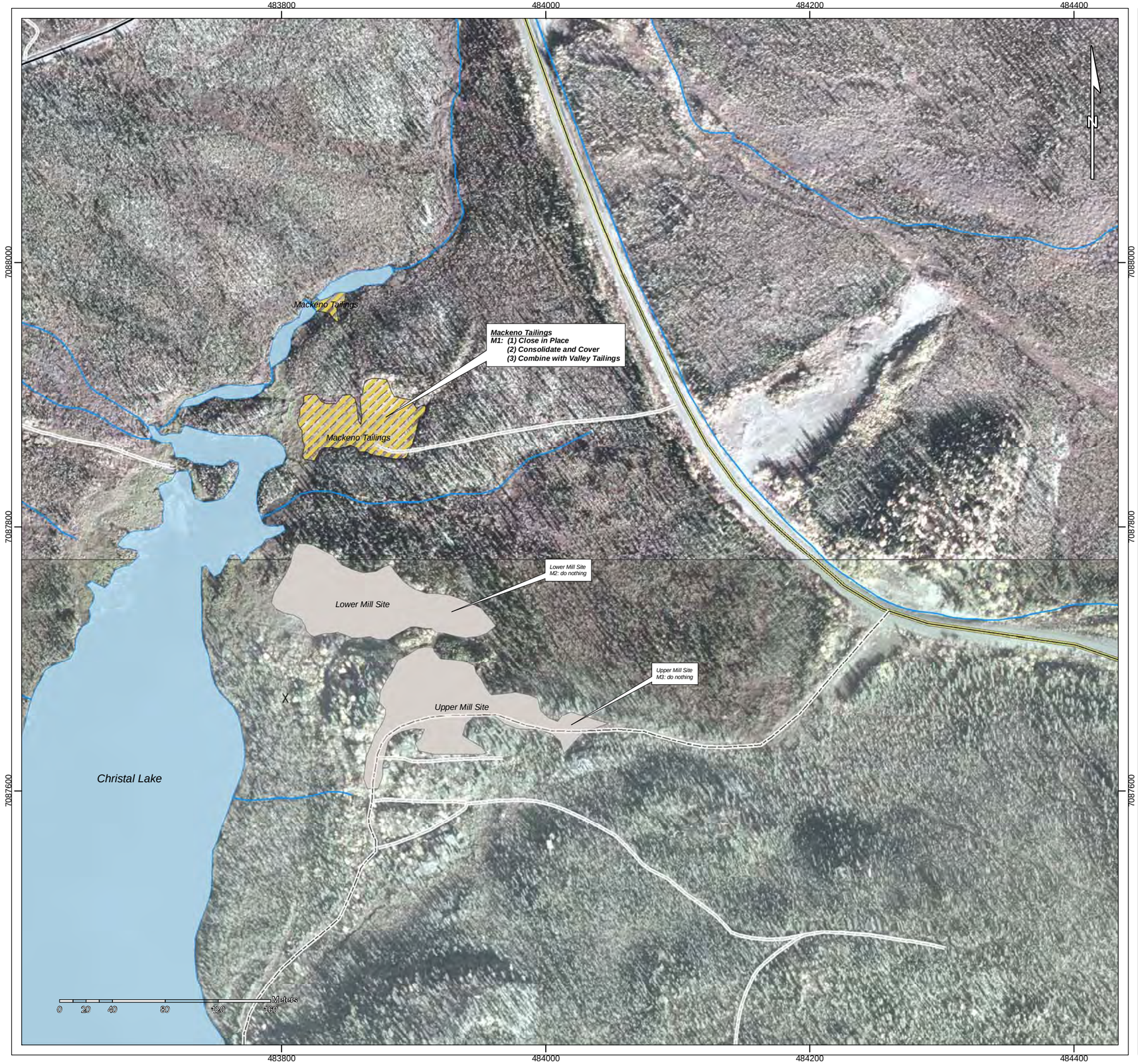
Drawn By: TL/JP

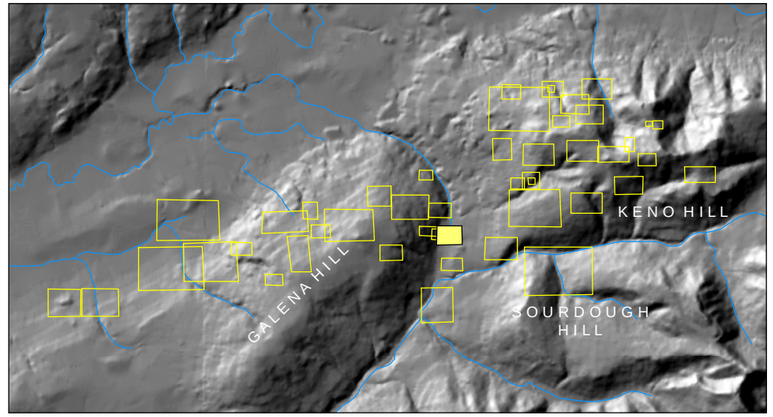
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Common Site Name: **Mackeno Tailings**

Site coordinates: easting northing

General Location Description	Component Type	Closure Activity No.	Closure Issue Categories					Proposed Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Mackeno Tailings	*tailings*	-	moose graze on the tailings at the edge of Christal Lake throughout the year; the tailings may pose a threat to the health of moose and other wildlife		Mackeno tailings porewater discharges directly to Christal Lake. Tailings in direct contact with stream	tailings erosion and slumping may occur; dry tailings may be dispersed by wind		*See "Complex Sites" sheet*	





Activity Number	Mackeno Components and Closure Activities Rationale
M1	See "Complex Sites" sheet
M2	Do Nothing
M3	Do Nothing

Legend

- Preferred Options
- Adit
- Showing
- Structures
- Waste Rock Dump
- WaterBodies
- Highway
- Local
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:2,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.11

Mackeno Tailings and Mill Site

Drawn By: TL/JP

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Common Site Name: **Valley Tailings Facility**

Site coordinates: easting northing

Component Description	Component Type	Closure Activity No. (map reference)	Closure Issue Categories					Proposed Component Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Valley Tailings	*tailings*	-	Exposed tailings may pose threat to wildlife grazing in the ponds	- Suspended solids in freshet flows also have concentrations of zinc - Windblown tailings have affected vegetation and soils around tailings impoundment area - High zinc in tailings pore water and subsurface peat layers - Potential for zinc remobilization during winter freeze period	- Diversions around tailings require frequent maintenance - Ponds are dewatered in the fall to provide treatment and storage capacity in the spring - Water balance of the VTF is not well understood	Dam stability has improved as permafrost has progressively degraded; at current time there is no permafrost in the dam area. Dam maintenance has also consequently become minimal.	Major facility with obvious visual impacts leading to speculation that all issues/problems in the valley are due to VTF. Talking to NND, they think that the dying trees in the valley are due to the VTF	*See "Complex Sites" sheet*	

474000 474200 474400 474600 474800 475000 475200 475400 475600 475800 476000 476200

7089200 7089000 7088800 7088600 7088400 7088200 7088000 7087800 7087600 7087400

N

Pond

Pond

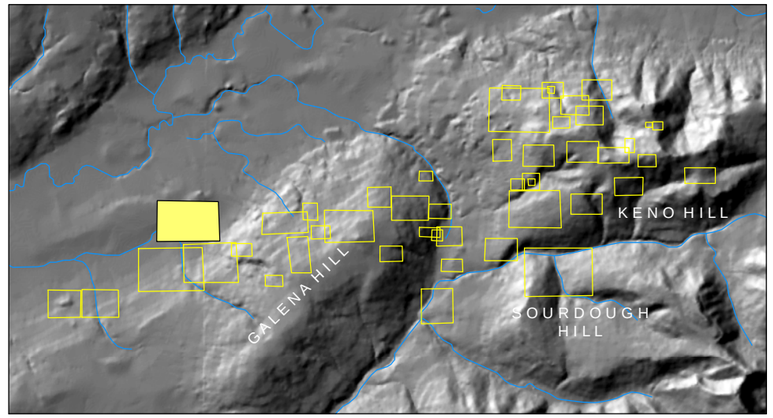
Tailings

Tailings

Tailings

Tailings

Meters
0 45 90 180 270 360



Activity Number	Valley Tailings Mine Components and Closure Activities Rationale
VT1	For closure options, see "Complex Sites" table

Legend

- Tailings
- Structures
- ValleyTailings

Universal Transverse Mercator
Zone 8N
North American Datum 1983
Contour Interval 10metres
1:3,500

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.12

Valley Tailings Area

Drawn By: TL/JP

APRIL 2011

Common Site Name: **Husky**

Site coordinates:	easting	northing
	473886	7086471

General Location Description	Component Type	Activity Number	Closure Issue Categories					Other	Preferred Component Closure Option	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest			
Husky Raise	*raise*	*H1*	not investigated; raise building locked at last visit, and during SRK 2006 and PWGSC 2000 visits							
Husky Shaft	*shaft*	*H2*	not investigated; shaft house locked at last visit, and during SRK 2006 and PWGSC 2000 visits							
Husky Shaft Dump	*dump*	*H3*	Vegetation below dump is heavily stressed	iron staining and precipitates; vegetation heavily stressed; acid						
Shaft Headframe	*infrastructure*	*H4*	not investigated; shaft house locked at last visit					building construction is wood frame, metal sheating, timber supports, concrete foundation; no paint on exterior; no asbestos on exterior		
Hoist House	*infrastructure*	*H5*	not investigated; raise building locked at last visit					wood frame, metal sheathing, fibreglass insulation, concrete foundation; no paint on exterior; no asbestos on exterior		
Boiler House	*infrastructure*	*H6*		friable asbestos present as waste (exterior and interior siding, vinyl and		not noted in SRK (2006) or PWGSC (2000)		wood frame, metal sheathing, wood panel doors, concrete foundation		
Storage Shed	*infrastructure*	*H7*				not noted in SRK (2006) or PWGSC (2000)		wood frame, metal sheathing, wooden foundation; no paint on exterior; no asbestos on exterior		
Large Storage Shed	*infrastructure*	*H8*				not noted in SRK (2006) or PWGSC (2000)		wood frame, metal sheathing, wooden foundation; no paint on exterior; no asbestos on exterior		
Fuel Storage	*misc*	*H9*		soil staining around perimeter of the tank						
Rail and Tresle	*misc*	*H10*	accessible and potentailly hazardous				possible community interest; 28 rail cars behind large storage shed			
Electrical Equipment	*misc*	*H11*	accessible and potentailly hazardous				transformers in use at PWGSC 2000 site visit			

474800

475000

7087200

7087000

N

Storage Shed
H7: remove metal and burn remainder

Husky Shaft Dump
H3: recontour to 2.5H:1V, cover and revegetate to reduce infiltration

Large Storage Shed
H8: remove metal and burn remainder

Rail and Tresle
H10: remove tresle and salvage

Shaft Headframe
H4: remove to Elsa for cleanup

Electrical Equipment
H11: investigate transformers for PCB concerns; remove to Elsa for cleanup

Fuel Storage
H9: remove tank to Elsa for cleanup and relocate hydrocarbon contaminated soils for remediation

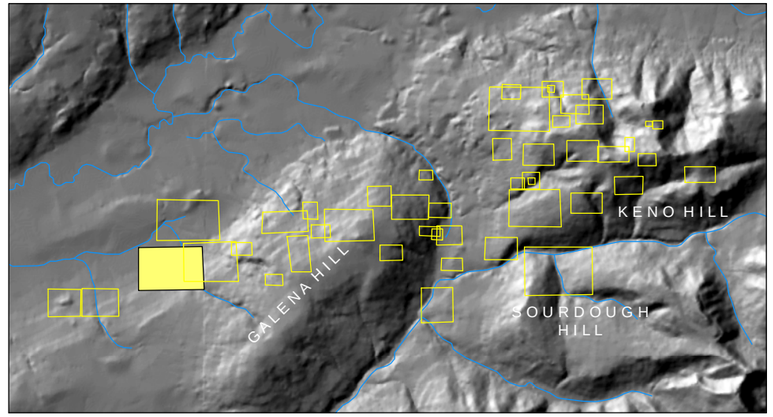
Husky Shaft
H2: fill and cap

Boiler House
H6: remove to Elsa for cleanup

Hoist House
H5: remove to Elsa for cleanup

Husky Raise
H1: fill and cap

0 5 10 20 30 40
Meters



Activity Number	*Husky Components and Closure Activities Rationale*
H1	*Husky Raise* *Filling and capping the raise will eliminate intrigue risk and access to workings.*
H2	*Husky Shaft* *Filling and capping the shaft will eliminate intrigue risk and access to workings.*
H3	*Husky Shaft Dump* *Ensures dump stability and addresses geochemical loading concerns.*
H4	*Shaft Headframe* *Removing eliminates safety and stability issues.*
H5	*Hoist House* *Removing eliminates safety and stability issues.*
H6	*Boiler House* *Removing eliminates safety and stability issues.*
H7	*Storage Shed* *Removing eliminates safety and stability issues.*
H8	*Large Storage Shed* *Removing eliminates safety and stability issues.*
H9	*Fuel Storage* *Provides for mitigation of existing hydrocarbon contamination.*
H10	*Rail and Tresle* *Trestle removal eliminates safety concerns.*
H11	*Electrical Equipment* *Removing eliminates safety and stability issues.*

Legend

- Preferred Options
- Waste Rock Dump
- Structures
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:1,250

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.13

Husky

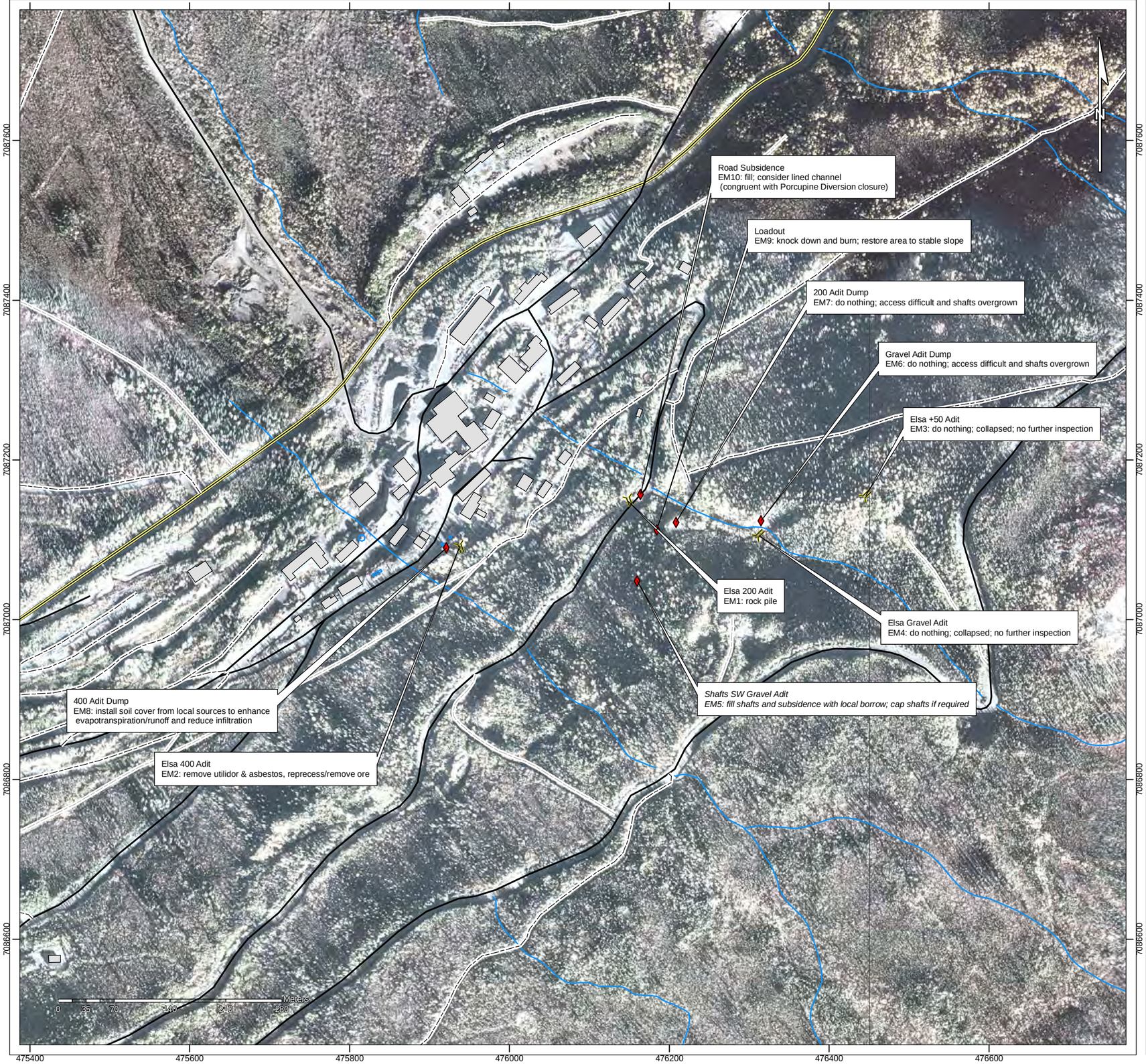
Drawn By: TL/JP

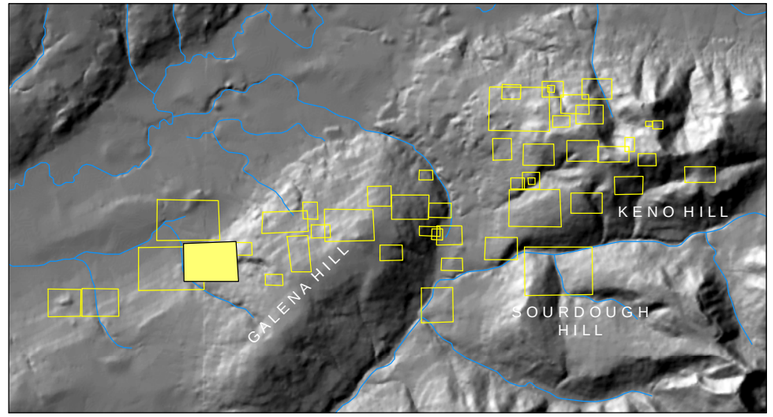
APRIL 2011

Common Site Name: **Elsa**

Site coordinates:	easting	northing	*coordinates are UTM zone 8N NAD83
	476000	7087000	

Component Description	Component Type	Closure Activity No. (map reference)	Closure Issue Categories					Proposed Component Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
+50 Level Adit	*adit*	*EM1*	minor debris in the form of piping, rails, barrels and sheet roofing			confirmed collapse; nearby raises overgrown and unable to locate		*do nothing*	*adit is confirmed collapsed and inaccessible; no activity required*
Gravel Level Adit	*adit*	*EM2*				confirmed collapse		*do nothing*	*adit is confirmed collapsed and inaccessible; no activity required*
200 Level Adit	*adit*	*EM3*	gated and secure; first few metres accessible		no drainage	timber supports intact		*rock pile*	*eliminates public access and physical stability issues at the portal*
400 Level Adit	*adit*	*EM4*	public access; utilidors; asbestos	low grade ore pile located at adit portal; asbestos	small flow volume; intermittent discharge - no lab data to assess WQ			*confirm connection with upper workings; seal portal*	*an adit seal will allow water to continue to discharge and be managed/monitored; it also prevents public access while at the same time maintains adit for heritage*
Shafts SW of Gravel Level Adit	*shaft*	*EM5*	shaft house collapsed over an open shaft, presents an intrigue risk; only one shaft located			ground subsidence immediately adjacent to the shaft house on all sides		*fill shaft and subsidence with local borrow. Cap shaft if required*	*eliminates safety and stability issues*
Gravel Level Adit Dump	*dump*	*EM6*		dump primarily consists of overburden; does not pose a chemical risk		steep terrain preventing revegetation		*do nothing*	*the dump is primarily overburden and highly oversteepened preventing vegetation; highly inaccessible to public*
200 Level Adit Dump	*dump*	*EM7*		most rock was used in construction in Elsa townsite, remaining rock does not pose a significant chemical risk				*do nothing*	*the dump is stable and mostly naturally overgrown; no activity necessary*
400 Level Adit Dump	*dump*	*EM8*		characterized as potentially acid-generating (SRK 2008 geochem study)	intermittent drainage from 400 level adit possibly impacted by dump contamination			*install soil cover from local sources to enhance evapotranspiration/runoff and reduce infiltration.*	*enhance evapotranspiration/runoff and reduce infiltration.*
Loadout structure (200 Level Adit)	*dump*	*EM9*	this structure is visible from Calumet Drive and has rail and rail cars sitting on it; presents an intrigue risk			timber loadout structure beginning to deteriorate		*knock down and burn wood. Reslope area to stable angle*	*knocking down and burning the loadout will eliminate physical safety issues*
Subsidence @ Calumet Drive	*workings*	*EM10*	open to workings		surface flow into workings has occurred in the past			*fill; consider lined channel (congruent with Porcupine Diversion closure)*	*an engineered channel will redirect flow and prevent further subsidence*





Activity Number	*Elsa Mine Components and Closure Activities Rationale*
EM1	*+50 Level Adit* *adit is confirmed collapsed and inaccessible; no activity required*
EM2	*Gravel Level Adit* *Adit is confirmed collapsed and inaccessible; no activity required*
EM3	*200 Level Adit* *Eliminates public access and physical stability issues at the portal*
EM4	*400 Level Adit* *An adit seal will allow water to continue to discharge and be managed/monitored; it also prevents public access while at the same time maintains adit for heritage*
EM5	*Shafts SW of Gravel Level Adit* *Eliminates safety and stability issues*
EM6	*Gravel Level Adit Dump* *The dump is primarily overburden and highly oversteepened preventing vegetation; highly inaccessible to public*
EM7	*200 Level Adit Dump* *The dump is stable and mostly naturally overgrown; no activity necessary*
EM8	*400 Level Adit Dump* *Enhance evapotranspiration/runoff and reduce infiltration.*
EM9	*Loadout structure (200 Level Adit)* *Knocking down and burning the loadout will eliminate physical safety issues*
EM10	*Subsidence @ Calumet Drive* *An engineered channel will redirect flow and prevent further subsidence*

Legend

- Preferred Options
- Adit
- Structures
- Highway
- Local
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:5,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.14

Elsa Mine

Drawn By: TL/JP

APRIL 2011

Common Site Name: **Dixie**

Site coordinates:	easting	northing	*coordinates are UTM zone 8N NAD83
	477000	7087200	

Component Description	Component Type	Closure Activity No. (map reference)	Closure Issue Categories					Proposed Component Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Adit	*adit*	*D1*	secured with doors and wire caging			may be unstable		*rock pile*	*eliminates access and safety issues*
Shaft	*shaft*	*D2*	needs inspection			needs inspection		*cap shaft*	*eliminates access and safety issues*
Vent Raises	*raise*	*D3*	need inspection			need inspection		*cap raises*	*eliminates access and safety issues*
Adit Dump	*dump*	*D4*		orange surface staining; classified as potentially acid-generating (SRK 2008 geochem study) although not large enough to produce significant loads		dump slope erosion via gullies; sinkhole		*pull back and reslope; install soil cover, as available locally, to enhance evapotranspiration/runoff and reduce infiltration.*	*eliminates potential physical stability and chemical contamination issues*
Loadout	*dump*	*D5*	loadout old, rotting; presents intrigue risk					*knock down and burn wood; reslope to stable angle*	*eliminates safety issues*
Solid Waste	*solid waste*	*D6*		several empty rusting barrels				*site cleanup*	*eliminates safety issues*
Debris	*solid waste*	*D7*	timber, barrels, rail lines and old piping on site					*site cleanup*	*eliminates safety issues*
Building	*infrastructure*	*D8*		hydrocarbons have been disturbed by ditching	potential for high flows in ditch to erode ditch wall and undercut building foundation	potential for high flows in ditch to erode ditch wall and undercut building foundation		*remove to Elsa for cleanup*	*eliminates safety and physical stability issues*
Tramline	*infrastructure*	*D9*	presents an intrigue risk					*remove to Elsa or No Cash 100 for cleanup*	*eliminates access and safety issues*

476800

477000

7087600

7087400

N

Debris
D7: site cleanup

Tramline
D9: remove to Elsa or No Cash 100 for cleanup

Dixie Adit Dump
D4: pull back and reslope; install soil cover, as available locally, to enhance evapotranspiration/runoff and reduce infiltration.

Solid Waste
D6: site cleanup

Loadout
D5: knock down and burn wood; reslope to stable angle

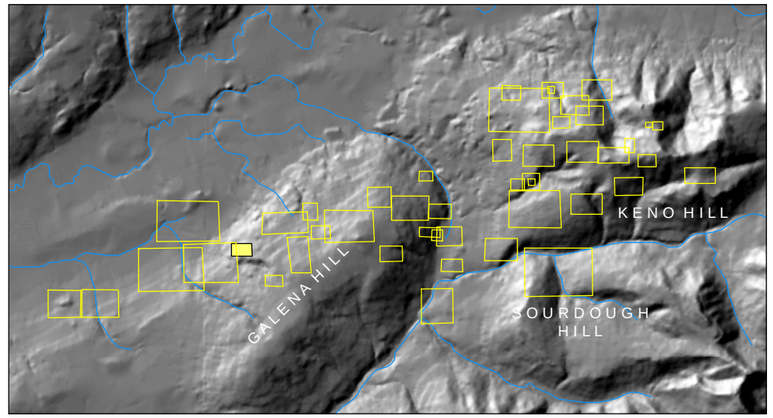
Dixie Shaft
D2: cap shaft

Dixie Adit
D1: rock pile

Vent Raises
D3: cap raises

Building
D8: remove to Elsa for cleanup

Meters
0 5 10 20 30 40



Activity Number	Dixie Components and Closure Activities Rationale
D1	*Adit* *Eliminates access and safety issues*
D2	*Shaft* *Eliminates access and safety issues*
D3	*Vent Raises* *Eliminates access and safety issues*
D4	*Adit Dump* *Eliminates potential physical stability and chemical contamination issues*
D5	*Loadout* *Eliminates safety issues*
D6	*Solid Waste* *Eliminates safety issues*
D7	*Debris* *Eliminates safety issues*
D8	*Building* *Eliminates safety and physical stability issues*
D9	*Tramline* *Eliminates access and safety issues*

Legend

- Preferred Options
- Adit
- Structures
- Waste Rock Dump
- Local Road
- Track
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:3,500

Sources:

Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.15

Dixie

Drawn By: TL/JP

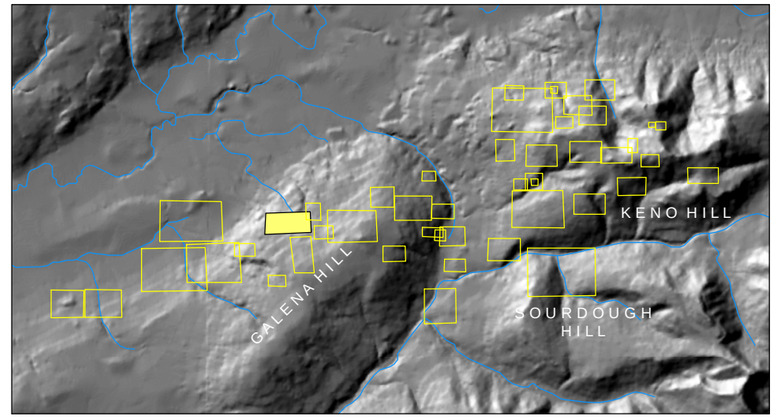
APRIL 2011

Common Site Name: **No Cash 100**

	easting	northing	
Site coordinates:	477230	7088058	*coordinates are UTM zone 8N NAD83

Component Description	Component Type	Closure Activity No. (map reference)	Closure Issue Categories					Proposed Component Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
No Cash 100 Level Adit	*adit*	*NC100-1*	potentially an intrigue risk; some remaining utilidors and scrap			adit is already naturally blocked (rock pile)		*Do nothing; existing rock pile*	*the adit is already covered; no activity is necessary*
Brefalt Shaft	*shaft*	*NC100-2*	accessible to public					*cap shaft*	*shaft is open inside the building*
Brefalt Shaft Building	*shaft*	*NC100-3*	accessible to public					*remove to Elsa for cleanup*	*eliminates safety, access and physical stability issues*
Shaft (south of abandoned tramway, north of Brefalt shaft dump)	*shaft*	*NC100-4*				collapsed; minor depression remains; not a risk		*do nothing*	*no action required*
Open Pits	*open pit*	*NC100-5*	accessible to public	area of minor stripping near adit is overgrown and with some debris	area of minor stripping near adit is overgrown	minor grade; no highwall		*minor grading; remove debris*	*eliminates safety, access and physical stability issues*
No Cash Pit Dump	*dump*	*NC100-6*						*reslope,scarify, cover and revegetate*	*eliminates potential physical stability and chemical contamination issues*
No Cash 100 Level Adit Dump	*dump*	*NC100-7*	dump at portal contains remnants of trestle structure - no rails observed in place	unknown acid-generation potential (not covered in SRK 2008 geochemical study)	waste rock does not block flow path	waste rock at portal spills into valley that forms the upper end of Sandy Creek drainage		*reslope,scarify, cover and revegetate*	*eliminates potential physical stability and chemical contamination issues*
Brefalt Shaft Dumps	*dump*	*NC100-8a and 8b*						*do nothing*	*access would impact area greater than leaving as is*
Tramline	*infrastructure*	*NC100-9*	presents an intrigue risk				potential heritage interest	*dismantle and burn*	*eliminates safety, access and physical stability issues*





Activity Number	No Cash 100 Components and Closure Activities Rationale
NC100-1	*No Cash 100 Level Adit* *The adit is already covered; no activity is necessary.*
NC100-2	*Brefalt Shaft* *Capping shaft removes safety issues.*
NC100-3	*Brefalt Shaft Building* *Removal eliminates safety, access and physical stability issues.*
NC100-4	*Shaft (south of abandoned tramway, north of Brefalt shaft dump)* *No further remediation required.*
NC100-5	*Open Pits* *Eliminates safety, access and physical stability issues.*
NC100-6	*No Cash Pit Dump* *Resloping and cover eliminates potential physical stability and chemical contamination issues.*
NC100-7	*No Cash 100 Level Adit Dump* *Eliminates potential physical stability and chemical contamination issues.*
NC100-8a	*Brefalt Shaft Dumps* *Access would impact area greater than leaving as is.*
NC100-8b	*Brefalt Shaft Dumps* *Access would impact area greater than leaving as is.*
NC100-9	*Tramline* *Removal eliminates safety, access and physical stability issues.*

Legend

- Preferred Options
- Structures
- Open Pit
- Waste Rock Dump
- Shaft
- Adit
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:2,500

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.16

No Cash 100

Drawn By: TL/JP

APRIL 2011

Common Site Name: **Townsite**

Site coordinates: easting northing

General Location Description	*Component Type*	*Activity Number*	Closure Issue Categories					Proposed Closure Measure	Closure Rationale
			Human & Wildlife Health and Safety	**Chemical Control**	**Water Management**	**Physical Stability**	**Community Interest**		
Townsite Adit	*adit*	*TS1*		does not produce water - no chemical load	does not produce water			*do nothing*	
Townsite Adit Dump	*dump*	*TS2*		unknown acid generation potential (not covered in 2008 SRK geochem study)				*scarify, cover and revegetate*	*eliminates potential physical stability and chemical contamination issues*
Loadout	*dump*	*TS3*				may pose a physical hazard		*tear down and remove debris. Reslope as required*	
Solid Waste	*waste*	*TS4*						*push down and cover with borrow*	
Building	*infrastructure*	*TS5*	accessible to public			may pose a physical hazard		*demolish and remove to Elsa for cleanup*	

479400

479600

7088000

7088000

N

Loadout
TS3: tear down and remove debris. Reslope as required

Townsite Adit
TS1: do nothing

Townsite Adit Dump
TS2: scarify, cover and revegetate

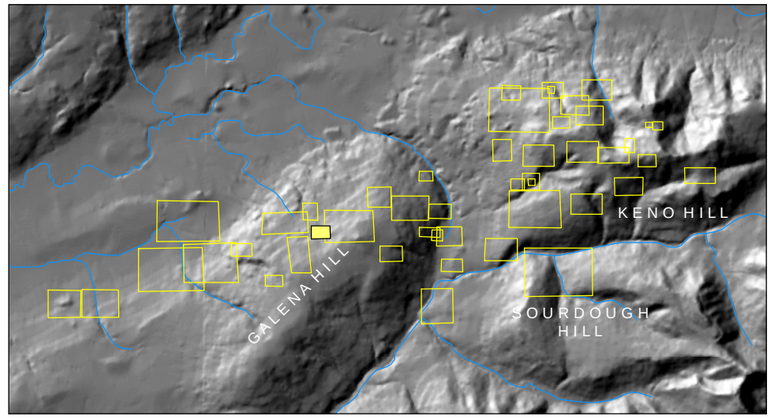
Building
TS5: demolish and remove to Elsa for cleanup

Solid Waste
TS4: push down and cover with borrow

Meters
0 5 10 20 30 40

479400

479600



Activity Number	*Townsite Components and Closure Activities Rationale*
TS1	*Preventing access to workings eliminates safety issues.*
TS2	*Eliminates potential physical stability and chemical contamination issues.*
TS3	*Removal and resloping eliminates safety and stability issues*
TS4	*Clean-up of site based on visbility from road*
TS5	*Removal eliminates safety and stability issues*

Legend

- Preferred Options
- Adit
- Structures
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:1,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.17

Townsite

Drawn By: TL/JP

APRIL 2011

Common Site Name: **Hector Calumet**

	easting	northing	
Site coordinates:	480900	7088300	*coordinates are UTM zone 8N NAD83

Component Description	Component Type	Closure Activity No. (map reference)	Closure Issue Categories					Proposed Component Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Hector 400 Level Adit	*adit*	*HC1*	sealed with insulated barrier		does not produce water			*consider for heritage*	*If Galena Hill is maintained for heritage, the Hector adit will be a major attraction and restoration will increase public safety*
Jock Shaft	*shaft*	*HC2*				shaft completely collapsed (PWGSC 2000)		*fill and cap as required*	*eliminates public safety and access issues*
Calumet "C" Structure	*open pit*	*HC3*	accessible to public	water entering H-C workings picks up high levels of contaminants	water drains into pit bottom and flows through to H-C workings			*berm perimeter (2.0 (m) high warning berm 5-10 (m) from crest of slope)*	*eliminates public safety and access issues*
Calumet 1 - 15 Pit	*open pit*	*HC4*	accessible to public	water entering H-C workings picks up high levels of contaminants	water drains into pit bottom and flows through to H-C workings	pit intersects old workings; footwall side weaker and fine-grained; subsidence in bottom of pit; tension cracks around pit; slabs coming off bench faces (2007 SRK Baseline Study)		*berm perimeter (2.0 (m) high warning berm 5-10 (m) from crest of slope); fill pit bottom with dump borrow material*	*eliminates public safety and access issues*
Calumet South Pit	*open pit*	*HC5*	accessible to public		no water noted in pit bottom	western slope of pit is unravelling extensively (2007 SRK Baseline Study)		*berm perimeter (2.0 (m) high warning berm 5-10 (m) from crest of slope)*	*eliminates public safety and access issues*
#1 Vein Pit (Hector Pit)	*open pit*	*HC6*	accessible to public	water entering H-C workings picks up high levels of contaminants	no water noted in pit; however, it is assumed that water drains into pit bottom and flows through to H-C workings	upper sides are steep, they are slabbing and unravelling; no large failures anticipated (2007 SRK Baseline Study)		*fill crown pillar and berm perimeter (2.0 (m) high warning berm 5-10 (m) from crest of slope)*	*eliminates public safety and access issues*
Trenching (4 - 11 Pit)	*open pit*	*HC7*	accessible to public	water entering H-C workings picks up high levels of contaminants	previously, all water from the top of the hill was channelled via a vein exploration trench into main crown pillar mining trench, this water likely ends up underground	no sign of shaft; crown pillar mined out (ACG 2009 field investigation)		*berm perimeter (2.0 (m) high warning berm 5-10 (m) from crest of slope); fill pit bottom with dump borrow material*	*eliminates public safety and access issues*
Hector Adit Dump	*dump*	*HC8*	there is a zone of impacted vegetation beneath the dump (PWGSC 2000; ACG 2009 field investigation) - anecdotal evidence implies that this may be the result of silt deposition from mine water released during operation	sulphur, zinc, and lead concentrations are elevated relative to most other dumps, and classification of ARD potential ranged from PAG to Uncertain (1995) to Uncertain to Non-PAG (2007); dump is large (198,000 tons; PWGSC 2000) and has the potential for significant loading to the environment - the suggestion is that porewater may reach up to 100mg/L zinc (SRK 2008 geochem study)	Sandy creek drainage may show the effects of drainage from the Hector-Calumet mine waste rock, as well as the Townsite dump; unmonitored drainages to the east of Sandy creek may be receivers of a significant portion of Hector adit loading and therefore the full extent of contamination may not be known			*pull back dump crest, reslope at least 2.5H:1V, install cover system to enhance evapotranspiration/runoff and reduce infiltration.*	*eliminates potential physical stability and chemical contamination issues*
Calumet "C" Structure Dump	*dump*	*HC9*		pit wall rock is non-potentially acid generating (SRK 2008 geochem study)				*install cover system to reduce infiltration.*	*eliminates potential physical stability and chemical contamination issues*

480000
480500
481000
481500
7083000
7082500
N

Hector 400 Level Adit Dump
HC8: (1) Cover for Revegetation
(2) Cover for Reduced Infiltration and Source Control
(3) Reclaim With No Cover

Calumet WRSA
HC10: pull back dump toe from road, reslope, cover with borrow material and revegetate; use some material as backfill for pits

Loadout
HC12: knock down and burn

Cribbing
HC13: pull down to pits road and bury in Adit Dump closure

Calumet 1-15 Pit
HC4: berm perimeter; fill pit bottom with dump borrow material

Calumet WRSA
HC10: pull back dump toe from road, reslope, cover with borrow material and revegetate; use some material as backfill for pits

Calumet South Pit
HC5: berm perimeter

Hector 400 Level Adit
HC1: consider for heritage

Powerlines
HC15: site cleanup

#1 Vein Pit (Hector Pit)
HC6: fill crown pillar and berm perimeter

#1 Vein Dump
HC11: pull back dump crest, reslope, cover with borrow material and revegetate

Buildings (3)
HC14: remove to Elsa for cleanup

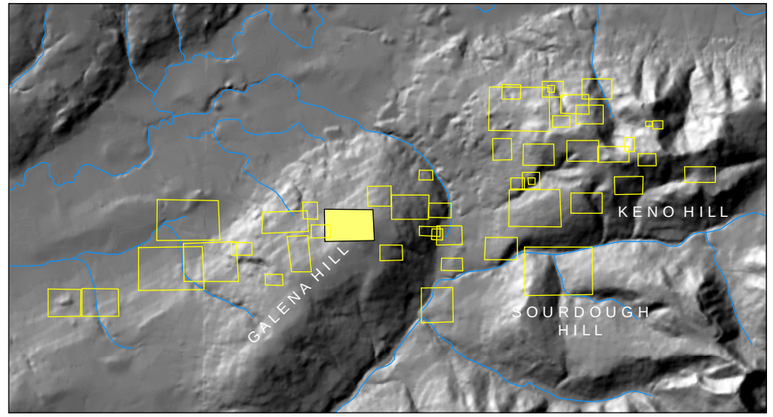
Trenching (4-11 Pit)
HC7: berm perimeter; fill pit bottom with dump borrow material

Calumet "C" Structure Dump
HC9: scarify top and revegetate

Calumet "C" Structure
HC3: berm perimeter

Jock Shaft
HC2: fill and cap

Meters
0 25 50 100 150 200



Activity Number	Hector-Calumet Mine Components and Closure Activities Rationale
HC1	*Hector 400 Level Adit* *If Galena Hill is maintained for heritage, the Hector adit will be a major attraction and restoration will increase public safety.*
HC2	*Jock Shaft* *Filling and capping the shaft will eliminate physical stability issues and increase safety.*
HC3	*Calumet "C" Structure* *The pits at the Hector-Calumet mine are generally quite large and it is neither feasible nor is it necessary to backfill them with borrow, though plentiful with the large volume of waste rock. Waste rock and pit wall rock is acid-generating (SRK 2008) and poses a chemical concern which is better managed through water diversion structures. Berming the pit will eliminate public safety and access issues while allowing water management activities to take place.*
HC4	*Calumet 1-15 Pit* *See "C" Structure.*
HC5	*Calumet South Pit* *See "C" Structure.*
HC6	*#1 Vein Pit (Hector Pit)* *See "C" Structure.*
HC7	*Trenching (4-11 Pit)* *See "C" Structure*
HC8	*Hector 400 Level Adit Dump* *See "Complex Sites" Sheet*
HC9	*Calumet "C" Structure Dump* *See Adit Dump.*
HC10	*Calumet WRSAs* *See Adit Dump.*
HC11	*#1 Vein Dump (Hector Pit Dump)* *See Adit Dump.*
HC12	*Loadout* *Removing the loadout eliminates safety issues.*
HC13	*Cribbing* *Removing the cribbing eliminates the risk of failure and ensures public safety.*

Activity Number	Hector-Calumet Mine Components and Closure Activities Rationale cont'd
HC14	*Buildings (3)* *Removing the buildings eliminates safety and physical stability issues.*
HC15	*Powerlines* *Removing the powerlines eliminates safety and physical stability issues.*

Legend

- Preferred Options
- Waste Rock Dump
- Open Pit
- Workings
- Shaft
- Adit
- Track
- Trail
- WaterCourses
- WaterBodies

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:7,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.18

Hector Calumet

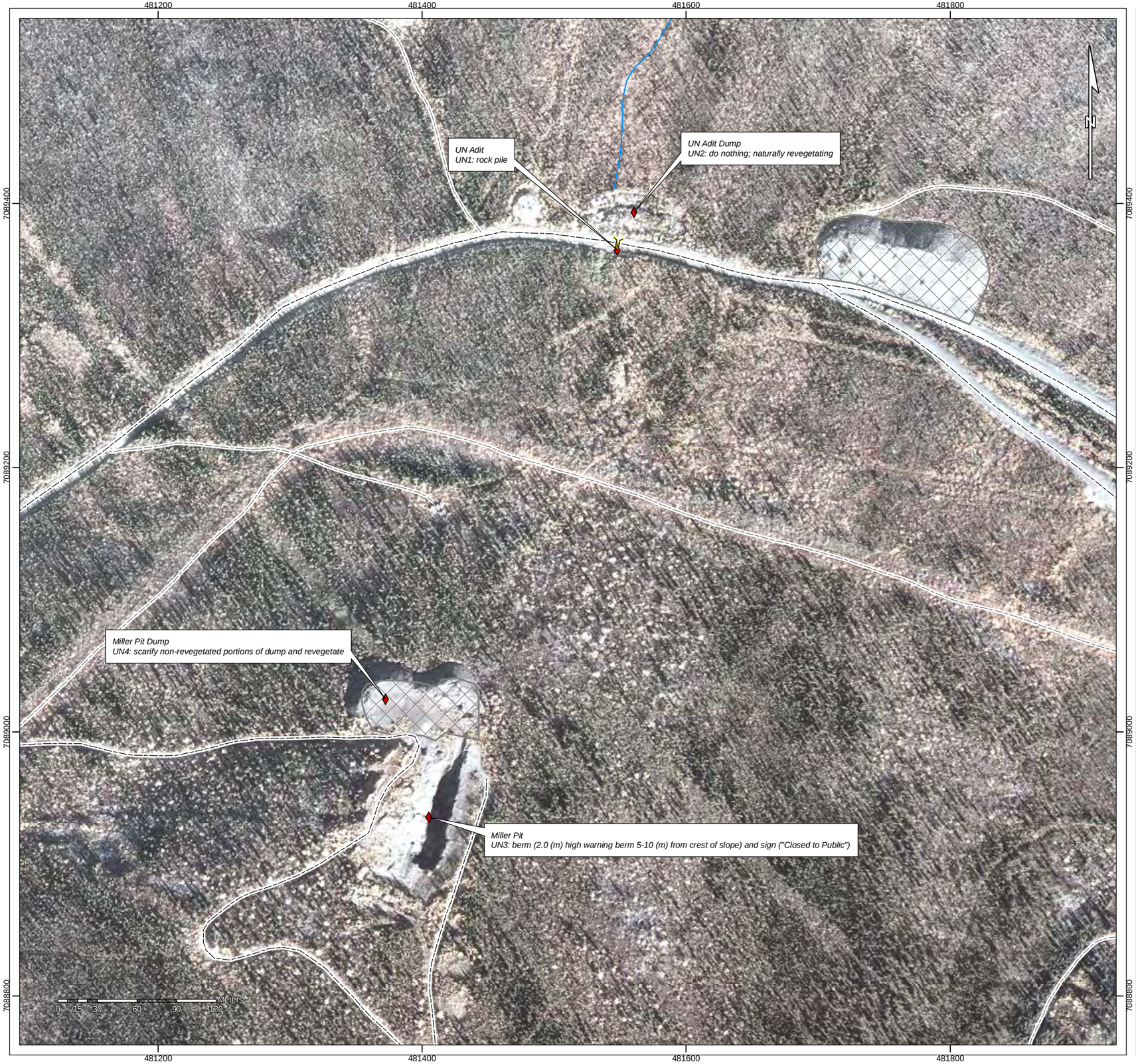
Drawn By: TL/JP

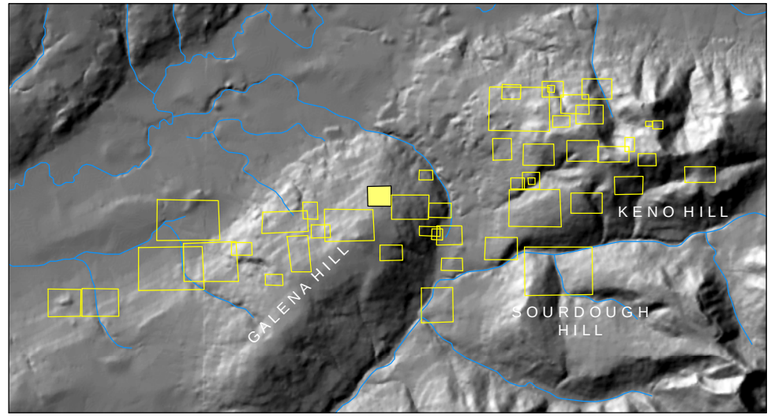
APRIL 2011

Common Site Name: **Dragon (UN) and Miller**

Site coordinates:	easting	northing	*coordinates are UTM zone 8N NAD83
	481500	7088800	

Component Description	Component Type	Closure Activity No. (map reference)	Closure Issue Categories					Proposed Component Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
UN Adit	*adit*	*UN1*		adit discharges up to 1.5mg/L Zn	produces little water (≈0.5L/sec)	adit collapsed		*rock pile closure*	*very low flow and no connection to receiving environment*
UN Adit Dump	*dump*	*UN2*	accessible to public			unknown acid-generation potential (not covered in SRK 2008 geochemical study)		*Cover and revegetate to reduce infiltration.*	
Miller Pit	*pit*	*UN3*	accessible to public					*berm (2.0 (m) high warning berm 5-10 (m) from crest of slope) and sign ("Closed to Public")*	*eliminates public safety and access issues*
Miller Pit Dump	*dump*	*UN4*	accessible to public			pit wall rock is non-potentially acid generating (SRK 2008)		*scarify non-revegetated portions of dump and revegetate*	*dump may revegetate with minimal activity*





Activity Number	UN and Miller Components and Closure Activities Rationale
UN1	*UN Adit* *Rock pile removes access to workings and allow free drainage.*
UN2	*UN Adit Dump* *Small volume of material so little concern.*
UN3	*Miller Pit* *Berm reduces public safety and access issues.*
UN4	*Miller Pit Dump* *Scarification to enhance revegetation.*

Legend

- Preferred Options
- Adit, 10
- Waste Rock Dump
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:3,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

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Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.19

Dragon (UN) and Miller

Drawn By: TL/JP

APRIL 2011

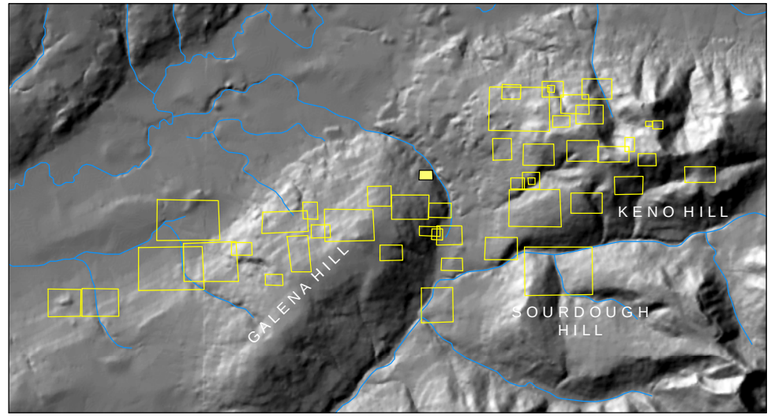
Common Site Name: **Bluebird**[1]

	easting	northing	
Site coordinates:	483031	7089792	*coordinates are UTM zone 8N NAD83

Component Description	Component Type	Closure Activity No. (map reference)	Closure Issue Categories					Proposed Component Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Building	*infrastructure*	*BB1*	some asbestos containing materials at cabin	minor oxidized vein material		building collapsed		*Remove asbestos; do nothing*	*asbestos must be removed for health and safety purposes*

1. Was not located during ACG August 2009 site visit





Activity Number	*Bluebird Components and Closure Activities Rationale*
BB1	*Bluebird Shaft #1* *Shafts are shallow and densely overgrown*
BB2	*Bluebird Shaft #2* *Shafts are shallow and densely overgrown*
BB3	*Bluebird Shaft #3* *Shafts are shallow and densely overgrown*
BB4	*Bluebird Shaft #4* *Shafts are shallow and densely overgrown*
BB5	*Building* *Asbestos must be removed for health and safety purposes*

Legend

- Preferred Options
- Shaft
- Watercourses
- Highway
- Local
- Track

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:1,500

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.20

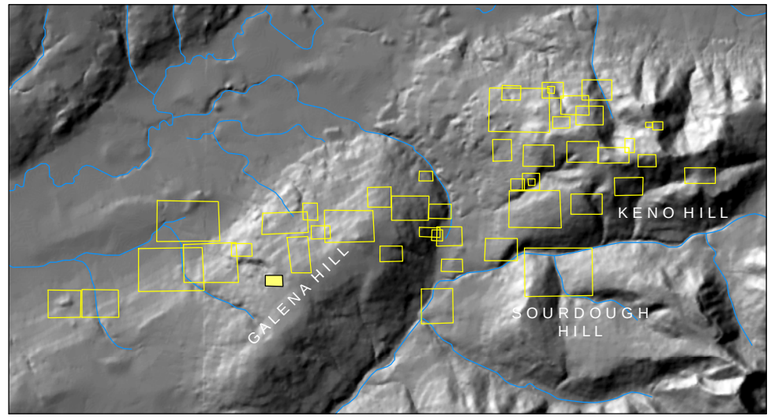
Bluebird

Drawn By: TL/JP

APRIL 2011

Component Description	Component Type	Closure Activity No. (map reference)	Closure Issue Categories					Proposed Component Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Coral and Wigwam									
Shaft #1	*shaft*		open to surface; drift visible from surface	no water	no water	subsidence near shaft		*fill*	*eliminates access and safety issues*
Shaft #2	*shaft*		collapsed; contains wooden ladder and wood and debris - may present a minor intrigue risk	no water	no water	minor subsidence near shaft; actively ravelling walls of waste rock @ angle of repose		*fill and cap as required*	*eliminates access and safety issues*
Stripping	*stripping*				trickle of seepage, reports to soil	minor depression		*do nothing*	
Betty									
Trench	*trenching*		overgrown with willows and difficult to identify		minor water collected in trench channelled towards Sandy Creek			*do nothing*	
Shallow shafts	*shaft*			exposed mineral soil in margins	standing water at bottom of both shafts	potential regressive thawing of permafrost		*fill*	*eliminates access and safety issues*
Waste Pile	*dump*		little to no vegetation ~10%	minor orange to dark brown staining				*do nothing*	
Collapsed cabin	*infrastructure*							*remove to Elsa for cleanup*	
Tin Can									
Shaft #1	*shaft*		open to surface; ground sluicing covered by dense alders		no water noted	minor subsidence; ground sluicing to east and southeast		*fill and cap as required*	*eliminates access and safety issues*
Shaft #2	*shaft*		open to surface; timber supports intact		no water noted	`		*fill and cap as required*	*eliminates access and safety issues*
Waste Pile	*dump*			orange surface staining to 0.3m; rinse pH 6.2 (SRK 2007 Baseline Report)				*do nothing*	*subject to additional verification of dump geochemistry*
Rico									
Haul road	*infrastructure*					haul road is an unmanaged mud track through the woods		*scarify portion of road, revegetate, and limit access*	
Rico Shaft	*shaft*		shaft is difficult to access from the road but marked and open					*fill and cap as required*	*eliminates access and safety issues*
Rico Adit	*adit*							*do nothing*	
Waste rock	*dump*		waste pile is overgrown with moss, lichen, heather and birch					*do nothing*	
Cabin	*infrastructure*		accessible to public			severely dilapidated		*dismantle and remove debris*	





Activity Number	Coral and Wigwam Components and Closure Activities Rationale
CW1	*Shaft #1* *Capping eliminates access and safety issues.*
CW2	*Shaft #2* *Capping eliminates access and safety issues.*
CW3	*Stripping* *No further remediation required.*

Legend

- Preferred Options
- Shaft
- Track
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:1,500

Sources:

Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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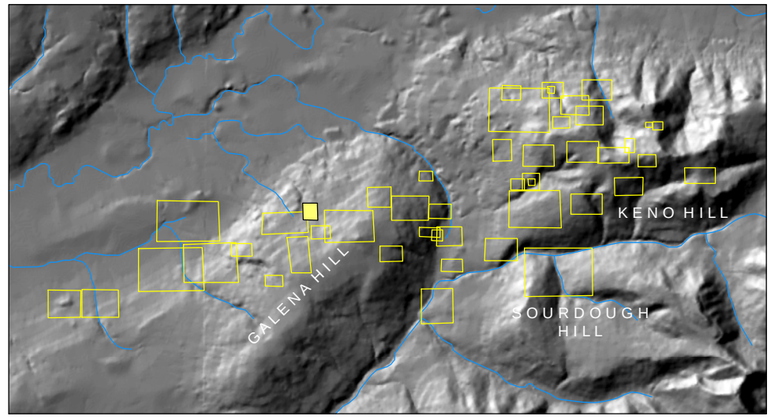
Figure 5.21

Coral and Wigwam

Drawn By: TL/JP

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479000
479200
7088800
7088600
N
Features at Betty site could not be located during 2009 site visit by ACG. Further investigation of the site required.
0 5 10 20 30 40 Meters



Activity Number	*Betty Components and Closure Activities Rationale*
Betty1	*Trench* *No further remediation required.*
Betty2	*Shallow shafts* *Filling eliminates access and safety issues.*
Betty3	*Waste Pile* *Use as fill helps to remove any geochemical concerns from waste.*
Betty4	*Collapsed cabin* *Removing eliminates safety and stability issues.*

Legend

- Preferred Options
- Shaft
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:1,500

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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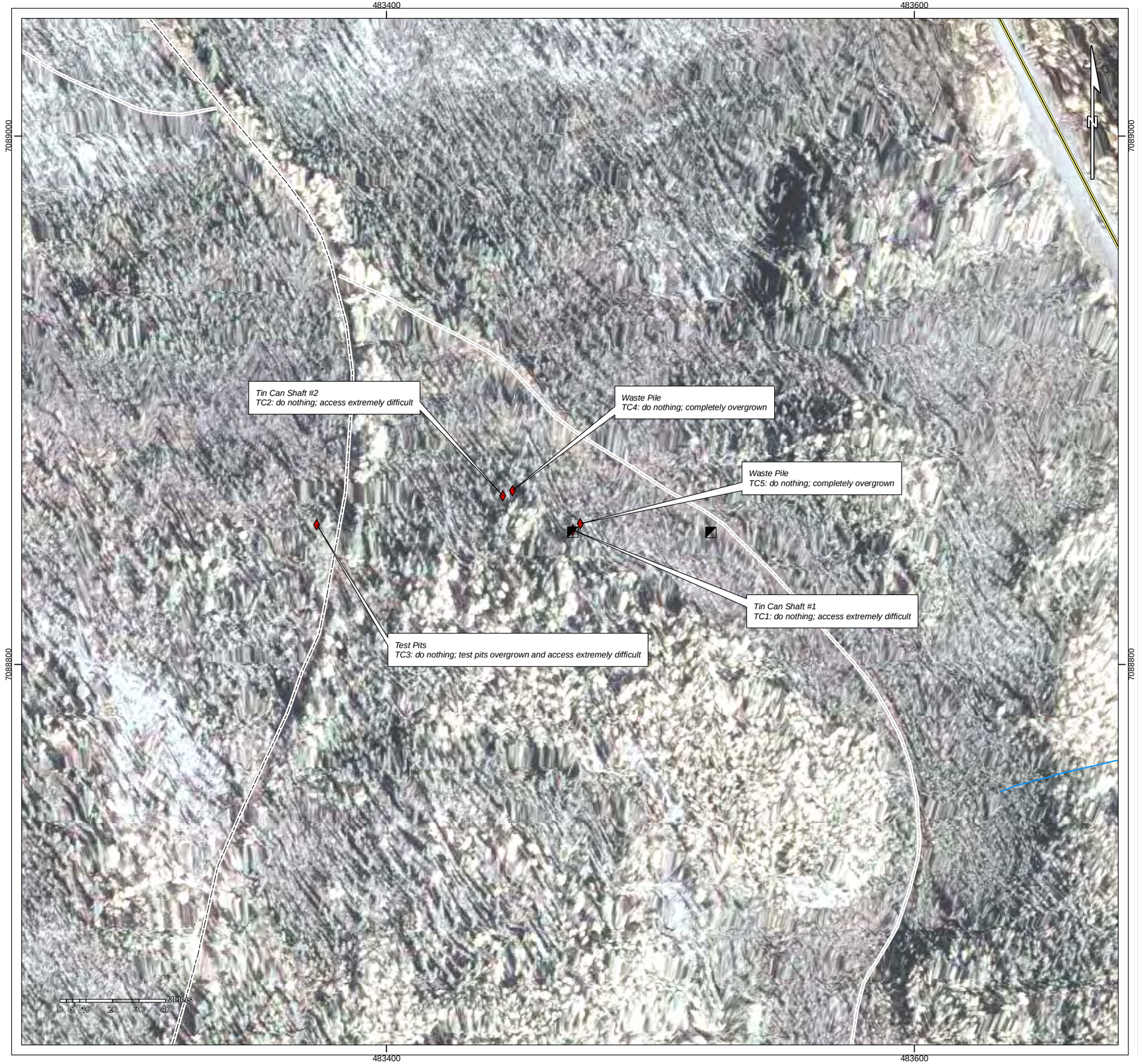
Keno Hill Silver District
Closure Options Report

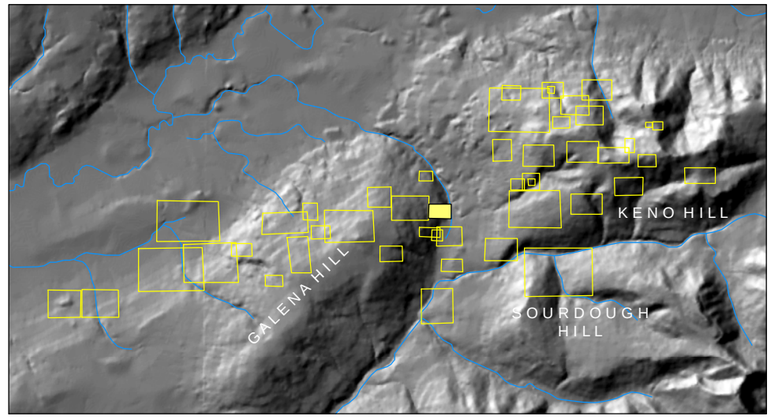
Figure 5.22

Betty

Drawn By: TL/JP

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Activity Number	Tin Can Components and Closure Activities Rationale
TC1	*Shaft #1* *Access is extremely difficult; shaft is collapsed and overgrown*
TC2	*Shaft #2* *Access is extremely difficult; shaft is collapsed and overgrown*
TC3	*Test Pits* *Access is extremely difficult; test pits are overgrown*
TC4	*Waste Pile #1* *Overgrown*
TC5	*Waste Pile #2* *Overgrown*

Legend

- Preferred Options
- Shaft
- WaterCourses
- Highway
- Local
- Track
- Trail

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:2,500

Sources:

Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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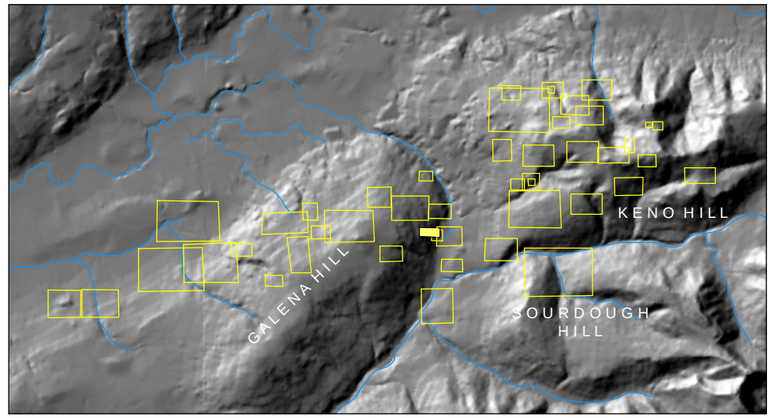
Figure 5.23

Tin Can

Drawn By: TL/JP

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Activity Number	Rico Components and Closure Activities Rationale
Rico1	*Rico Adit* *No further remediation required.*
Rico2	*Rico Shaft* *Eliminates access and safety issues*
Rico3	*Waste rock* *Dump naturally revegeted*
Rico4	*Waste rock* *Dump naturally revegeted*
Rico5	*Cabin* *Secure structure to prevent access.*

Legend

- Preferred Options
- Shaft
- Adit
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:1,000

Sources:

Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Figure 5.24

Rico

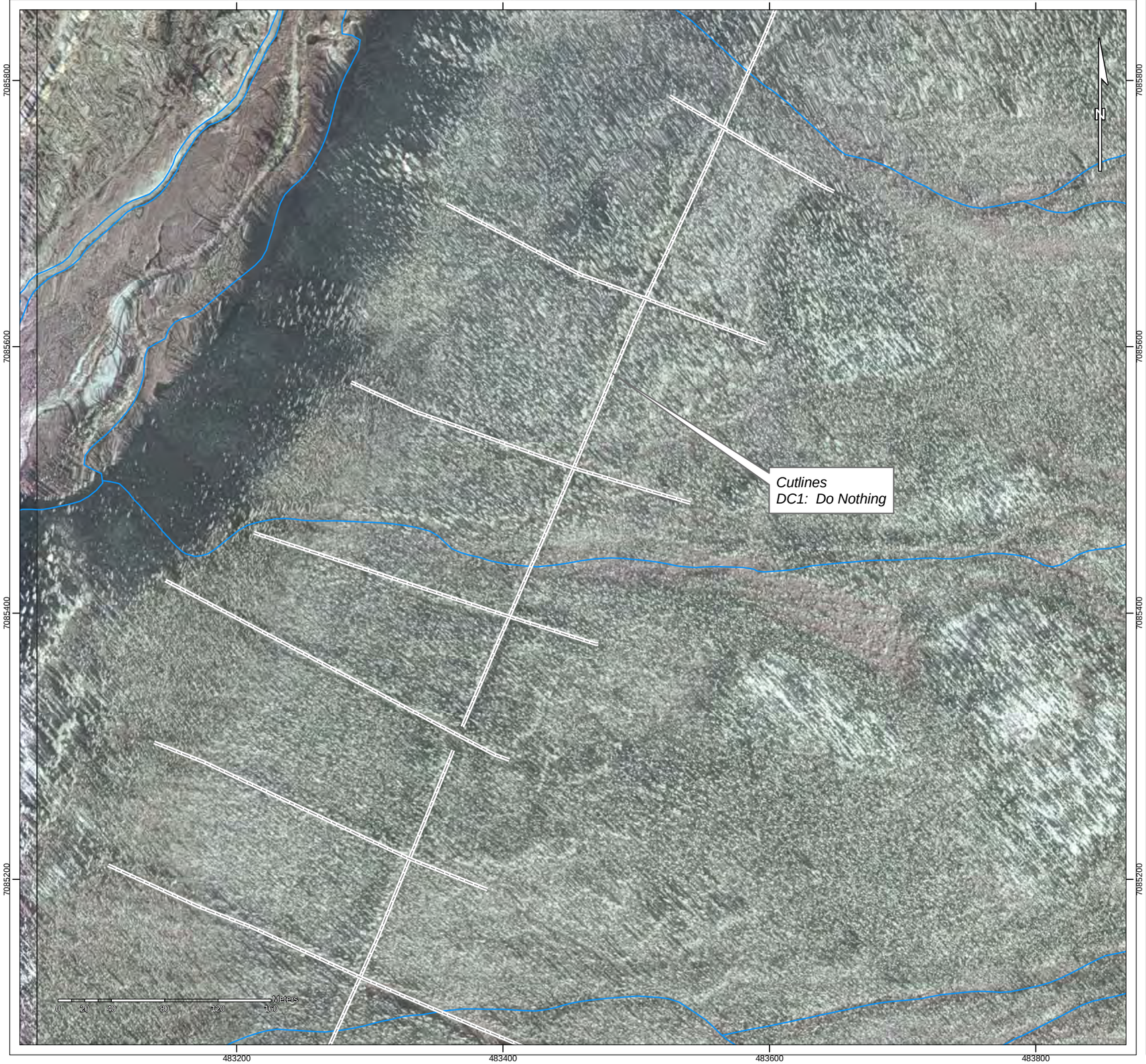
Drawn By: TL/JP

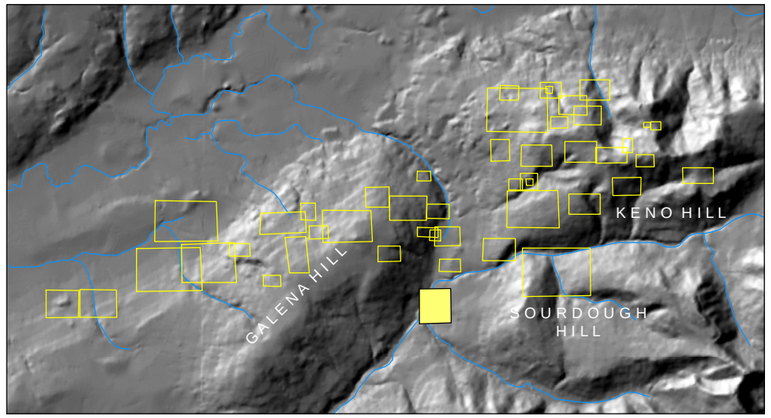
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Common Site Name: **Duncan Creek**

Site coordinates:	easting	northing	*coordinates are projected to UTM zone 8 N, Nad 1983
	483291	7085124	

General Location Description	Component Type	Closure Activity No.	Closure Issue Categories					Proposed Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Cutlines	trenching	DC1	complete revegetation of this area has occurred			no trenches have been located; however, there is indication from aerial photographs that permafrost degradation has occurred along linear depressions		*do nothing*	*access may impact area greater than leaving as is*





Activity Number	Duncan Creek Components and Closure Activities Rationale
DC1	Cutlines Remediation activities may impact area to greater extent than leaving as is

Legend

- Preferred Options
- Showing
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:3,000

Sources:

Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.25

Duncan Creek

Drawn By: TL/JP

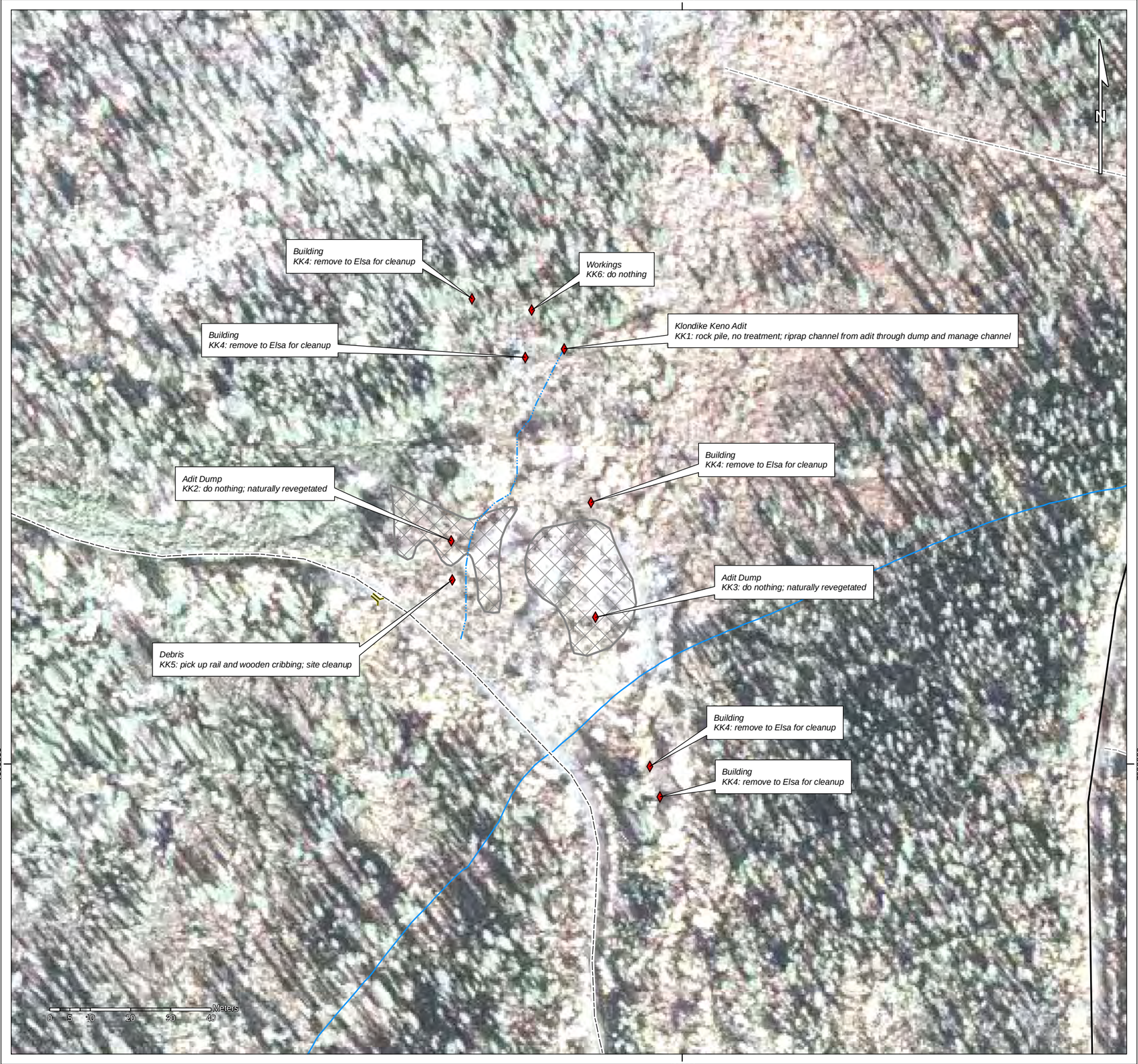
APRIL 2011

Common Site Name: **Klondike Keno**

Site coordinates:	easting	northing
	485597	7090841

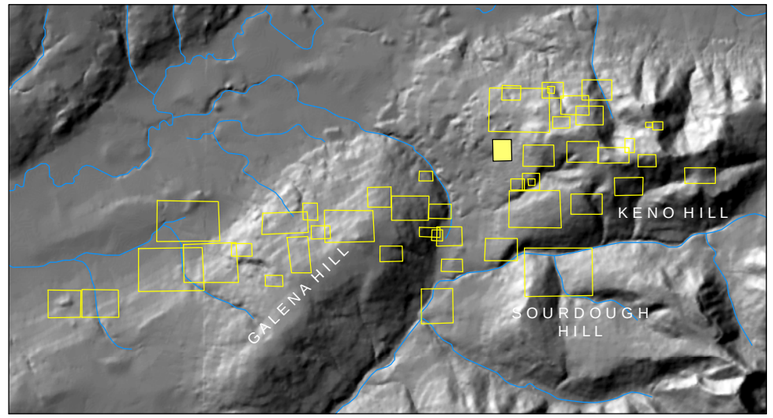
General Location Description	Component Type	Closure Activity No.	Closure Issue Categories					Proposed Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Klondike Keno Adit	*adit*	*KK1*	debris near adit portal; adit is partly open and accessible to public		adit discharges through dumps	linear depression along collapsed drift from adit		*rock pile, no treatment; riprap channel from adit through dump and manage channel*	*rock pile will eliminate access issues and allow adit to free drain*
Adit Dumps	*dump*	*KK2*	dumps are naturally revegetated	minor localized orange-staining				*do nothing; naturally revegetated*	*access to the dump is through thick vegetative cover and dumps are similarly covered; resloping would produce more disturbance than necessary*
Buildings	*infrastructure*	*KK3*	asbestos in buildings; accessible to public	buildings contain asbestos containing materials				*remove to Elsa for cleanup*	*with asbestos materials moved to Elsa, safety issues associated with hazardous materials are reduced*
Debris	*misc*	*KK4*	piping, wood and metal debris spread across site					*pick up rail and wooden cribbing; site cleanup*	*with debris removed, safety issues associated with hazardous materials are reduced*
Linear depression between collapsed portal and collapsed adit	*misc*	*KK5*				collapse is stable		*do nothing*	*collapse appears stable and thickly overgrown with vegetation*

485600



7090800

485600



Klondike Keno Mine Components and Closure Activities Rationale

KK1 *Klondike Keno Adit*
Rock pile will eliminate access issues and allow adit to free drain.

KK2 *Adit Dump*
Access to the dump is through thick vegetative cover and dumps are similarly covered; resloping and work on the dumps would produce more disturbance than necessary.

KK3 *Buildings*
With asbestos materials moved to Elsa, safety issues associated with hazardous materials are reduced.

KK4 *Debris*
With deris removed, safety issues associated with hazardous materials are reduced.

KK5 *Water Management*
Discharge from the adit is currently free-flowing and scours the dump. An engineered riprap channel is required to avoid the dump toe and manage drainage pathway.

KK6 *Workings*
Collapse appears stable and thickly overgrown with vegetation.

Legend

- Preferred Options
- Waste Rock Dump
- Adit
- WaterCourses
- Local
- Track
- Trail

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:1,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.26

Klondike Keno

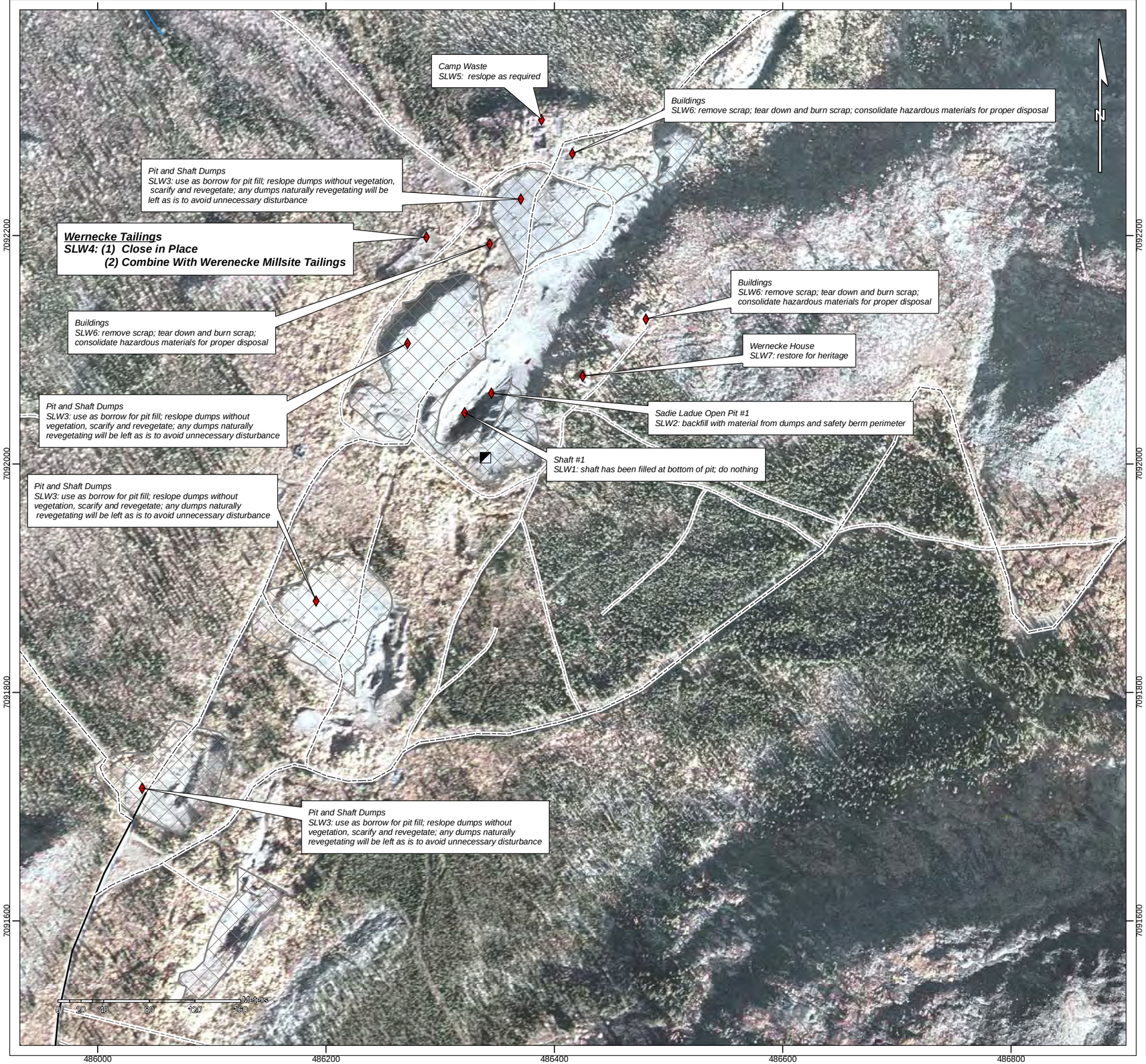
Drawn By: TL/JP

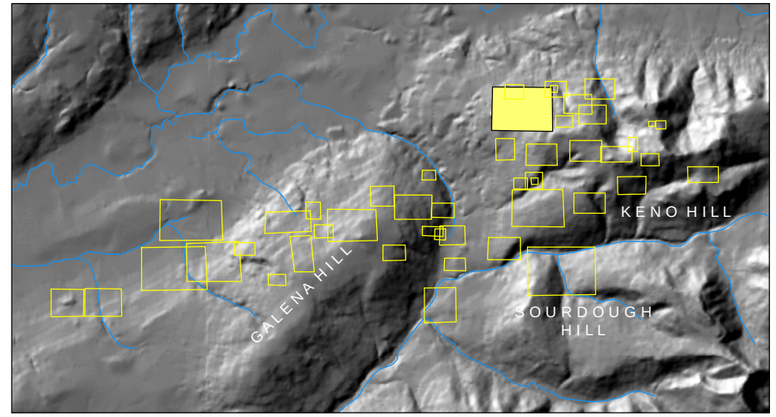
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Common Site Name: **Sadie Ladue (Wernecke)**

Site coordinates: easting northing

General Location Description	Component Type	Closure Activity No.	Closure Issue Categories					Proposed Closure Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Sadie Ladue Shaft	*shaft*	*SLW1*				shaft is filled at bottom of pit			
Sadie Ladue Open Pit	*open pit*	*SLW2*						*backfill with material from dumps and safety berm perimeter*	
Sadie Ladue Pit and Shaft Dumps	*dump*	*SLW3*						*use as borrow for pit fill; reslope dumps without vegetation, scarify and revegetate; any dumps naturally revegetating will be left as is to avoid unnecessary disturbance*	
Tailings	*tailings*	*SLW4*			visible gullying			*See "Complex Sites" sheet*	
Rock Piles	*waste*	*SLW5*							
Infrastructure	*infrastructure*	*SLW6*				buildings on the site are partially or fully collapsed; debris remains an issue	the old mill infrastructure remains and is in poor condition	*remove scrap; tear down and burn scrap; consolidate hazardous materials for proper disposal*	
Wernecke House	*infrastructure*	*SLW7*	during the Wernecke House restoration, the house is unstable and easily accessible to the public				Wernecke House is currently being undergoing restoration by the citizens of Keno City; may be considered heritage	*restore for heritage*	





Activity Number	Sadie Ladue Werenecke Components and Closure Activities Rationale
SLW1	Sadie Ladue Shaft Included in pit closure
SLW2	Sadie Ladue Open Pit Backfilling and berming reduce infiltration and metal leaching.
SLW3	Sadie Ladue Pit and Shaft Dumps Resloping to ensure stability; scarification to promote revegetation.
SLW4	Tailings See "Complex Sites" sheet
SLW5	Rock Piles Reslope to ensure stability
SLW6	Infrastructure Removing eliminates safety and stability issues
SLW7	Wernecke House Ongoing Restoration Project

Legend

- Preferred Options
- Adit
- Structures
- Track
- Waste Rock Dump
- Trail
- Shaft
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:3,500

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Figure 5.27

Sadie Ladue/Wernecke

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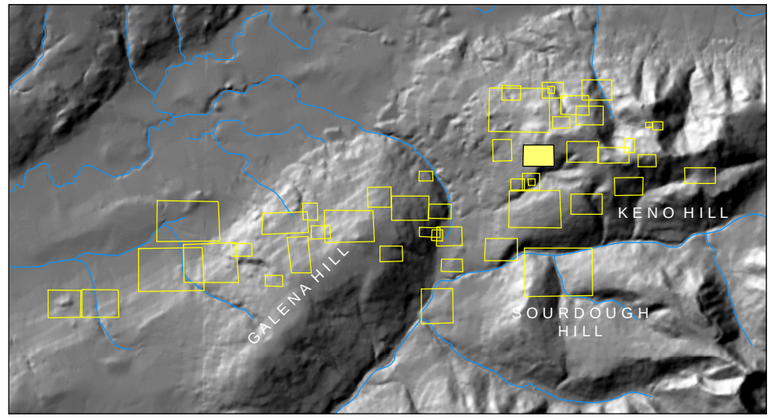
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Common Site Name: **Lucky Queen Adit/Black Cap**

Site coordinates:	easting	northing
	486877	7090633

General Location Description	Component Type	Closure Activity No.	Closure Issue Categories					Proposed Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Lucky Queen Adit Area									
Lucky Queen 500 Adit	*adit*	*LQA1*	portal was completely dismantled by vandals (inspected 2006); site is easily accessible			timber support and rock at portal are collapsed and rock piled	vandalism	*existing rock pile (check stability and upgrade if necessary) and revegetate*	
Lucky Queen 500 Adit Dump	*dump*	*LQA2*			dumps are high above the treeline, dry and unvegetated			*pull back, scarify and naturally revegetate*	
Black Cap Adit Area									
Brewis Adit	*adit*	*BC1*						*improve condition of existing rock pile*	
Black Cap Adit	*adit*	*BC2*		water chemistry being verified	adit discharges water at a rate of ≈1L/sec			*existing rock pile; verify chemistry @ adit and if necessary install passive treatment system*	
North Black Cap Pit	*open pit*	*BC3a*						*berm perimeter*	
South Black Cap Pits	*open pit*	*BC3b*						*berm perimeter*	
Black Cap Adit and Pit Dumps	*dump*	*BC4a through BC4d*			dumps are high above the treeline, dry and unvegetated			*pull back, scarify (or reslope depending on nature of toe), no revegetation (altitude is too high and dumps are too expansive for growth)*	*the large size of the Black Cap dumps and their elevation above the treeline prevents ability to revegetate*
Loadout	*dump*	*BC5*						*knock down and burn wood; reslope as required*	
Rail Lines	*infrastructure*	*BC6*	accessible to public					*salvage*	
Debris	*misc*	*BC7*	accessible to public; potential for asbestos containing materials (ACM)			`		*site cleanup, pull out utilidors and remove scrap; consolidate and landfill any ACM*	





Activity Number	Black Cap/Lucky Queen Adit Mine Components and Closure Activities Rationale
LQA1	*Lucky Queen 500 Adit* *The portal to the workings was completely dismantled by vandals in 2006, highlighting that the site is easily accessible and vandalism is a concern.Timber and rock the portal are mostly collapsed into a rock pile. Checking the stability of the current rock pile and upgrading if necessary will prevent future access and increase safety.*
LQA2	*Lucky Queen 500 Adit Dump* *Because the dump is near the treeline and with little moisture, there is little value in actively vegetating the dump surface. The dump is of low geochemical concern. By pulling back the crest and scarifying the dump, any vegetation that can naturally grow in this high-altitude area will be able to do without a cover.*
BC1	*Brewis Adit* *Improving the condition of the existing rock pile will improve physical stability and continue to prevent access.*
BC2	*Black Cap Adit* *The adit discharges water of unknown quality. A bioreactor may be necessary as contingency treatment if water is found to be contaminated. The existing rock pile will continue to prevent access.*
BC3/4	*North and South Black Cap Pits* *Berming pit perimeters and erecting signs will improve safety conditions and prevent access.*
BC5	*Black Cap Adit and Pit Dumps* *Because the dumps are above the treeline and with little moisture, there is little value in actively vegetating the dump surfaces. The dumps are of low geochemical concern. Pulling back the crests and resloping where necessary will make the dumps physically stable. Vegetation is unlikely to be able to grow on the surfaces.*
BC6	*Loadout* *The loadout structure is deteriorating and is a hazard. Knocking down and burning the loadout will eliminate physical safety issues.*
BC7	*Rail lines* *Removing and salvaging where possible will eliminate safety/vandalism issues.*
BC8	*Debris* *Removing debris to a dump site will eliminate safety/vandalism issues.*

Legend

- Preferred Options
- Open Pit
- Waste Rock Dump
- Adit
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:3000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Figure 5.28

Black Cap and Lucky Queen Adit Area

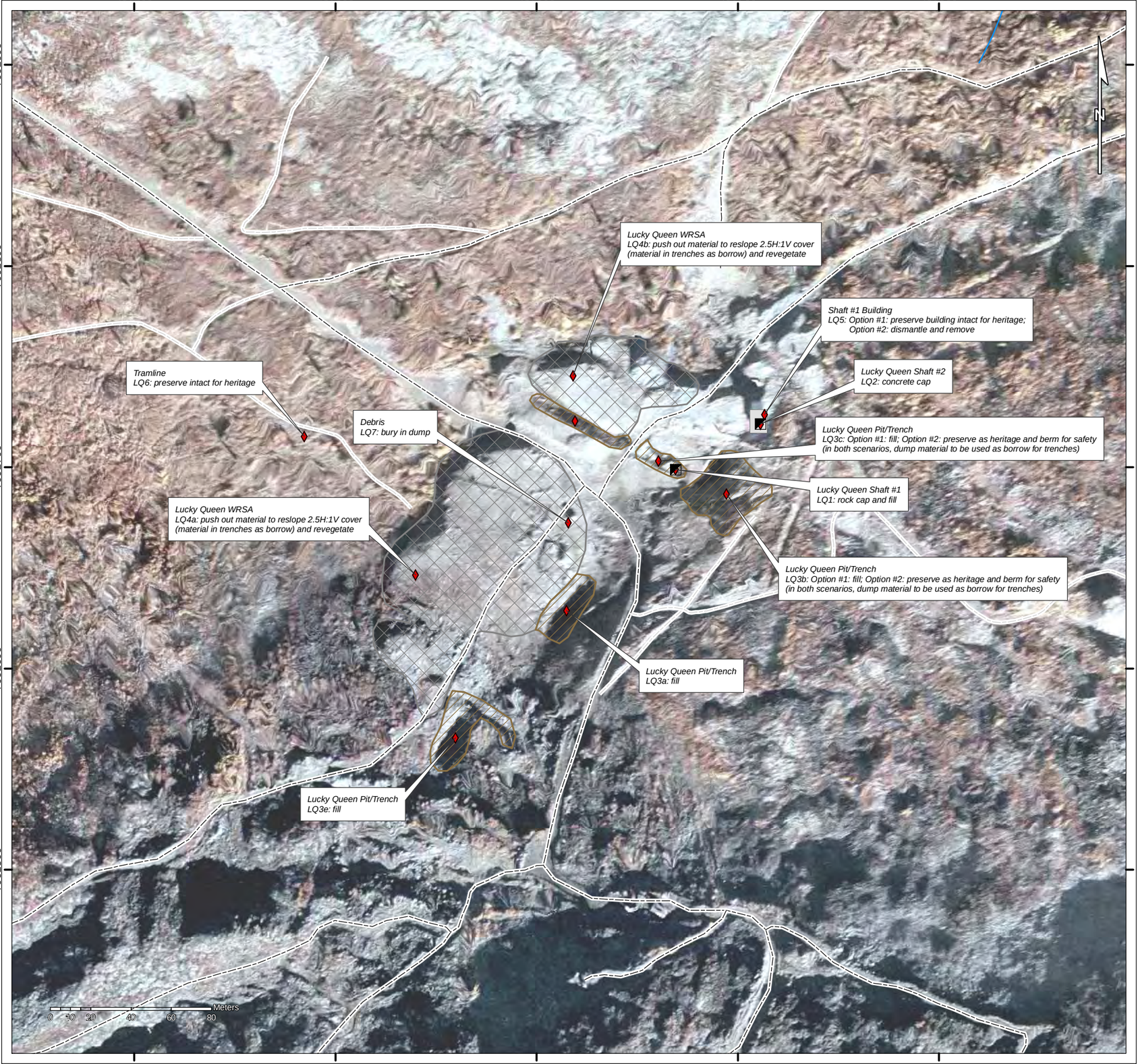
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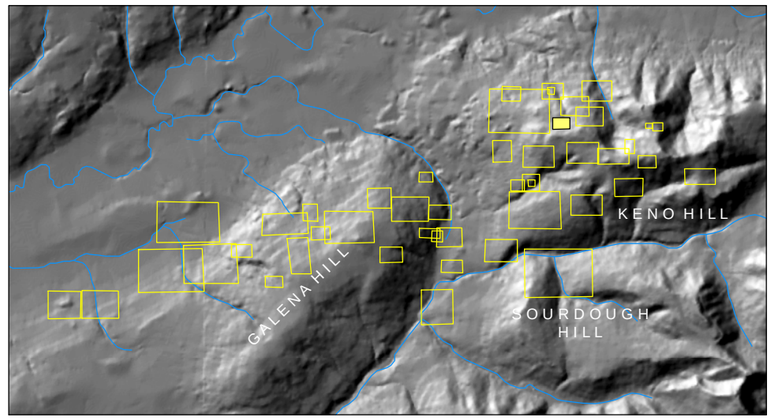
APRIL 2011

Common Site Name: **Lucky Queen**

Site coordinates:	easting	northing
	486577.07	7090560.84

General Location Description	Component Type	Closure Activity No.	Closure Issue Categories					Proposed Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Lucky Queen Shaft #1	*shaft*	*LQ1*	easily accessible		does not produce water			*concrete cap*	
Lucky Queen Shaft #2	*shaft*	*LQ2*	collapsed and inaccessible; open for roughly a metre		shaft is producing water			*rock cap and fill*	
Pits and Trenches	*open pit*	*LQ3a through LQ3e*			shaft #2 is producing water and pooling in trenches (has spilled over roadway in the past)	pits and trenches appear to be stable		*Option #1: fill; Option #2: preserve as heritage and berm for safety (in both scenarios, trench material to be used as borrow for dumps)*	
WRSAs	*dump*	*LQ4*						*push out material to reslope 2.5H:1V cover (material in trenches as borrow) and revegetate*	
Shaft #1 Building	*infrastructure*	*LQ5*	easily accessible			building and timber hoist support structure are both in good condition	shaft building may be considered heritage	*dismantle and remove*	
Tramline	*infrastructure*	*LQ6*					potential heritage interest	*dismantle and burn*	
Debris	*misc*	*LQ7*						*bury in dump*	





Activity Number	Lucky Queen Shaft Area Components and Closure Activities Rationale
LQ1	*Lucky Queen Shaft #1* *Although the shaft does not produce water, to prevent access and saftey issues, a concrete cap will be emplaced over the shaft opening.*
LQ2	*Lucky Queen Shaft #2* *This shaft is collapsed and inaccessible; however, it is open for roughly a meter and produces non-contaminated water. To eliminate safety issues, rock fill will be inserted into the open portion of the shaft.*
LQ3	*Pit and Trenches* *Access to the pits and trenches at this site will be inhibited through either the use of safety berms or backfilled.*
LQ4	*WRSAs* *These dumps were not addressed in the SRK geochemical study, however; they will be resloped, covered with material from the trenches and revegetated. By doing this, any potential geochemical concerns will be mitigated.*
LQ5	*Shaft #1 Building* *Although this building was built in th 1980s, it may be retained for heritage purposes (one of the benefits of doing so is that it is in relatively good condition). If it is not retained, it will be dismantled and removed to prevent safety issues and vandalism.*
LQ6	*Tramline* *The tramline is in good condition and will be preserved and improved for its heritage value.*
LQ7	*Debris* *To eliminate safety concerns, all site debris will be buried in the dumps during dump closure.*

Legend

- Preferred Options
- Waste Rock Dump
- Open Pit/Trench
- Structures
- Shaft
- Track
- Trail
- Watercourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:2,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.29

Lucky Queen Shaft Area

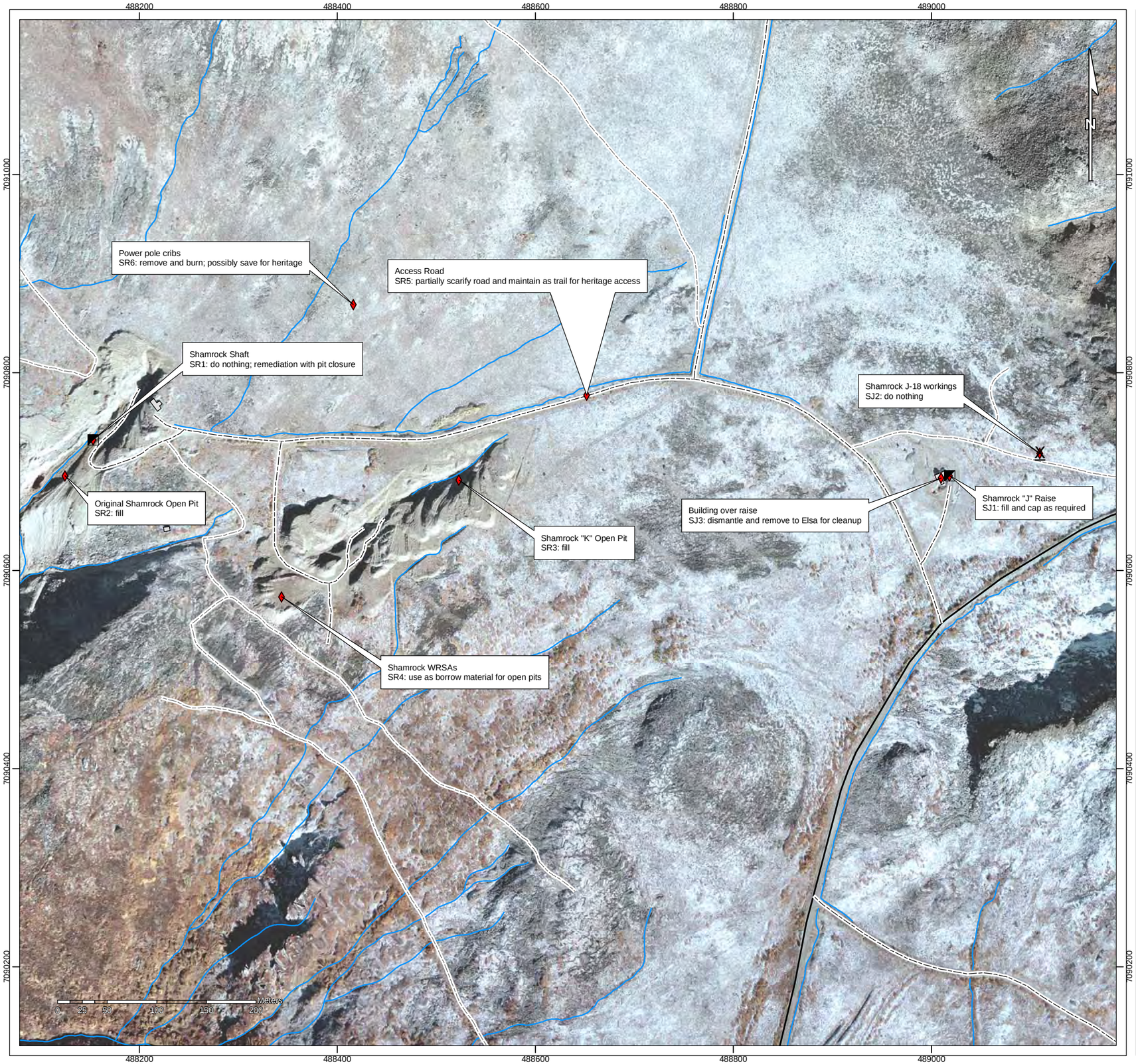
Drawn By: TL/JP

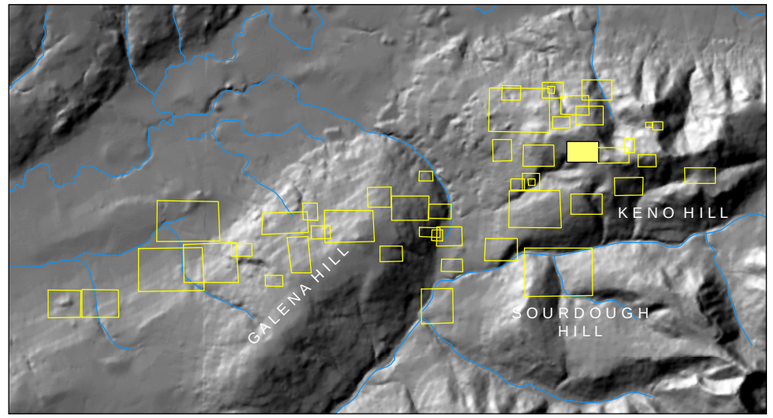
APRIL 2011

Common Site Name: **Shamrock**

Site coordinates:	easting	northing
	488018	7090536

General Location Description	Component Type	Closure Activity No.	Closure Issue Categories					Proposed Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Shamrock J-18 Mine									
Shamrock "J" Raise	*shaft*	*SJ1*	shaft is open					*fill and cap as required*	*eliminates access issues*
Shamrock Workings	*workings*	*SJ2*				no subsidence observed		*do nothing*	*no further inspection required*
Building over raise	*infrastructure*	*SJ3*	buildings are accessible to public					*dismantle and remove to Elsa for cleanup*	*Buildings will be buried in Elsa, a central landfill approved for asbestos material*
Shamrock									
Shamrock Shaft	*shaft*	*SR1*	shaft is located at bottom of open pit and is filled with waste rock; no access		no water has been noted	shaft is filled		*do nothing; remediation with pit closure*	*will be covered with pit borrow*
Original Shamrock Open Pit	*open pit*	*SR2*	pit is accessible off of main road			pits and trenching appear stable		*fill*	*reduces accessibility and safety hazards and creates better aesthetic*
Shamrock "K" Open Pit	*open pit*	*SR3*	pit is accessible off of main road and open on one end to a steep slope			pits and trenching appear stable		*fill*	*reduces accessibility and safety hazards and creates better aesthetic*
Shamrock WRSAs	*dump*	*SR4*		characterized as non-potentially acid-generating (SRK 2008 geochem study)				*use as borrow material for open pits*	*eliminates waste rock piles*
Access Road	*infrastructure*	*SR5*	access road provides easy access to open pits				may wish to maintain some sort of access to the area for heritage value	*partially scarify road and maintain as trail for heritage access*	*provides access for sites in heritage plan*
Power pole cribs	*infrastructure*	*SR6*					cribbing is dilapidated; potentially salvageable for heritage	*remove and burn; possibly save for heritage*	*possible heritage value*





Activity Number	Shamrock Components and Closure Activities Rationale
SJ1	*Shamrock "J" Raise* *Filling and capping eliminates access issues*
SJ2	*Shamrock Workings* *No further remediation required*
SJ3	*Building over raise* *Buildings will be buried in Elsa, a central landfill approved for asbestos material*
SR1	*Shamrock Shaft* *Covered during pit infilling*
SR2	*Original Shamrock Open Pit* *Reduces accessibility and safety hazards and creates better aesthetic*
SR3	*Shamrock "K" Open Pit* *Reduces accessibility and safety hazards and creates better aesthetic*
SR4	*Shamrock WRSAs* *Eliminates waste rock piles*
SR5	*Access Road* *Provides access for sites in heritage plan*
SR6	*Power pole cribs* *Possible heritage value*

Legend

- Preferred Options
- Shaft
- Showing
- Structures
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:4,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.30

Shamrock

Drawn By: TL/JP

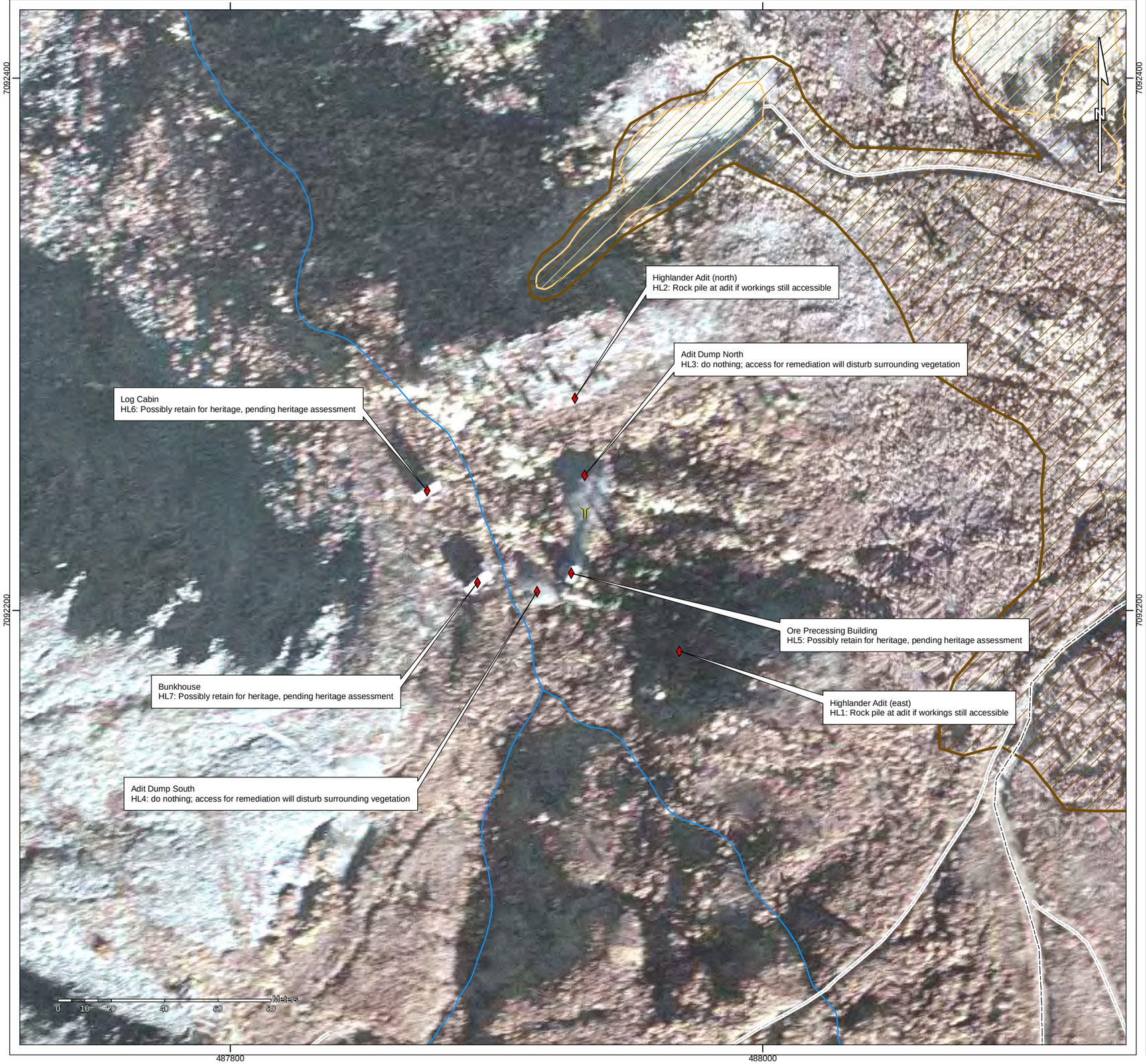
APRIL 2011

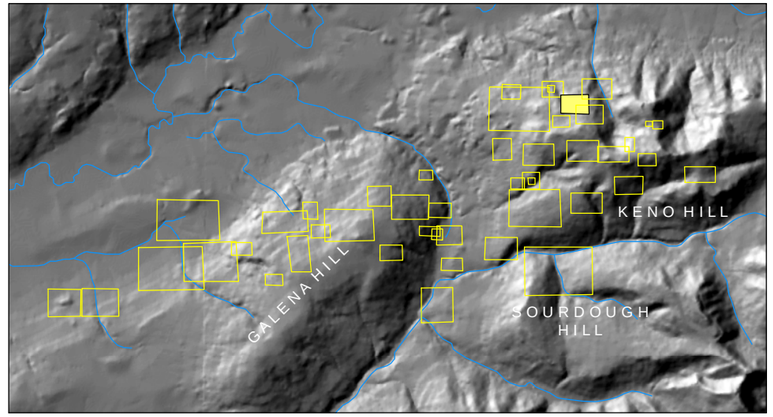
Common Site Name: **Highlander**

	easting	northing
Site coordinates:	487933.00	7092237.00

General Location Description	Component Type	Closure Activity No.	Closure Issue Categories					Proposed Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Adit - east of Gambler gulch and south of pit	*adit*				SRK 2007 Baseline Report notes adit is producing water @2L/min - water clear and colourless with no precipitates or staining. Other ACG inspections have shown flows to be ephemeral in nature			*do nothing*	
Adit - north of Highlander-WR-1 pit[1]									
Adit Dumps (north)	*dump*			very small dumps with little or no vein material; no orange staining observed (SRK 2007 Baseline Report)				*do nothing*	
Adit Dump (south)	*dump*			very small dump with little vein material				*do nothing*	
Collapsed cabin	*infrastructure*		accessible to public					*do nothing*	

1. Could not locate during site visit in August 2009





Activity Number	*Highlander Components and Closure Activities Rationale*
HL1	*Adit - east of Gambler gulch and south of pit* *Rock pile prevents access to workings.*
HL2	*Adit - north of Highlander-WR-1 pit1* *Rock pile prevents access to workings.*
HL3	*Adit Dumps (north)* *No further remediation required*
HL4	*Adit Dump (south)* *No further remediation required*
HL5	*Ore processing building* *Possibly retain for heritage, pending heritage assessment*
HL6	*Wood frame cabin* *Possibly retain for heritage, pending heritage assessment*
HL7	*Wood fram bunkhouse* *Possibly retain for heritage, pending heritage assessment*

Legend

- Preferred Options
- Structures
- Waste Rock Dump
- Trenching
- Disturbance
- Adit
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:1,500

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Keno Hill Silver District
Closure Options Report

Figure 5.31

Highlander

Drawn By: TL/JP

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Common Site Name: **Cub and Bunny**

Site coordinates:	easting	northing
	488540.00	7091951.00

General Location Description	Component Type	Closure Activity No.	Closure Issue Categories					Proposed Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Adit	*adit*	*CB1*						*adit is collapsed and inaccessible, does not produce water; do nothing*	
Open Pit/Trench	*trenching*	*CB2*			some trenches collect and channel water; all are overgrown			*do nothing; naturally revegetated*	
Clearing, Stripping, Trenching	*trenching*	*CB3*	extensive area of disturbance with partial natural vegetative overgrowth					*do nothing; naturally revegetated*	
Trails	*infrastructure*	*CB4*	trails are overgrown and obscured					*do nothing*	
Buildings	*infrastructure*	*CB5a and CB5b*				cabins are dilapidated		*do nothing*	
Metal Debris	*misc*	*CB6*	oxidized metal debris found near adit					*pick up debris and remove from site to consolidated garbage dump in Elsa*	

488000 488200 488400 488600

7092400 7092200 7092000 7091800

N

Area of Trenching/Stripping
CB3: do nothing; naturally revegetated

Cabin #1
CB5a: do nothing

Cabin #2
CB5b: do nothing

Area of Trenching/Stripping
CB3: do nothing; naturally revegetated

Trails
CB4: do nothing

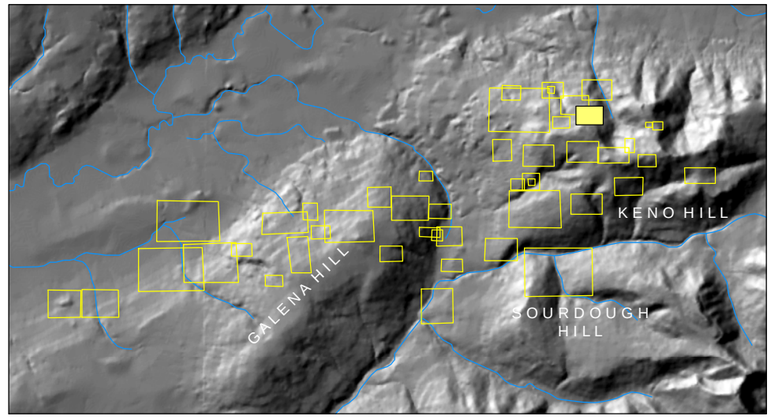
Open Pit/Trench
CB2: do nothing; naturally revegetated

Metal Debris
CB6: pick up debris and remove from site to consolidated garbage dump

Area of Trenching/Stripping
CB3: do nothing; naturally revegetated

Cub and Bunny Adit
CB1: adit is collapsed and inaccessible, does not produce water; do nothing

Meters
0 20 40 80 120 160



Activity Number	*Cub and Bunny Mine Components and Closure Activities Rationale*
CB1	*The adit is fully collapsed and does not produce water; no closure activities are required.*
CB2	*This pit has minor dark brown vein staining but does not pose a geochemical risk. It is naturally revegetating and appears stable.*
CB3	*Disturbances caused by trenching are naturally revegetated. Ponding in some trenches occurs but is not a problem. No activities are necessary.*
CB4	*The trails are mostly overgrown hummocks with no perceptible use; no closure activities are required*
CB5	*As the buildings are highly inaccessible with overgrowth of both the trails and buildings themselves, there is no value in disrupting the vegetation to access and remove the debris*
CB6	*By manually picking up and removing the metal debris scattered around the site, there will be little disturbance to the area and safety and geochemical risks posed by the metal will be mitigated.*

Legend

- Preferred Options
- Adit
- Waste Rock Dump
- Track
- Trenching
- Trail
- Disturbance
- WaterCourses
- Structures

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:3,500

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.32

Cub and Bunny

Drawn By: TL/JP

APRIL 2011

Common Site Name: **Keno 200 Area**

Site coordinates: easting northing

General Location Description	Component Type	Closure Activity No.	Closure Issue Categories					Proposed Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Keno 200 Adit	*adit*	*K200_1*	adit structure accessible to public					*existing rock pile; do nothing*	
Porcupine Adit	*adit*	*K200_2*	building has asbestos containing materials					*remove building and ACM materials; rock pile adit entrance*	*asbestos materials to be collected for disposal*
Comstock Adit	*adit*	*K200_3*	adit structure accessible to public		may be producing water			*remove adit building, rock pile*	
Keno 200/Porcupine Pit	*pit*	*K200_4*	highwall is accessible to public; no berms			adit daylighting to pit is collapsed		*berm highwall*	
Porcupine Shaft	*shaft*	*K200_5*						*rock cap and fill*	
Keno 200 WRSA	*dump*	*K200_6*		waste rock shows no surface staining; unknown acid-generation potential (not covered in SRK 2008 geochemical study)				*revegetate*	
Porcupine WRSA	*dump*	*K200_7*		waste rock shows no surface staining; unknown acid-generation potential (not covered in SRK 2008 geochemical study)				*reslope and revegetate*	
Comstock WRSA	*dump*	*K200_8*		waste rock shows no surface staining; unknown acid-generation potential (not covered in SRK 2008 geochemical study)				*reslope and revegetate*	
Porcupine Loadout	*dump*	*K200_9*						*remove and burn wood; reslope as required*	
Comstock Loadout	*dump*	*K200_10*						*remove and burn wood; reslope as required*	
Keno 200 rail and cars	*infrastructure*	*K200_11*						*remove existing rail and reconstruct tracks and example rail cars for heritage*	
Buildings	*infrastructure*	*K200_12*	some buildings contain asbestos containing materials					*remove buildings, including those over adit and shaft structures; possibly retain Keno 200 adit structure and garage at Comstock Adit for possible heritage*	
Debris	*misc*	*K200_13*	accessible to public					*remove from site to Elsa*	

489400 489600 489800 490000

7090200 7090000 7089800

Building
K200_12c: remove buildings, including those over adit and shaft structures; possibly retain Keno 200 adit structure and garage at Comstock Adit for possible heritage

Building
K200_12a: remove buildings, including those over adit and shaft structures; possibly retain Keno 200 adit structure and garage at Comstock Adit for possible heritage

Keno 200 Adit
K200_1: existing rock pile; do nothing

Porcupine Shaft
K200_5: rock cap and fill

Porcupine Pit
K200_4: berm highwall

Comstock Adit
K200_3: remove adit building, rock pile

Keno 200 WRSA
K200_6: revegetate

Debris
K200_13: remove from site to Elsa

Comstock Dump
K200_8: reslope and revegetate

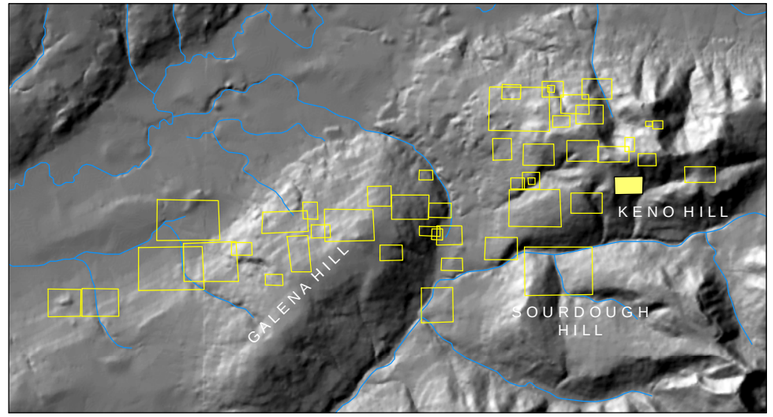
Porcupine Loadout
K200_9: remove and burn wood; reslope as required

Rail and cars
K200_11: remove existing rail and reconstruct tracks and example rail cars for heritage

Porcupine WRSA
K200_7: reslope and revegetate

N

0 15 30 60 90 120 Meters



Activity Number	*Keno200 Mine Components and Closure Activities Rationale*
K200_1	*Keno 200 Adit* *No further remediation required*
K200_2	*Porcupine Adit* *Removing eliminates safety and stability issue. Rock pile prevents access to workings.*
K200_3	*Comstock Adit* *Removing eliminates safety and stability issue. Rock pile prevents access to workings*
K200_4	*Keno 200/Porcupine Pit* *Berm is for safety*
K200_5	*Porcupine Shaft* *Filling and capping the shaft will eliminate intrigue risk and access to workings.*
K200_6	*Keno 200 WRSA* *Resloping and revegetation to ensure dump stability*
K200_7	*Porcupine WRSA* *Resloping and revegetation to ensure dump stability*
K200_8	*Comstock WRSA* *Resloping and revegetation to ensure dump stability*
K200_9	*Porcupine Loadout* *Removing and resloping eliminates safety and stability issues*
K200_10	*Comstock Loadout* *Removing and resloping eliminates safety and stability issues*
K200_11	*Keno 200 rail and cars* *Items have some heritage value and do not present a safety risk*
K200_12a - thru 12c	*Buildings* *Items have some heritage value and do not present a safety risk*
K200_13	*Debris* *Removing eliminates safety and stability*

Legend

- Preferred Options
- Structures
- Waste Rock Dump
- Shaft
- Adit
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:3,500

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.33

Keno 200

Drawn By: TL/JP

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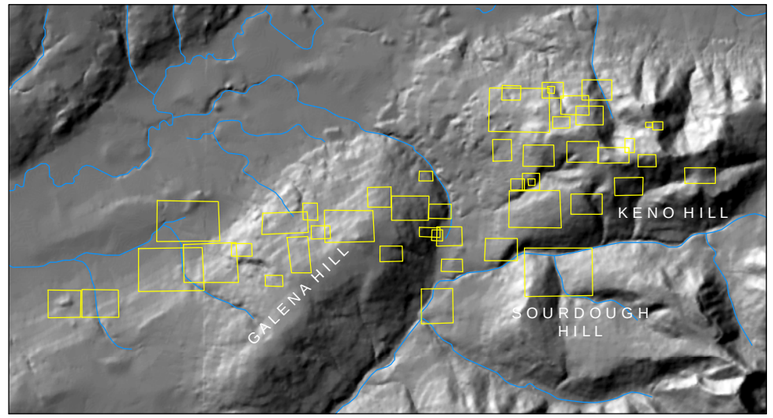
Common Site Name: **5-2 Adit**

Site coordinates: easting northing

General Location Description	Component Type	Closure Activity No.	Closure Issue Categories					Proposed Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
5-2 Adit	*adit*	*5-2Adit-1*			adit producing water ≈0.25L/sec			*existing rock pile; do nothing*	
No. 4 Lower Adit[1]	*adit*	*5-2Adit-2*						*do nothing*	
Unknown Shaft near 5-2 Adit	*shaft*	*5-2Adit-3*			shaft contains shallow water			*fill shaft and cap if required*	
Trench near 5-2 Adit	*trenching*	*5-2Adit-4*						*do nothing*	*Revegetated, no sign of mineralization; no activity required*
Building over Unknown Shaft	*infrastructure*	*5-2Adit-5*						*knock down and burn, debris to Elsa dump*	

1. Was not located during August 2009 site visit





Activity Number	5-2 Area Components and Closure Activities Rationale
5-2_1	5-2 Adit No further remediation required
5-2_2	No. 4 Lower Adit1 No further remediation required
5-2_3	Unknown Shaft near 5-2 Adit Filling shafts removes safety hazards
5-2_4	Trench near 5-2 Adit Revegetated, no sign of mineralization; no activity required
5-2_5	Building over Unknown Shaft Removing eliminates safety and stability issues

Legend

- Preferred Options
- Adit
- Shaft
- Waste Rock Dump
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:1,000

Sources:

Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

Figure 5.34

5-2 Adit Area

Drawn By: TL/JP

APRIL 2011

Common Site Name: **Keno No. 9 System**

Site coordinates: easting northing

General Location Description	Component Type	Closure Activity No.	Closure Issue Categories					Proposed Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
No. 1 Vein Adit	*adit*	*K9S1*	collapse of supports for drift has created open hole with high potential for access due to proximity to signpost			collapsed supports for drift		*bury in pit infill*	
No. 3 Vein Adit	*adit*	*K9S2*	no access due to Faro Gulch cirque					*bury in pit infill*	
Faro Gulch Portal	*adit*	*K9S3*						*no access, do nothing*	
12 Vein Adit	*adit*	*K9S4*						*no access, do nothing*	
No. 9 Vein Shaft	*shaft*	*K9S5*						*no access, do nothing*	
No. 1 Vein Pit	*pit*	*K9S6*						*backfill with nearby borrow material*	
No. 9 Vein Pit	*pit*	*K9S7*						*backfill with nearby borrow material*	
Trenching @ 1 and 9 Veins	*trenches*	*K9S8*						*backfill with nearby borrow material*	
No. 5 Vein Trenches	*trenches*	*K9S9*						*backfill with nearby borrow material*	
WRSAs	*dump*	*K9S10*						*use as source for borrow; do nothing*	
Access Road	*infrastructure*	*K9S11*						*maintain access road for site-wide heritage plan*	
Signpost	*misc*	*K9S12*				`	heritage	*maintain for heritage*	
Infrastructure							heritage	*maintain for heritage*	
Wernecke Monument	*misc*	*K9S13*					heritage	*maintain for heritage*	

489200 489400 489600 489800 490000

7091000 7090800 7090600 7090400

No. 1 Vein Pit
K9S6: backfill with nearby borrow material

No. 3 Adit
K9S2: bury in pit infill

No. 9 System WRSAs
K9S9: backfill with nearby borrow material

Faro Gulch Adit
K9S3: no access, do nothing

12 Vein Adit
K9S4: no access, do nothing

Signpost
K9S11: maintain access road for site-wide heritage plan

No. 1 Adit
K9S1: bury in pit infill

No. 3 Vein Pit
K9S7: backfill with nearby borrow material

Wernecke Monument
K9S12: maintain for heritage

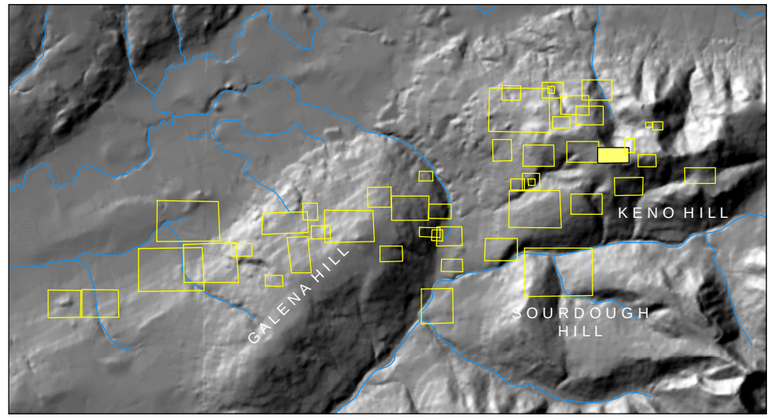
Access Road to No. 9
K9S10: use as source for borrow; do nothing

No. 9 Shaft
K9S5: no access, do nothing

No. 5 Vein Trenches
K9S8: backfill with nearby borrow material

N

Meters
0 20 40 80 120 160



Activity Number	Keno No. 9 Mine Components and Closure Activities Rationale
K9S1	*No. 1 Vein Adit* *Prevents access to undergeround workings*
K9S2	*No. 3 Vein Adit* *Prevents access to undergeround workings*
K9S3	*Faro Gulch Portal* *No further works deemed necessary*
K9S4	*12 Vein Adit* *No further works deemed necessary*
K9S5	*No. 9 Vein Shaft* *No further works deemed necessary*
K9S6	*No. 1 Vein Pit* *Infilling to reduce infiltration and metal loadings along with safety concerns*
K9S7	*No. 9 Vein Pit* *Infilling to reduce infiltration and metal loadings along with safety concerns*
K9S8	*Trenching @ 1 and 9 Veins* *Filling removes safety concerns*
K9S9	*No. 5 Vein Trenches* *Filling removes safety concerns*
K9S10	*WRSAs* *Small piles of waste rock do not require additional remediation*
K9S11	*Access Road* *Access road provides access to Signpost and Wernecke Monument*
K9S12	*Signpost* *Tourist attraction*
K9S13	*Wernecke Monument* *Tourist attraction*

Legend

- Preferred Options
- Shaft
- Test Pit
- Workings
- Waste Rock Dump
- Structures
- Adit
- WaterBodies
- WaterCourses
- Trail
- Track

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:3,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Keno Hill Silver District
Closure Options Report

Figure 5.35

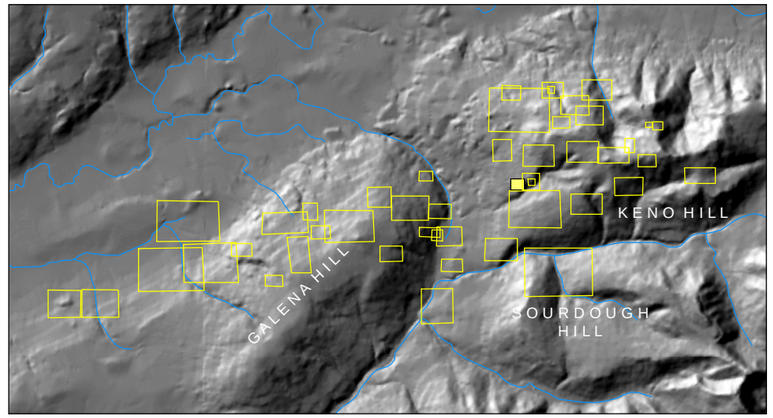
Keno No. 9 System

Drawn By: TL/JP

APRIL 2011

General Location Description	Component Type	Closure Activity No.	Closure Issue Categories						Proposed Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest	Other		
Kijo										
Upper Adit/Trench	*adit/trench*	*Kijo1a*							*do nothing*	*No additional remedial works deemed necessary*
Middle Adit/Trench	*adit/trench*	*Kijo1b*							*do nothing*	*No additional remedial works deemed necessary*
Lower Adit/Trench	*adit/trench*	*Kijo1c*							*do nothing*	*No additional remedial works deemed necessary*
Waste material from trench	*dump*	*Kijo2*		minor staining on clasts					*do nothing*	*No additional remedial works deemed necessary*
Croesus No. 1										
Adits	*adit*	*?*				reported to be collapsed; not located in August 2009 site visit			*do nothing*	*collapsed; access difficult*
Shafts	*shaft*	*?*				reported to be filled; not located in August 2009 site visit			*do nothing*	*collapsed; access difficult*
Trenching	*trenching*	*?*		minor veining observed in trench					*do nothing*	*naturally revegetating*
Lake										
Adits	*adit*	*?*	high intrigue risk; accessible to public			hanging wall of shaft collapsed; may deteriorate to produce an open hole			*do nothing*	*The adit is completely collapsed and covered by rock*
Shafts	*shaft*	*?*	high intrigue risk; accessible to public		water observed in shaft	hanging wall of shaft collapsed; may deteriorate to produce an open hole; minor subsidence			*remove timber and debris; fill and cap as required*	*Covering the shaft will eliminate intrigue risk and access to workings.*
Trenching	*trenching*	*?*							*do nothing*	*trenches are stable and overgrown with natural vegetation*
Waste rock	*dump*	*?*							*regrade as required to ensure stability*	*No concerns noted with waste dump to warrant covering*
Stone										
Lower Adit Level	*adit*	*Stone1a*	access is difficult but possible						*remove timber and debris; rock fill as required to prevent access*	*Upgrading existing rock pile will eliminate intrigue risk and access to workings.*
Middle Adit Level	*adit*	*Stone1b*	access is difficult but possible						*remove timber and debris; rock fill as required to prevent access*	*Upgrading existing rock pile will eliminate intrigue risk and access to workings.*
Upper Adit Level	*adit*	*Stone1c*	access is difficult but possible						*remove timber and debris; rock fill as required to prevent access*	*Upgrading existing rock pile will eliminate intrigue risk and access to workings.*
Lower Adit Waste Rock	*dump*	*Stone2a*		minor staining					*do nothing*	*No additional remedial works deemed necessary*
Middle Adit Waste Rock	*dump*	*Stone2b*		minor staining					*do nothing*	*No additional remedial works deemed necessary*
Upper Adit Waste Rock	*dump*	*Stone2c*		minor staining					*do nothing*	*No additional remedial works deemed necessary*
Gold Hill No.2										
Trenching	*trenching*	*GH2-1*							*fill if deemed to be a safety concern; otherwise do nothing*	*infilling if required*
Waste Rock	*dump*	*GH2-2*							*do nothing*	*small volume of waste rock with no current concerns*
Site Debris	*misc.*	*GH2-3*							*remove to Elsa for cleanup*	*clean-up removes unsightly debris*
Fox										
Trenching	*trenching*	*Fox1*	overgrown and difficult to identify site		ponded water in bottom of Trench #1				*do nothing; possible regrading for aesthetics*	*depending on outcome of objectives, this site may be regraded and filled for aesthetic reasons*
Divide										
Trenching Zone A	*trenching*	*DV1a*			trenches free-drain	solifluction in most trenches			*do nothing*	*No additional remedial works deemed necessary*
Trenchinc Zone B	*trenching*	*DV1b*			trenches free-drain	solifluction in most trenches			*do nothing*	*No additional remedial works deemed necessary*
Building	***infrastructure***	***DV2***				**collapsed**			***remove to Elsa for cleanup***	*Removing eliminates safety and stability issues*
Silver Basin										
Hand Shafts	*shaft*	*?*							*fill*	*Infilling shafts removes safety hazards*
Trenching	*trenching*	*?*							*do nothing*	*filling and regrading not necessary based on trench geometry*
Waste rock	*dump*	*?*							*do nothing*	*filling and regrading not necessary based on waste rock geometry*
Monument & Ladue Fraction										
Trenching	*trenching*	*MLF1*							*do nothing*	*No additional remedial works deemed necessary*
Waste rock	*dump*	*MLF2*							*do nothing*	*No additional remedial works deemed necessary*
Apex										
Shaft	*shaft*	*Apex1*	open for 2m			timber shaft supports are rotten			*fill and cap if required*	*Covering the shaft will eliminate intrigue risk and access to workings.*
Trenching	*trenching*	*Apex2*							*do nothing*	*No additional remedial works deemed necessary*
Cabin	*infrastructure*	*Apex3*	intrigue risk						*remove to Elsa for cleanup*	
Eagle										
Shaft	*shaft*	*Eagle1*				completely collapsed			*fill with trench material*	*trench has fully collapsed and been partially destroyed by trenching*
Main Trench	*trenching*	*Eagle2*				trench walls are stable			*do nothing*	*walls are stable; partial revegetation*
Waste Rock	*dump*	*Eagle3*		minor orange staining		waste rock is stable and comprises trench walls			*do nothing*	*walls are stable; partial revegetation*
Cabin	*infrastructure*	*Eagle4*				structure dilapitated but erect			*remove to Elsa for cleanup*	
Gerlitski										
Trenching	*trenching*	*Gerlitski1*							*do nothing*	*trenches are stable and naturally revegetating*
Waste rock	*dump*	*Gerlitski2*	stressed vegetation below dump	heavy staining; stressed vegetation below dump					*do nothing*	*dumps are naturally revegetating*
Christal (Dorothy)										
Shaft #1	*shaft*	*Christal1a*				collapsed			*fill as required*	*Filling will eliminate intrigue risk and access to workings.*
Shaft #2	*shaft*	*Christal1b*				collapsed			*fill as required*	*Filling will eliminate intrigue risk and access to workings.*
Shaft #3	*shaft*	*Christal1c*	*not found during site visits*						*fill as required*	*Filling will eliminate intrigue risk and access to workings.*
Trenching	*trenching*	*Christal2*							*do nothing*	
Waste rock	*dump*	*Christal3*							*do nothing*	*completely naturally revegetated*
Buildings	*infrastructure*	*Christal4a thru c*				buildings are variously collapsed			*remove to Elsa for cleanup*	





Activity Number	*Kijo Components and Closure Activities Rationale*
Kijo1a	*Upper Adit/Trench* *No additional remedial works deemed necessary*
Kijo1b	*Middle Adit/Trench* *No additional remedial works deemed necessary*
Kijo1c	*Lower Adit/Trench* *No additional remedial works deemed necessary*
Kijo2	*Waste material from trench* *No additional remedial works deemed necessary*

Legend

- Preferred Options
- Adit
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
Contour Interval 10metres
1:3,500

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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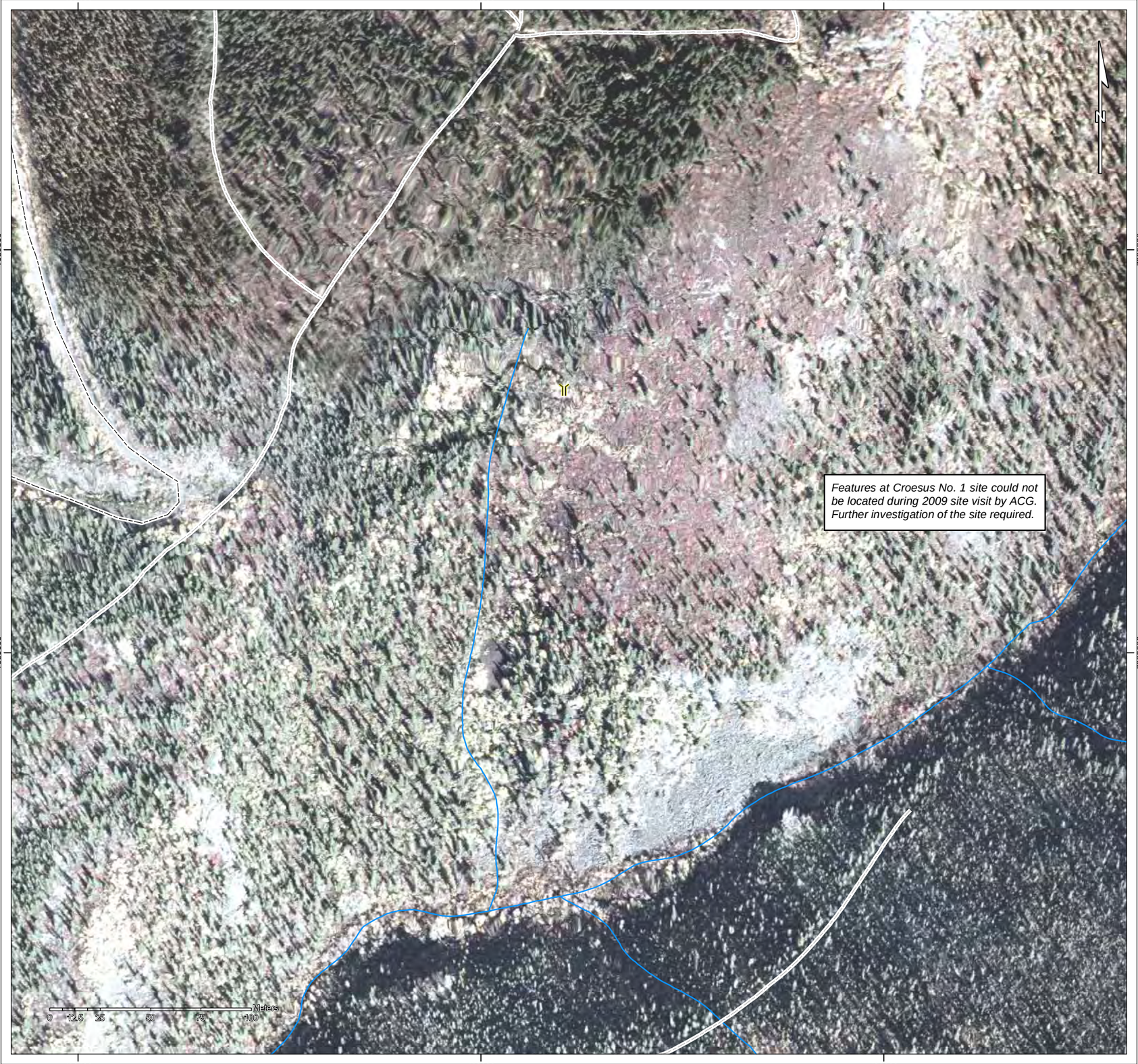
Keno Hill Silver District
Closure Options Report

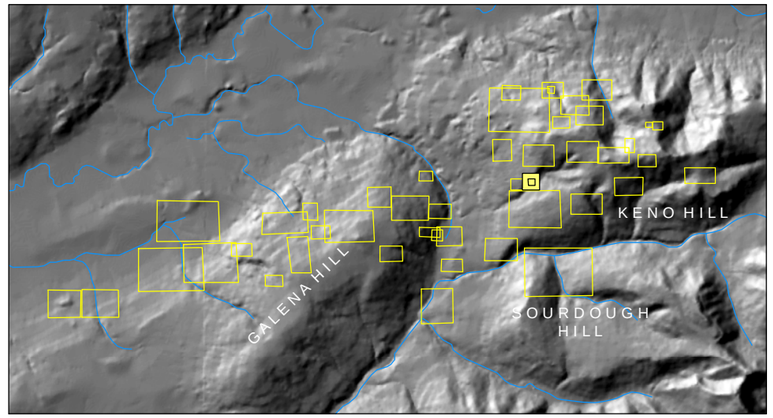
Figure 5.36

Kijo

Drawn By: TL/JP

APRIL 2011





Activity Number	*Croesus No. 1 Components and Closure Activities Rationale*
Croesus1	*Adits* *No additional remedial works deemed necessary*
Croesus2	*Shafts* *No additional remedial works deemed necessary*
Croesus3	*Trenching* *No additional remedial works deemed necessary*

Legend

- Preferred Options
- Adit
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:2,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Closure Options Report

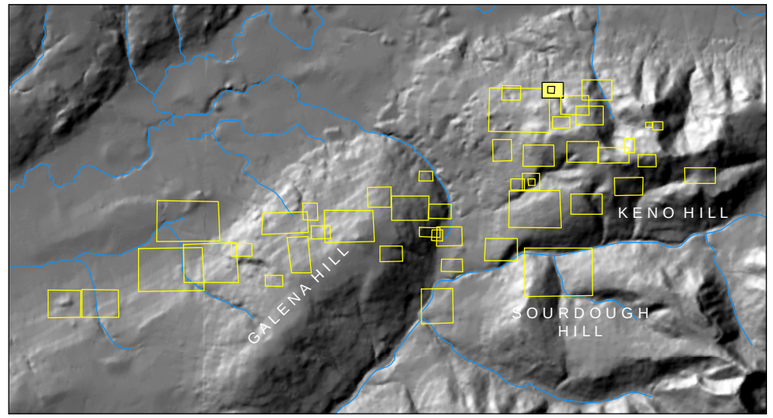
Figure 5.37

Croesus No. 1

Drawn By: TL/JP

APRIL 2011





Activity Number	Lake Components and Closure Activities Rationale
Lake1	*Adits* *The adit is completely collapsed and covered by rock*
Lake2	*Shafts* *Covering the shaft will eliminate intrigue risk and access to workings.*
Lake3	*Trenching* *Trenches are stable and overgrown with natural vegetation*
Lake4	*Waste rock* *No concerns noted with waste dump to warrant covering*

Legend

- Preferred Options
- Shaft
- Local
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:2,000

Sources:

Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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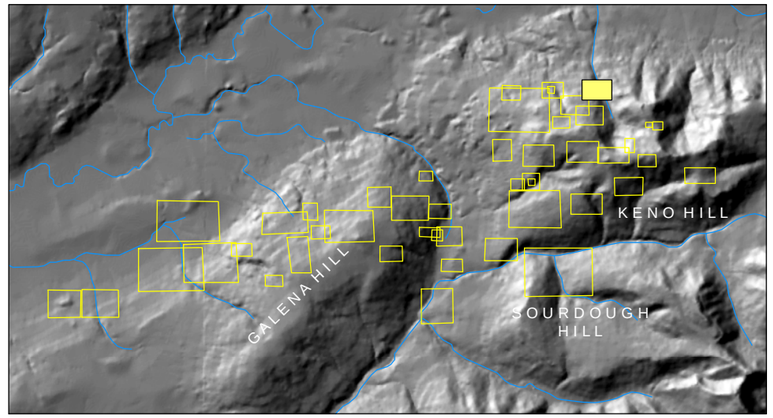
Keno Hill Silver District
Preferred Closure Options Report

Lake

Drawn By: TL/JP

MARCH 2011





Activity Number	*Stone Components and Closure Activities Rationale*
Stone1a	*Lower Adit Level* *Upgrading existing rock pile will eliminate intrigue risk and access to workings.*
Stone1b	*Middle Adit Level* *Upgrading existing rock pile will eliminate intrigue risk and access to workings*
Stone1c	*Upper Adit Level* *Upgrading existing rock pile will eliminate intrigue risk and access to workings.*
Stone2a	*Lower Adit Waste Rock* *No additional remedial works deemed necessary*
Stone2b	*Middle Adit Waste Rock* *No additional remedial works deemed necessary*
Stone2c	*Upper Adit Waste Rock* *No additional remedial works deemed necessary*

Legend

- Preferred Options
- Adit
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:2,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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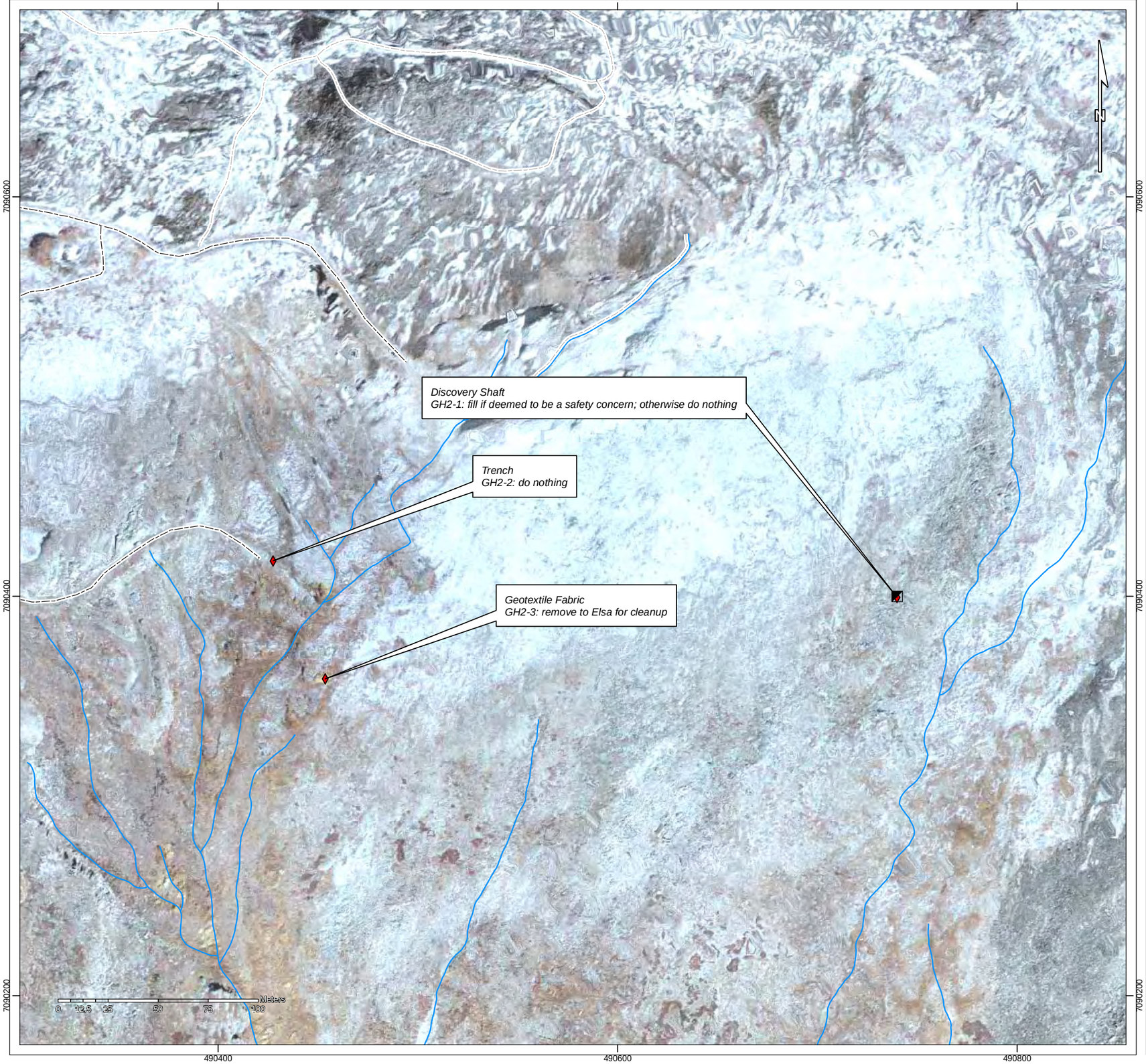
Keno Hill Silver District
Closure Options Report

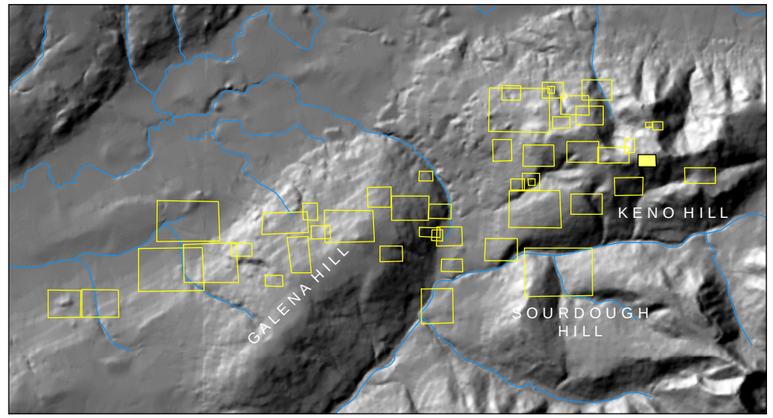
Figure 5.39

Stone

Drawn By: TL/JP

APRIL 2011





Activity Number	*Gold Hill No. 2 Components and Closure Activities Rationale*
GH2-1	*Trenching* *Infilling if required*
GH2-2	*Waste Rock* *Small volume of waste rock with no current concerns*
GH2-3	*Site Debris* *Clean-up removes unsightly debris*

Legend

- Preferred Options
- Shaft
- Trail
- <all other values>

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:2,000

Sources:

Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Keno Hill Silver District
Closure Options Report

Figure 5.40

Gold Hill No. 2

Drawn By: TL/JP

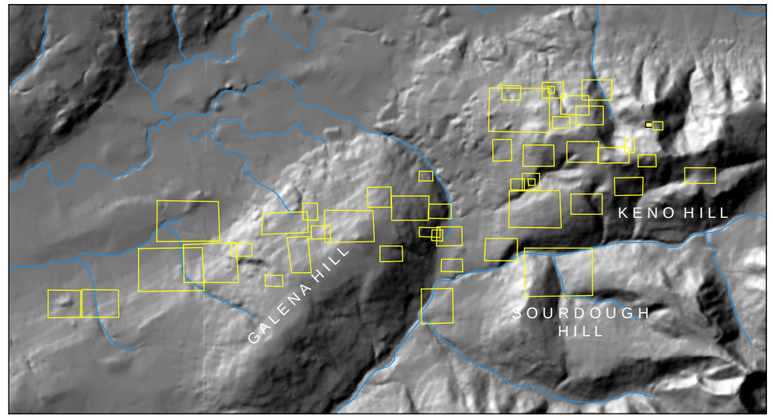
APRIL 2011

490600
490800
7091600
7091400

Area of Trenching
Fox1: do nothing

N

0 5 10 20 30 40
Meters



Activity Number	Fox Components and Closure Activities Rationale
Fox1	Trenching Depending on outcome of objectives, this site may be regraded and filled for aesthetic reasons

Legend

- Preferred Options
- Shaft, 0
- Track
- Trail
- <all other values>

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:2,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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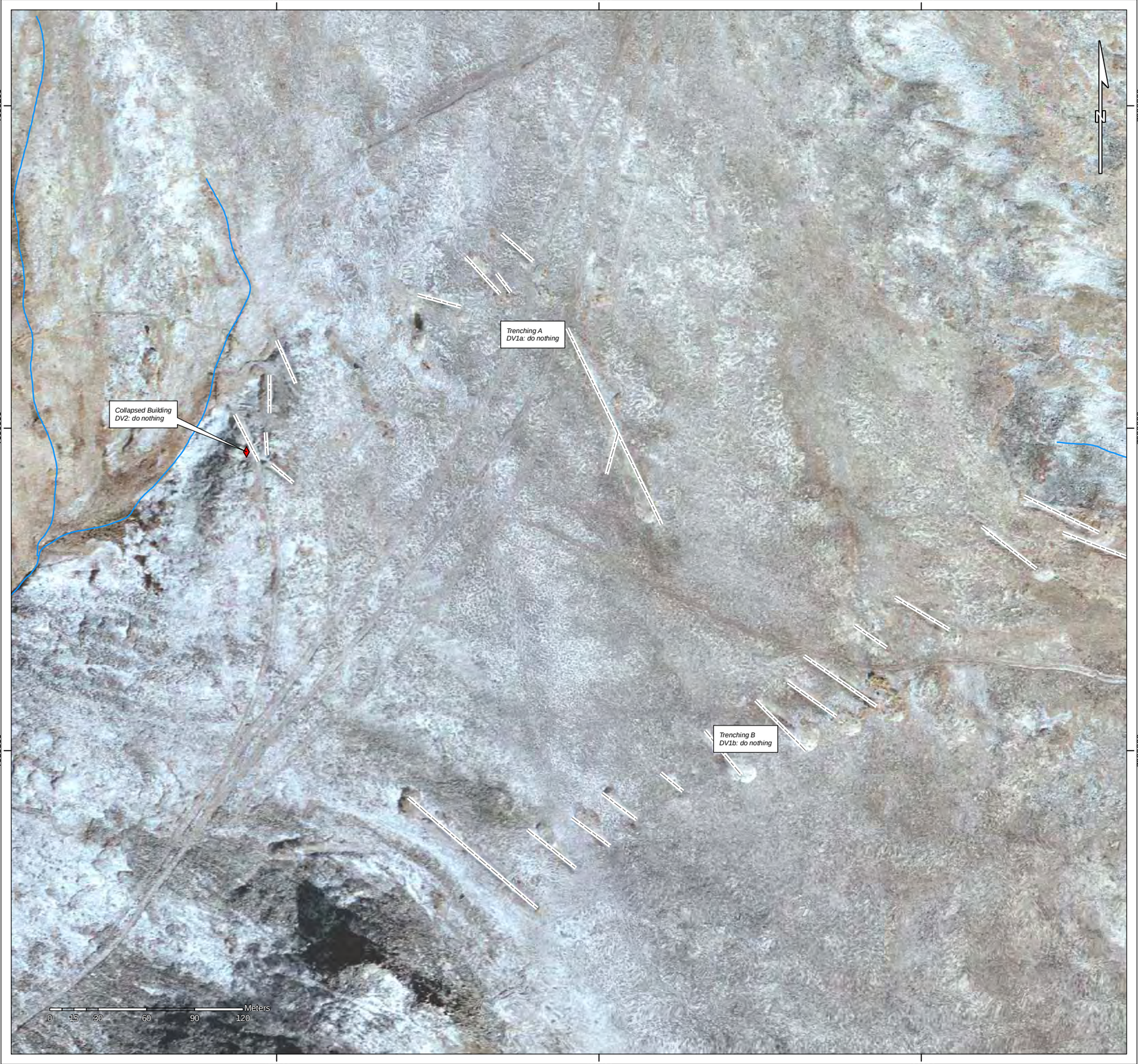
Keno Hill Silver District
Closure Options Report

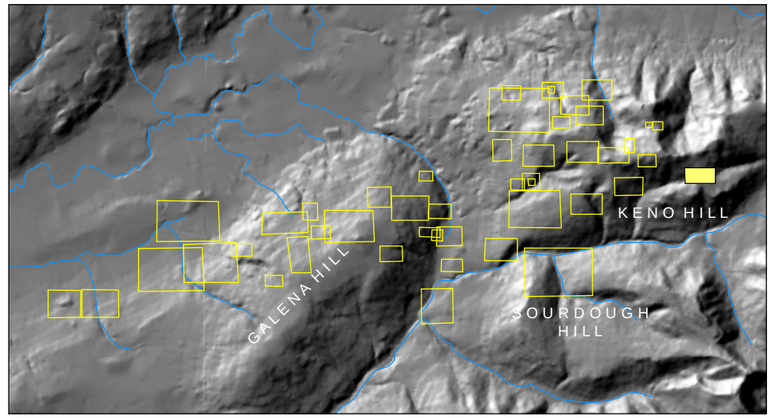
Figure 5.41

Fox

Drawn By: TL/JP

APRIL 2011





Activity Number	Divide Components and Closure Activities Rationale
DV1a	*Trenching* *No additional remedial works deemed necessary*
DV1b	*Oil Barrel* *Removing prevents potential for accidental spillage of barrel contents*
DV2	*Building* *Removing eliminates safety and stability issues*

Legend

- Preferred Options
- Showing
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:3,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Keno Hill Silver District
Closure Options Report

Figure 5.42

Divide

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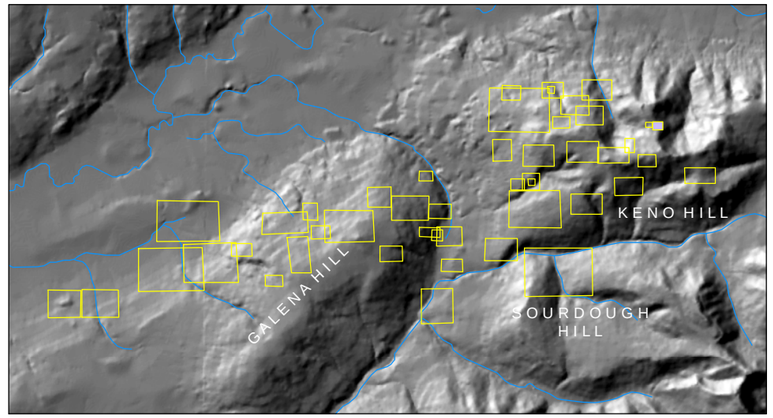
490600 490800 491000

7091600 7091400

Features at Silver Basin site could not be located during 2009 site visit by ACG. Further investigation of the site required.

N

Meters
0 10 20 40 60 80



Activity Number	*Silver Basin Components and Closure Activities Rationale*
SB1	*Hand Shafts* *Infilling shafts removes safety hazards*
SB2	*Trenching* *No additional remedial works deemed necessary*
SB3	*Waste rock* *No additional remedial works deemed necessary*

Legend

- Preferred Options
- Shaft, 0
- Track
- Trail
- <all other values>

Universal Transverse Mercator
Zone 8N
North American Datum 1983
Contour Interval 10metres
1:3,500

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Keno Hill Silver District
Closure Options Report

Figure 5.43

Silver Basin

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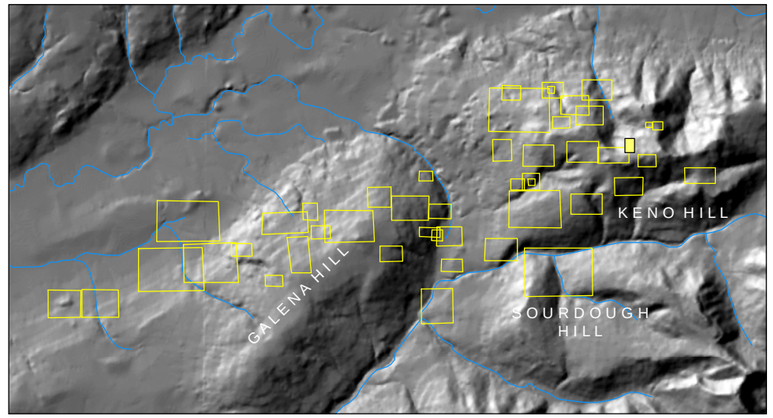
489800 490000 490200

7091200 7091000 7090800 7090600

Features at Monument and Ladue Fraction site could not be located during 2009 site visit by ACG as a result of extremely steep slope conditions and weathering. Further investigation of the site required.

N

0 15 30 60 90 120 Meters



Activity Number	Monument and Ladue Fraction Components and Closure Activities Rationale
	Adit *Trenching* *No additional remedial works deemed necessary*
	Waste rock *No additional remedial works deemed necessary*

Legend

- Preferred Options
- Adit, 0
- <all other values>
- Track
- Trail

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:2,500

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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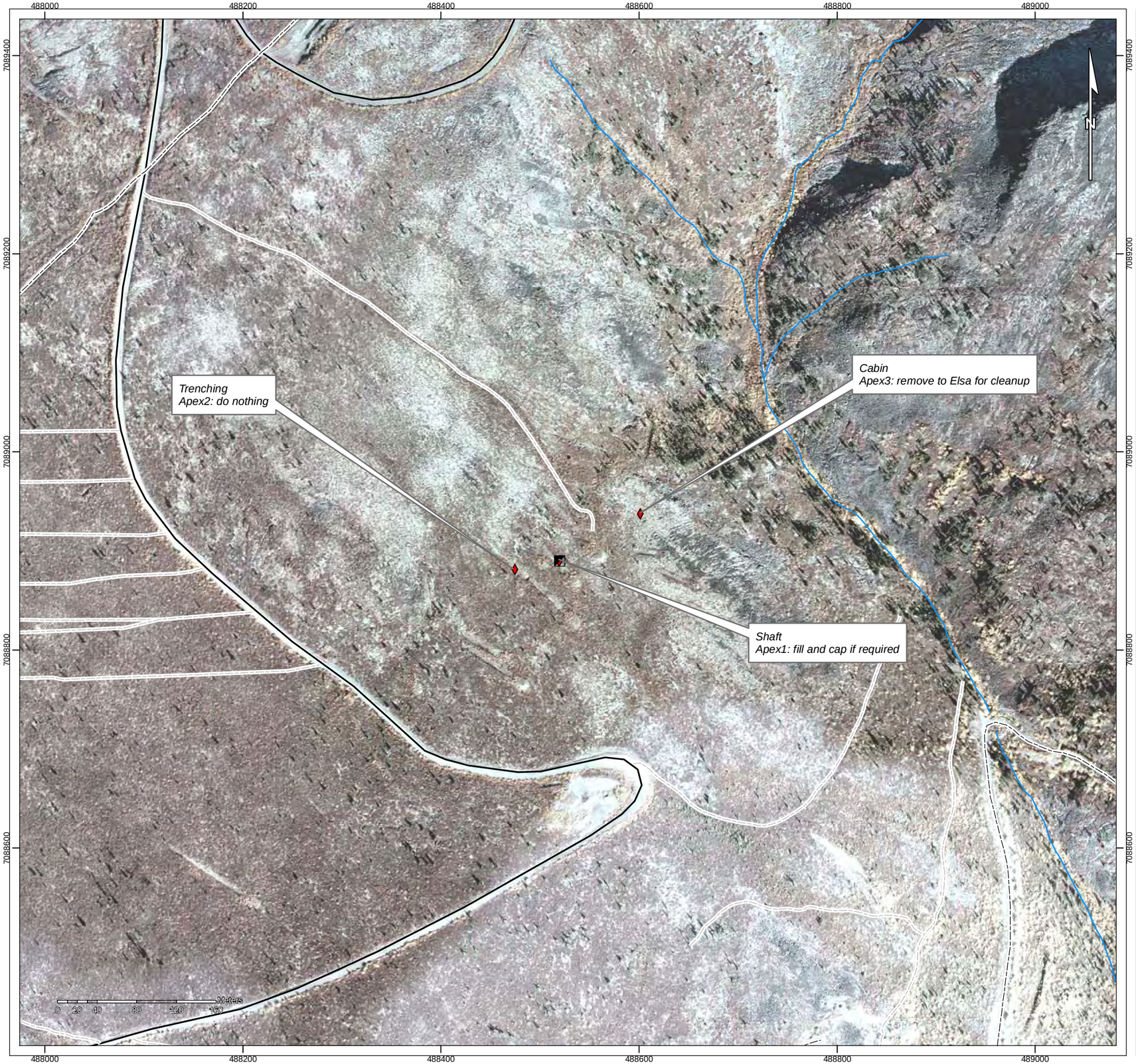
Keno Hill Silver District
Closure Options Report

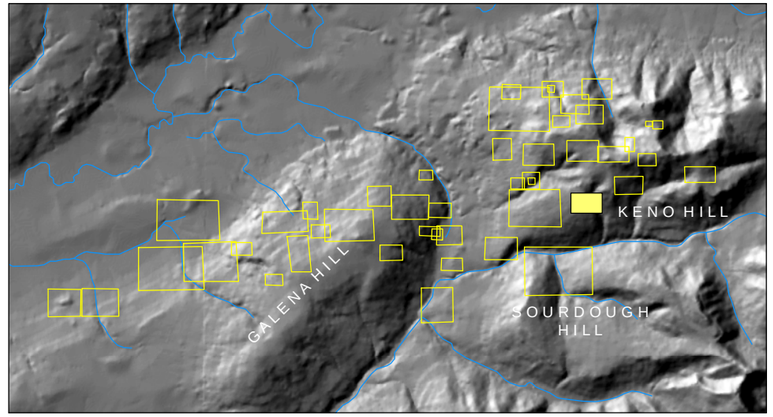
Figure 5.44

Monument and Ladue Fraction

Drawn By: TL/JP

APRIL 2011





Activity Number	Apex Components and Closure Activities Rationale
Apex1	*Shaft* *Covering the shaft will eliminate intrigue risk and access to workings.*
Apex2	*Trenching* *No additional remedial works deemed necessary; trenching is naturally revegetated*
Apex3	*Cabin* *No additional remedial works deemed necessary*

Legend

- Preferred Options
- Shaft
- Showing
- Local
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:3,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Keno Hill Silver District
Closure Options Report

Figure 5.45

Apex

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481600 481800 482000 482200

7087400 7087200 7087000

Cabin
Eagle4: remove to Elsa for cleanup

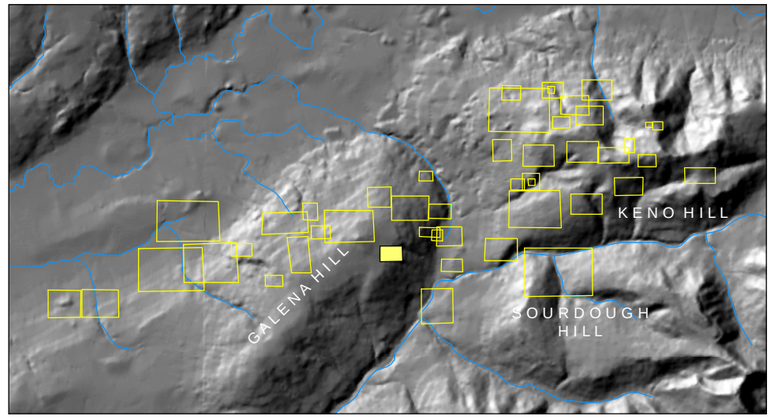
Main Trench
Eagle2: do nothing

Shaft
Eagle1: fill with trench material

Waste Rock
Eagle3: do nothing

N

0 10 20 40 60 80 Meters



Activity Number	*Eagle Components and Closure Activities Rationale*
Eagle1	*Trench has fully collapsed and been partially destroyed by trenching*
Eagle2	*Walls are stable; partial revegetation*
Eagle3	*Stable; partial revegetation*
Eagle4	*Removes intrigue risk*

Legend

- Preferred Options
- Shaft, 0
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:1,500

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

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Keno Hill Silver District
Closure Options Report

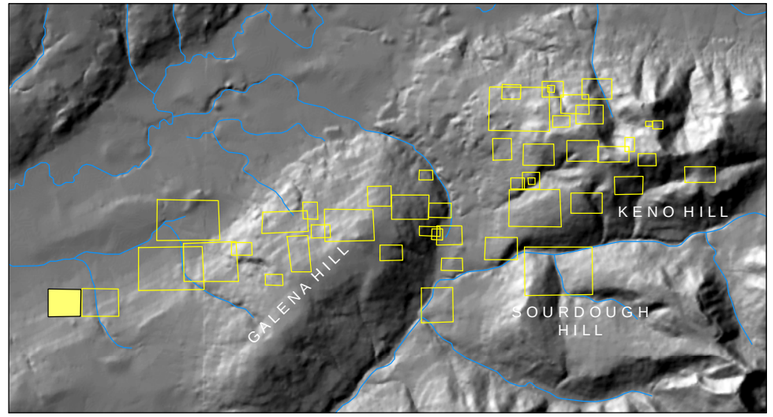
Figure 5.46

Eagle

Drawn By: TL/JP

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Activity Number	Gerlitski Components and Closure Activities Rationale
Gerlitski1	*Trenching* *No additional remedial works deemed necessary*
Gerlitski2	*Waste rock* *No concerns noted with waste dump to warrant covering*

Legend

- Showing
- Preferred Options
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:3,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

ERDC

ACCESS CONSULTING GROUP

Keno Hill Silver District
Closure Options Report

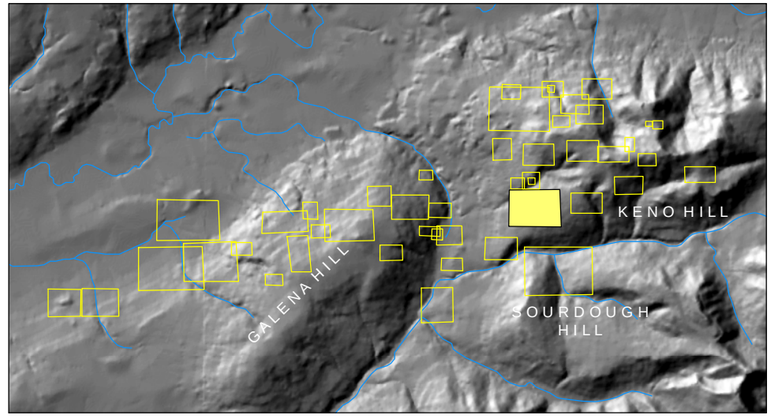
Figure 5.47

Gerlitski

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Activity Number	Christal (Dorothy) Components and Closure Activities Rationale
Christal1a	Shaft #1 Filling and capping the shaft will eliminate intrigue risk and access to workings.
Christal1b	Shaft #2 Filling and capping the shaft will eliminate intrigue risk and access to workings.
Christal1c	Shaft #3 Filling and capping the shaft will eliminate intrigue risk and access to workings.
Christal2	Trenching Trenching is naturally overgrown.
Christal3	Waste Rock Waste rock is completely naturally revegetated.
Christal4a through 4c	Cabin Removal will eliminate intrigue risk.

Legend

- Preferred Options
- Shaft
- Local
- Track
- Trail
- WaterCourses

Universal Transverse Mercator
Zone 8N
North American Datum 1983
1:3,000

Sources:
Access Mining Consultants Ltd., 1996a. United Keno Hill Mines Limited Report No. UKH/96/01 Site Characterization

Access Mining Consultants Ltd., 1996b. United Keno Hill Mines Limited Report No. UKH/96/02 Closure Plan for Current Conditions

SRK Consulting Engineers and Scientists, 2007. Draft Preliminary Environmental Baseline Assessment, United Keno Hill Mines. SRK Project Reference Number: SRK 1CA009.000

Public Works and Government Services Canada, 2000. Keno Valley/Dublin Gulch Environmental Baseline Assessment. Environmental Services, Public Works and Government Services Canada

ERDC

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Keno Hill Silver District
Closure Options Report

Figure 5.48

Christal (Dorothy)

Drawn By: TL/JP

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6. Closure Option Discussion

This section provides an overview of the closure options that have been advanced for further consideration for mine area components across the KHSD. As outlined in Section 4.4 many aspects of these closure options have been subject to a risk assessment process. A package of information has been presented for the purposes of the risk assessment, including the following:

1. Summary of the mine area component
2. Description of each option
3. Summary table of closure issues associated with the mine area component
4. Visual depiction of the closure options
5. High level closure cost estimate comparisons for each of the options

As a result of consultation discussions conducted in 2010, and subsequent to the risk assessment process, an expanded consideration of some of the key closure options at complex sites was conducted in discussion with INAC, YG, and FNNND.

It is important to note that each of the closure options has a number of variants that could be applied to the option. For example, a closure option of long-term active water treatment has variants based on different reagent types, sludge handling approaches, etc. Each of these variants is not presented as a separate closure option, but rather a variant of the primary option where it assumed that the details will be worked out during detailed design after a closure option has been selected.

6.1.1 **Technical Fact Summaries**

Technical closure studies within the KHSD have been ongoing since 2006. The technical closure studies are designed to address information gaps and provide the necessary technical and scientific information to guide closure option selection and ultimately closure design. Fact sheets have been prepared that present a brief summary of the pertinent facts and conclusions of each of the closure studies completed (Appendix A).

More detailed information can be found in the final reports for each of the technical studies as outlined in Section 1.1.

6.2 **Valley Tailings**

The Valley Tailings Facility (VTF) is located in the valley just north of the town site of Elsa Townsite. Closure-related issues have been previously described in (SRK 2008a, 2008b, 2009a, 2009b). The main issues that require assessment in the selection of remedial alternatives for closure at the current time are:

- Wind erosion and dispersion of tailings to nearby areas
- Surface water management around the tailings areas
- Erosion of tailings and transport of tailings to downstream areas of Flat Creek
- Mobilization of metals (total and dissolved fractions) and sulphate from tailings
- Long-term maintenance of man-made structures, including dams and diversions.

The proposed remedial alternatives for reclaiming the VTF and Level 5 cost estimates for the alternatives (considered to be accurate to +100% / -50%) are provided.

6.2.1 **BACKGROUND**

Mills operated in Elsa from 1932 to 1942 and from 1949 to 1988 (UKHM, 1996). A total of 5.3 million Imperial tons of ore was milled at Elsa from 1936 to 1989, which yielded 4.6 million tonnes of tailings (Hawthorne 1996). The ore mineralogy included primarily lead, zinc, and silver sulphides with variable amounts of lead, zinc, and calcium sulphate minerals (SRK, 2009b; 2009c).

Tailings produced from milling operations were discharged onto the hillside below the mill and also placed over the original Flat Creek stream channel in the valley below (Figure 6-1). Three dams were constructed to contain tailings and tailings drainage water (UKHM, 1996). Dam No. 1 was constructed in 1968 and was subsequently fortified after a failure. Dam No. 2 was constructed in 1972, and Dam No. 3 was constructed in 1979. Permafrost soils under all three dams have thawed since construction, resulting in an unknown amount of subsidence of the dams. For purposes of discussion, Figure 6-1 illustrates two areas, a hillside area where tailings are

discontinuous and are partially covered by vegetation and tailings areas that are continuous.

Dam No. 2 and Dam No. 3 were constructed to create ponds and thereby increase the residence time of tailings pond water prior to discharge and improve water quality especially during freshet and periods of high precipitation. Since care and maintenance activities began at the site lime has been added to the pond behind Dam No. 3 during freshet to reduce zinc concentration below currently permitted discharge levels (0.5 mg/L). In 2008, 5.95 tonnes of lime was used for treatment, which resulted in the removal of approximately 2000 kg of zinc from the pond water. Improved management of diversions has reduced the amount of water requiring treatment, and has also reduced the amount of lime addition required.

A series of diversions were also constructed to convey surface water away from the tailings deposits and dams. These diversions include (Figure 6-1):

- A north diversion channel for diversion of Flat Creek flows around the facility, currently discharging into the No Cash bog area to the northeast of the VTF.
- A south diversion channel (also with east to west flows) for interception of north-flowing runoff from Porcupine Creek and re-direction of flow to the west of Dam No. 3.

The valley bottom where the bulk of the tailings are deposited was originally a relatively flat boggy area underlain by peat up to a few meters in thickness and/or peaty soils with permafrost (SRK, 2009b; 2009c). Tailings in the valley bottom are saturated at depths of 1 to a few meters below the surface. Analyses of porewater within the tailings show elevated metal (cadmium, lead, iron, manganese, zinc) and sulphate concentrations (ERDC, 2007; SRK 2009c). However, groundwater below the peat layer beneath the tailings and water in the ponds behind the ponds, have significantly lower metal concentrations than in what is observed in tailings porewater, indicating that attenuation processes are occurring in the peat (SRK, 2009c; 2009d).

The tailings behind Dam No. 1, where wet, have re-vegetated and vegetation has also been re-established in other wet areas. The dry, sandy, upper part of the tailings deposit is barren. The dry tailings are subject to periodic wind erosion from time to time. The tailings generally have an excess of acid generation potential compared to acid neutralization potential (SRK, 2009c). However, most paste pH values for the

tailings are in the neutral to slightly acidic range (SRK, 2009c). The pH in the top 2-3 cm is about 6.7 to 6.8, which has been judged to be close enough to neutral as to not be a significant impediment to plant growth (Withers, 2008). Withers (2008) reports that the major factor limiting long-term plant growth on the tailings is the development of surface salts with a high zinc sulphate content that create an impermeable and toxic surface soil layer unsuitable for plant growth.

6.2.2 **COMMON FEATURES FOR ALTERNATIVES**

The remedial alternatives described in Section 6 have a number of common features with respect to:

- Area and volumes of tailings
- Borrow sources
- Cover thicknesses
- Lime amendment
- Water treatment

These common features are described in the following sections.

6.2.2.1 Tailings Areas and Volumes

The distribution of tailings is shown on Figure 6-1. Estimated volumes and areas are provided in Table 6-1. The areas in Table 6-1 are estimated from interpretations of tailings coverage in Autocad drawings of the VTF and adjacent Elsa hillside. The volumes in Table 6-1 are estimated from the areas and interpolations of thicknesses for the valley bottom tailings considered to be accurate to about plus or minus 0.5 m, and rough approximations for the Elsa hillside where tailings are known to occur in variable thickness and lateral extent but which have not yet been accurately mapped. The tailings are categorized as follows, referring to the colored areas in Figure 6-1:

- Elsa hillside (blue) – discontinuous small areas of tailings accumulations from the historic use of Porcupine Creek drainage as a route for tailings disposal. Tailings are of variable thickness and areal extent and re-vegetated in some areas.
- Valley bottom tailings (pink) – thicker deposits of mostly dry tailings in the former Flat Creek valley located behind Dam No. 1 and southeast of Dam No. 3 and extending southward to the Elsa hillside.

- Pond tailings – submerged and seasonally wet tailings behind Dams No. 1, No. 2, and No. 3

Area	Area (m^2)	Volume (m^3)
Elsa Hillside Tailings	70,000	36,000
Valley Bottom Tailings	608,000	1,217,000
Pond 1	67,000	245,000
Pond 2	44,000	45,000
Pond 3	94,000	15,000
Total	883,000	1,558,000

Table 6-1. Summary of Estimated Areas and Volumes of Tailings

6.2.2.2 Borrow Sources

A potential borrow source for cover material has been identified by Alexco (2007). The borrow source is located north of Dam No. 3 (Figure 6-1) and is comprised of glacial silty to sandy till, sands, and gravels with a thin layer of organic material at the surface. The volume of borrow material in the area outlined in Figure 6-1 has been estimated at 1,523,000 m^3 (SRK, 2009b). After excavation of the borrow material to create cover for reclamation of the tailings areas, the borrow area would need to be covered and reclaimed as well. Organic material (peat) would be obtained from a nearby area and tilled into the borrow area, fertilized, and seeded after cover excavation is completed.

Rehabilitation of existing diversions and stabilization of the Porcupine Creek channel would require placement of riprap. An existing bedrock quarry located about 0.75 to 1 km east of the borrow area and north of the existing tailings has been identified as a suitable nearby source for riprap.

6.2.2.3 Cover Thickness

Cover placement is a major component of each alternative. There are two main types of areas that would receive covers consisting of material from the borrow source. These are:

- Areas of existing thick tailings and areas of consolidated tailings located in the valley bottom behind Dam No. 1 – these areas would receive a 1-m cover

- Areas from which tailings will have been removed for consolidation – these areas would receive a 0.3-m cover
-

The rationale for the 1 m cover depth is to provide sufficient rooting depth for the majority of vegetation above underlying tailings, which limits the potential for metals accumulation in vegetation. The 0.3-m cover is to provide a top drainable media for promoting seed germination and rooting in areas comprised of no soil, thin soil, or primarily peat. These cover approaches are conservative estimates based on experience in Yukon and other areas and may be optimized with additional evaluation of soil types and thicknesses.

6.2.2.4 Lime Amendment

Excavation, relocation, and grading activities have the potential to mobilize metals from porewater and salts in the tailings for a short period after reclamation before establishment of a vegetated cover. SRK (2009c) has determined through a series of experimental tests that the addition of lime during tailings reclamation should significantly reduce metal release. The dosage rate recommended by SRK (2009c) is 6 kg $Ca(OH)_2$ per dry tonne of tailings based on their test results for achieving a target pH of 9.5. The method of lime application would be determined during detailed design. Methods under consideration are broadcasting over existing tailings in their current position or consolidated tailings in their final position with tilling to mix or addition to tailings slated for removal prior to excavation with the assumption that the lime would be mixed into tailings by subsequent placement and grading.

6.2.2.5 Water Treatment

The VTF currently includes a series of ponds that store water from seasonal runoff and shallow groundwater inflows. The water in these ponds is of variable water quality often requiring lime addition to Pond 3 to reduce zinc concentrations to less than the discharge critera of 0.5 mg/L. Groundwater is encountered at 1 to 2 m below ground surface in much of the VTF, meaning a portion of the tailings is water saturated. The remedial activities of excavation, relocation, consolidation, and grading have the potential to release dissolved metals from the water-saturated tailings due to exposure to air and general mixing and overturn. For these reasons, a water treatment plant is a component of each alternative. The rate of water treatment is estimated at 6.6 L/s with a probable range of 5 to 7 L/s based on data for discharge flow measured at the Dam No. 3 decant flume as reported in ERDC (2007)

6.2.3 **REMEDIAL ALTERNATIVE DESCRIPTIONS**

Four remedial alternatives have been developed. They are grouped into the following categories:

- **Alternative 1** - Cover in Place (limited relocation)
- **Alternative 2** - Relocation-Consolidation of Shallow Tailings and Cover
  - **Alternative 2A** - Dams No.1, No. 2, and No. 3 remain
  - **Alternative 2B** - Dams No.1, No. 2, and No. 3 are removed
- **Alternative 3** - Relocation-Consolidation of All Tailings to Synthetic Lined Facilities

Descriptions of the alternatives are provided in the following sections. The alternatives are compared side by side in Table 6-2.

6.2.3.1 Alternatives considered but not advanced

The only alternative considered but not advanced is the reprocessing of the tailings as a closure approach. Reprocessing the tailings would be a separate project that is currently under consideration, but the assessment of this type of a mining operation would likely involve operation of a mill or heap leach facility that would require substantially different assessment than this closure plan.

6.2.4 **Alternative 1 - Cover in Place**

The specific goal of Alternative 1 is to minimize the relocation of tailings. The ponds and dams would remain in their current configuration. Figure 6-2 shows a map view with text description of Alternative 1.

6.2.4.1 Tailings Relocation

Alternative 1 would involve relocation of tailings only where necessary to rehabilitate existing drainage ways or place new diversions. Tailings would be removed from areas subject to erosion into the eastern end of the south diversion channel and southeastern end of the north diversion channel (green area in Figure 6-2). The tailings removed from these areas would be placed on top of existing tailings in two areas north of the south diversion (brown areas in Figure 6-2).

The tailings along the channel and banks of Porcupine Creek on the Elsa hillside would be removed and also relocated on top of existing tailings in two areas north of the south diversion (brown areas in Figure 6-2). The relocated tailings from Porcupine Creek are

estimated to comprise about one third of the total amount of tailings on the Elsa hillside. The remaining two thirds of tailings would be closed in place. Many of these areas are already vegetated but it is anticipated that there will be a need for direct seeding and addition of soil amendments to promote growth, particularly for areas currently devoid or sparsely vegetated at the current time.

6.2.4.2 Cover

Cover material would be obtained from the borrow area located northwest of Dam No. 3. The areas of unsubmerged tailings in the valley bottom located east and south of the ponds would be covered with 1 m of material. The area from which tailings have been removed would be covered with 0.3 m of material.

Relocated tailings would be amended with lime at a rate of 6 kg/tonne prior to placement to minimize metals mobilization. Also, the existing areas of unsubmerged tailings would be broadcast with lime at a rate of 6 kg/tonne for the top 1 meter and tilled to mix the lime into the surface layer to minimize metals mobilization prior to placement of the 1 m cover. The peat layer underlying tailings in the valley is assumed to provide sufficient capacity to continue to attenuate metals released from tailings leaching processes for perpetuity. The cover material would be amended with organic material and fertilizer and seeded to promote vegetation growth.

The dams and submerged tailings in Ponds 1, 2, and 3 would remain. Dams No. 1, No. 2 and No. 3 would be re-sloped with clean waste rock material to provide a structural buttress at the toes of these dams to provide increased certainty of long-term stability.

6.2.4.3 Water Management

Diversions would be established along the east, north, and south sides of the tailings area to intercept surface water runoff and convey this water around and away from the tailings to prevent contact of surface water with tailings. The existing Porcupine diversion would be rehabilitated. The south diversion would discharge into the rehabilitated Porcupine diversion, which would flow to a sediment pond in the valley bottom below Dam No. 3. The north diversion would wrap around the east side of the tailings and then around the north side of the facility and also discharge into the sediment pond. The No Cash Ditch diversion would be rehabilitated to achieve design criteria for size and slope for its catchment area. Riprap would be added to the stream channel of Porcupine Creek in the steeper areas of Elsa hill to minimize erosion and sediment transport. A sediment pond would be placed downstream of Dam No. 3 to

reduce suspended sediment loads prior to discharge to Flat Creek. An additional sediment pond would be placed on Flat Creek near the Silver King highway to reduce suspended loads downstream in Flat Creek and the Porcupine diversion.

Ponds 1, 2, and 3 would be retained to collect water from surface drainage from the area between the north and south diversion and shallow groundwater moving downgradient from the tailings areas. Water collected in Pond 3 would be directed to a water treatment plant prior to discharge to Flat Creek.

6.2.4.4 Post Construction Requirements

Water treatment would be required for Alternative 1 for an extended period of time. Movement of tailings is likely to mobilize suspended solids from the tailings areas, and possibly cause release of dissolved metals from the tailings. Pond 3 would be used as a storage reservoir to feed the water treatment plant. The rate of water treatment is estimated to average about 5 to 7 L/s, based on the catchment area within the planned diversions. The water treatment plant would be operated for approximately 5 to 6 months per year during the warmer months when surface flows occur until the water quality in Pond 3 is of a sufficient quality to allow direct discharge to the environment.

Routine dam inspections would be required because the dams would remain in their existing configuration. Monitoring of the surface and groundwater would be required. Monitoring of vegetation would be required to determine the rate and effectiveness of reclamation work. General maintenance would be required on the diversion channels.

6.2.4.5 Risks

The following risks are considered to be present for Alternative 1:

- All dams are subject to potential failure in the event of an intense precipitation event or freshet, or a seismic event
- Water treatment may be needed for a long period of time because the area of tailings contributing mobilized metals to the shallow groundwater system would not have been reduced from its current configuration. Closure costs may be underestimated because of an extended period of water treatment plant operation.
- Water treatment plant failure would potentially result in the discharge of water to Flat Creek that does not meet water quality criteria.

- Alternative 1 would involve the addition of lime to only the top layer of tailings prior to cover placement; hence this alternative has less capacity for reducing in situ metal mobilization than other alternatives where lime would be mixed into relocated material as well as the top surface of tailings receiving relocated tailings.
- The peat layer underlying tailings may fail over time with respect to attenuation capacity and ability to reduce vertical infiltration, resulting in metal transport to the shallow groundwater system below the peat.
- Poor cover performance could lead to continued movement of elevated metal contents into the ponds, requiring prolonged water treatment and creating a potential exposure route for wildlife. The area of cover is greatest for Alternative 1; hence the potential for cover failure is greater compared to the other alternatives.

6.2.4.6 Aesthetic and Sustainability Considerations

The following aesthetic and sustainability considerations are a component of Alternative 1:

- The site would remain largely in its current appearance, which may have an unacceptable visual appeal.
- A water treatment plant would be operated seasonally for a prolonged time period, requiring additional traffic for transport of chemicals, equipment, and work force.
- The upper reach of Flat Creek remains in a manmade set of diversions rather than the natural stream course.
- Consolidated tailings areas and areas of tailings relocation may appear unnatural until vegetation is established.
- Dams will require ongoing inspections and potential maintenance in perpetuity.

6.2.5 **Alternative 2A – Relocation-Consolidation of Shallow Tailings and Cover; Dams Remain**

The specific goals of Alternative 2A are to consolidate tailings into a smaller footprint to minimize cover requirements and reduce the area of potential metals mobilization. The pond and dams would remain in their current configuration. Figure 6-3 shows a map view with text descriptions of Alternative 2A.

6.2.5.1 Tailings Relocation

Alternative 2A would involve relocating shallow tailings from the following areas:

- Elsa hillside (blue area on Figure 6-3)
- Area of between the Elsa hillside and valley bottom extending to Pond 3 (green area on Figure 6-3)
- Unsubmerged tailings on the southeast side of Ponds 2 and 3 (purple areas on Figure 6-3)

The tailings excavated from these areas would be consolidated on top of existing valley bottom area shown on Figure 6-3 as the brown-colored Consolidation Area.

The Elsa hillside tailings would be excavated from identified pockets and discontinuous deposits as identified by field investigation. The areas of relocated tailings in the valley bottom would be over-excavated by approximately 0.5 m into the underlying peat layer to remove material potentially containing elevated metal contents resulting from vertical migration of water through the tailings into the peat. The unsubmerged tailings in Ponds 2 and 3 would be excavated to the extent possible and placed on top of existing tailings behind Pond 1.

6.2.5.2 Cover

The Consolidated Area and the Cover in Place Area of tailings would be covered with 1 m of material from the borrow area. The areas from which tailings are removed would be covered with 0.3 m of borrow material. The cover material for all areas would be amended with organic material and fertilizer and seed to promote vegetation growth.

Relocated tailings would be amended with lime at a rate of 6 kg/tonne prior to placement to minimize metals mobilization. Also, the existing areas of unsubmerged tailings area of consolidation would be broadcast with lime at a rate of 6 kg/tonne for the top 1 meter and tilled to mix the lime into the surface layer to minimize metals mobilization prior to placement of the 1 m cover. The peat layer underlying tailings in the valley is assumed to continue to attenuate metals released from tailings leaching processes.

Dams No. 1, No. 2, and No. 3 and Ponds 1, 2, and 3 would remain in their existing configuration and the submerged tailings in the ponds would remain covered by water.

Dams No. 1, No. 2, and No. 3 would be re-sloped with rock material to provide a structural buttress at the toes of these dams to provide certainty of long-term stability.

6.2.5.3 Water Management

Diversions would be established along the east, north, and south sides of the tailings area to intercept surface water runoff and convey this water around and away from the tailings to prevent contact of surface water with tailings. The existing Porcupine diversion would be rehabilitated. The south diversion would discharge into the rehabilitated Porcupine diversion and flow to a sediment pond in the valley bottom below Dam No. 3. The north diversion would wrap around the east side of the tailings and then around the north side of the facility and also discharge into the sediment pond. The No Cash Ditch diversion would be rehabilitated to achieve design criteria for size and slope of its catchment area. Riprap would be added to the stream channel of Porcupine Creek in the steeper areas of Elsa hill to minimize erosion and sediment transport. A sediment pond would be placed downstream of Dam No. 3 to reduce suspended sediment loads prior to discharge to Flat Creek. An additional sediment pond would be placed on Flat Creek near the Silver King highway to reduce suspended loads downstream in Flat Creek and the Porcupine diversion.

Ponds 1, 2, and 3 would be retained to collect water from surface drainage from the area between the north and south diversion and shallow groundwater moving downgradient from the tailings areas. Water collected in Pond 3 would be directed to a water treatment plant prior to discharge to Flat Creek.

6.2.5.4 Post Construction Requirements

Treatment of water collected in the ponds would be required for Alternative 2A. Pond 3 would be used as a storage reservoir to feed the water treatment plant. The rate of water treatment is estimated to be similar to Alternative 1, or an average of about 5 to 7 L/s. The duration of water treatment is anticipated to be less than Alternative 1 because of consolidation of tailings into a smaller footprint and addition of lime to a comparatively larger volume of relocated tailings is assumed to provide benefits to the water quality in Pond 3. The water treatment plant would be operated for approximately 5 to 6 months per year during the warmer months when surface flows occur until the water quality in Pond 3 is of a sufficient quality to allow direct discharge to the environment.

Routine dam inspections would be required because the dams would remain in their existing configuration. Monitoring of the surface and groundwater would be required. Monitoring of vegetation would be required to determine the rate and effectiveness of reclamation work. General maintenance would be required on the diversion channels.

6.2.5.5 Risks

The following risks would occur for Alternative 2A:

- All dams are subject to potential failure in the event of an intense precipitation event or freshet, or a seismic event.
- Water treatment would be needed for at least five years. Water treatment plant failure would potentially result in the discharge of water to Flat Creek that does not meet water quality criteria.
- Poor cover performance could lead to continued movement of elevated metal contents into the ponds, requiring additional water treatment and creating a potential exposure route for wildlife.
- Poor mixing or poor performance of lime amendment in combination with exposure of relocated tailings to air may result in at least a short-term elevation in metals release to the shallow groundwater system beneath the tailings in the valley bottom. This process may increase water treatment costs in the short term when metal levels are highest.
- The peat layer underlying tailings may fail over time with respect to attenuation capacity and ability to reduce vertical infiltration, resulting in metal transport to the shallow groundwater system below the peat.

6.2.5.6 Aesthetic and Sustainability Considerations

The following aesthetic and sustainability considerations are a component of Alternative 2A:

- The site would remain largely in its current appearance, which may have an unacceptable visual appeal.
- A water treatment plant would be operated seasonally for at least five years, requiring additional traffic for transport of chemicals, equipment, and work force.
- The upper reach of Flat Creek remains in a manmade set of diversions rather than the natural stream course.

- Consolidated tailings areas and areas of tailings relocation may appear unnatural until vegetation is established
- Dams will require ongoing inspections and potential maintenance in perpetuity.

6.2.6 **Alternative 2B – Relocation-Consolidation of Shallow Tailings and Cover; Dams Removed**

The specific goals of Alternative 2B are to consolidate tailings in a smaller footprint to minimize cover requirements and metals mobilization similar to Alternative 2A. In addition, the ponds and dams would be removed to eliminate these manmade structures and their associated potential risks. Figure 6-4 shows a map view with text descriptions of Alternative 2B.

6.2.6.1 Tailings Relocation

The relocation plan for shallow tailings is similar to Alternative 2A in that Alternative 2B would involve relocating shallow tailings from the following areas:

- Elsa hillside (blue area on Figure 6-4)
- Area between the Elsa hillside and valley bottom extending to Pond 3 (green area on Figure 6-4)

The Elsa hillside tailings would be excavated from identified pockets and discontinuous deposits as identified by field investigation. The areas of relocated tailings in the valley bottom would be over-excavated by approximately 0.5 m into the underlying peat layer to remove material potentially containing elevated metal contents resulting from vertical migration of water through the tailings into the peat.

The tailings excavated from these areas would be consolidated on top of existing tailings in the valley bottom area shown on Figure 6-4 as the brown-colored Consolidation Area.

A difference with Alternative 2A is that in Alternative 2B the submerged and unsubmerged tailings in Ponds 1, 2, and 3 would be left in place and subsequently drained and covered (see below).

6.2.6.2 Cover

The Consolidated Area and the Cover in Place Area of tailings would be covered with 1 m of material from the borrow area. The areas from which tailings are removed would

be covered with 0.3 m of borrow material. The cover material for all areas would be amended with organic material and fertilizer and seed to promote vegetation growth.

Ponds 1, 2, and 3 would be drained and water collected in a new pond constructed downstream of the current location of Dam No. 3. The collected water would be treated and discharged to Flat Creek. A drainage layer will be created in the center of Dams No. 1, No. 2, and No. 3 by the excavation of a drainage area which would be filled with gravel to allow groundwater to drain and pass through after cover placement. Borrow material would be brought in to bring the depression areas of the ponds up to grade. The re-filled pond areas would be covered with 1 m of borrow material and graded so that the surface has a gradual 2° slope from east to west. Figure 6-5 illustrates dam removal and pond covering approaches used in Alternative 2B.

Relocated tailings placed in the Consolidation Area would be amended with lime at a rate of 6 kg/tonne prior to placement to minimize metals mobilization. Also, the existing areas of unsubmerged tailings area of consolidation would be broadcast with lime at a rate of 6 kg/tonne for the top 1 meter and tilled to mix the lime into the surface layer to minimize metals mobilization prior to placement of the 1 m cover. The drained pond areas would also receive lime amendment prior to cover placement to minimize metal mobilization. The peat layer underlying tailings in the valley is assumed to continue to attenuate metals released from tailings leaching processes.

6.2.6.3 Water Management

Diversions would be established along the east, north, and south sides of the tailings area to intercept surface water runoff and convey this water around and away from the tailings to prevent contact of surface water with tailings. The existing Porcupine diversion would be rehabilitated. The south diversion would discharge into the rehabilitated Porcupine diversion and flow to a sediment pond in the valley bottom below Dam No. 3. The north diversion would wrap around the east side of the tailings and then around the north side of the facility and also discharge into the sediment pond. The No Cash Ditch diversion would be rehabilitated to achieve design criteria for size and slope for its catchment area. Riprap would be added to the stream channel of Porcupine Creek in the steeper areas of Elsa hill to minimize erosion and sediment transport. A sediment pond would be placed downstream of Dam No. 3 to reduce suspended sediment loads prior to discharge to Flat Creek. An additional sediment pond would be placed on Flat Creek near the Silver King highway to reduce suspended loads downstream in Flat Creek and the Porcupine diversion.

An additional pond would be constructed below the base of the former location of Dam No. 3. This pond would be designed to collect seepage water flowing through the refilled ponds and breached dams prior to pumping to the water treatment plant.

6.2.6.4 Post Construction Requirements

Water treatment would be required for the water collected below former Dam No. 3. The rate of water treatment is estimated to average about 5 to 7 L/s. The duration of water treatment is anticipated to be less than Alternatives 1 and 2A because of the consolidation of tailings into a smaller footprint and the addition of lime to a comparatively larger volume of relocated tailings and the addition of lime to tailings in the areas of the former ponds. The water treatment plant would be operated for approximately 5 to 6 months per year during the warmer months when surface flows occur until the water quality in Pond 3 is of a sufficient quality to allow direct discharge to the environment.

Routine dam inspections would no longer be required because the dams would be removed. Monitoring of the surface and groundwater would be required. Monitoring of vegetation would be required to determine the rate and effectiveness of reclamation work. General maintenance would be required on the diversion channels.

6.2.6.5 Risks

The following risks would occur for Alternative 2B:

- The potential exists for seasonal pooling of water in the areas of the former ponds if slopes and covers over the former pond areas have poor performance.
- Water treatment would be needed for at least five years. Water treatment plant failure would potentially result in the discharge of water to Flat Creek that does not meet water quality criteria.
- Poor cover performance could lead to continued movement of elevated metal contents to the sediment pond, requiring water treatment and creating a potential exposure route for wildlife.
- The peat layer underlying tailings may fail over time with respect to attenuation capacity and ability to reduce vertical infiltration, resulting in metal transport to the shallow groundwater system below the peat.
- Poor mixing or poor performance of lime amendment in combination with exposure of relocated tailings to air may result in at least a short-term elevation

in metals release to the shallow groundwater system beneath the tailings in the valley bottom. This process may increase water treatment costs in the short term when metal levels are highest.

6.2.6.6 Aesthetic and Sustainability Considerations

The following aesthetic and sustainability considerations are a component of Alternative 2B:

- The dams and ponds are removed, which may increase the visual appeal of the site due to the removal of most of the manmade structures.
- A water treatment plant would be operated seasonally for a short time period of approximately five years, requiring additional traffic for transport of chemicals, equipment, and work force.
- The upper reach of Flat Creek remains in a manmade set of diversions rather than the natural stream course.
- Consolidated tailings areas and areas of tailings relocation may appear unnatural until vegetation is established

6.2.7 **Alternative 3 – Relocation-Consolidation of All Tailings to Synthetic Lined Facilities**

The specifics goals of Alternative 3 are to remove tailings from their existing location in the natural drainage of North Flat Creek, and to consolidate tailings in facilities with synthetic liners to eliminate potential releases of metals and sulphate and return the valley tailings area to a more natural configuration. In addition, the ponds and dams would be removed to eliminate these manmade structures and potential risks. Figure 6-6 shows a map view with text descriptions of Alternative 3.

6.2.7.1 Tailings Relocation

Alternative 3 would involve construction of two lined facilities located northwest of the existing valley tailings. A smaller facility would be used to contain drier tailings excavated from the Elsa hillside (blue area on Figure 6-6), valley edge (pink area on Figure 6-6), and top meter of the thicker tailings east of Pond 1 (green area on Figure 6-6). The tailings in drier areas would be over-excavated by about 0.5 m to remove peat and soils potentially containing mixed in tailings and elevated metals. Standard excavation and hauling in trucks would be used to move the drier tailings to the smaller lined facility. The drier tailings would be placed at slopes of approximately 5:1, resulting

in a final height of approximately 20 m in the smaller lined facility at the end of relocation.

The larger lined facility would be used to contain the wet tailings located below the phreatic surface in the thick area of tailings east of Pond 1 (green area on Figure 6-6) and wet and submerged tailings relocated from Ponds 1, 2, and 3. The wet tailings would be transported to the larger lined facility by a combination of hauling and slurry pumping.

Lime would be added to the tailings transported to both storage facilities at the same rate of 6 kg/tonne as used for the other alternatives. Due to the large amount of tailings relocation, the lime cost would be high. The rate of lime amendment may be decreased given the saturated state of the wet tailings facility and consequent lack of air exposure; however, any change in the rate would require more detailed analysis of the lime titration data given in SRK (2009c), and possibly additional testwork.

6.2.7.2 Cover

The tailings in the lined facilities would be covered with 1 m of material from the borrow area as illustrated in Figure 6-7. The dams would be flattened and any excess material from the dams may also be used as cover material. The areas from which tailings were removed would be covered with 0.3 m of cover. The covers would be amended with organic material, fertilizer, and seeded to promote vegetation growth after placement and grading.

6.2.7.3 Water Management

The water in Ponds 1, 2, and 3 would be pumped and treated at a water treatment plant prior to discharge to Flat Creek until the tailings removal project is completed. Drainage ways along the southern and northern sides of the former VTF would be re-established in their native configuration to convey surface water from the Elsa hillside and Porcupine Creek to the Porcupine diversion. The north drainage way would connect to the natural drainage path of Flat Creek on the east side of the current tailings location and directed to the sediment pond, approximating the natural path of Flat Creek prior to the VTF. The existing Porcupine diversion would be rehabilitated and routed to a sediment pond in Flat Creek downstream of the former location of Dam No. 3.

The No Cash Ditch diversion would be rehabilitated to achieve design criteria for size and slope of its catchment area. Riprap would be added to the stream channel of

Porcupine Creek in the steeper areas of Elsa hill to minimize erosion and sediment transport. A sediment pond would be placed downstream of the former Dam No. 3 to reduce suspended sediment loads prior to discharge to Flat Creek. An additional sediment pond would be placed on Flat Creek near the Silver King highway to reduce suspended loads downstream in Flat Creek and the Porcupine diversion.

6.2.7.4 Post construction Requirements

Water treatment would be required for water pumped from the ponds and during construction. Monitoring of the surface and groundwater downgradient of the lined facilities would be required. Temporary monitoring of surface water quality at the sediment pond would be needed until it is evident that the reclaimed areas have stabilized at which point water quality criteria may be met. Monitoring of vegetation would be required to determine the rate and effectiveness of reclamation work. General maintenance may be required on the diversion channels.

6.2.7.5 Risks

The following risks would occur for Alternative 3:

- Water treatment would be needed at least during the construction period. Water treatment plant failure would potentially result in the discharge of water to Flat Creek that does not meet water quality criteria.
- An additional area of new ground disturbance is created by the construction of the lined facilities resulting in a short-term decrease in aesthetic appeal. Ultimately after reclamation the facilities are expected to be designed to blend in with natural features in the area.
- Excavation of wet tailings with heavy equipment and slurry pumps may be difficult, depending on perched groundwater levels in the lower portions of the valley bottom and climatic conditions thereby resulting in possible cost increases.
- Poor cover performance at the lined facilities could lead to releases of metals and sulphate to downgradient soils and possibly Flat Creek, which may require long term requirement for water treatment.
- Poor mixing or poor performance of lime amendment in combination with exposure of relocated tailings to air may result in at least a short-term elevation in metals release to the shallow groundwater system beneath the tailings in the valley bottom. This process may increase water treatment costs in the short term when metal levels are highest.

6.2.7.6 Aesthetic and Sustainability Considerations

The following aesthetic and sustainability considerations are a component of Alternative 3:

- The dams and ponds are removed, which may increase the visual appeal of the site due to the removal of most of the manmade structures.
- New areas for tailings storage facilities require disruption of new ground, although the facilities may be designed to blend in with the surrounding landscape.
- New facilities may have unnatural appearance until vegetation is established.
- The upper reach of Flat Creek would be restored to approximate its pre-mining drainage pattern.

6.2.8 **SUMMARY**

The main components, costs, and risks of each alternative are summarized side by side in Table 6-2. The major features of each alternative are:

- **Alternative 1:** This alternative requires the least amount of material movement and surface disruption resulting in decreased construction time, comparatively more simple engineering design requirements, and lowest cost.
- **Alternative 2A:** This alternative would result in consolidation of the tailings into a small footprint with the installation of a robust cover over the tailings. The cover and large addition of lime should reduce metal mobilization in both the short-term and long-term. The dams and ponds are retained resulting in lower construction costs than Alternatives 2B and 3.
- **Alternative 2B:** The main features of this alternative are similar to Alternative 2A except that the dams and ponds would be removed. Removal of the dams and ponds eliminates these structures as points of potential failure and long-term maintenance and also significantly reduces the number of unnatural, manmade structures in the valley.
- **Alternative 3:** This alternative completely removes the tailings from the vicinity of Flat Creek and consolidates them in an engineered facility designed to prevent transport pathways to the environment. This approach minimizes the potential for tailings and metal transport to the groundwater and surface water reducing overall risk to the environment as well as removing all of the manmade

structures in the valley such that the upper reach of Flat Creek is returned to its more natural course, but at the highest relative cost.

6.2.8.1 Adaptive Management of Tailings Closure

The main monitoring location currently affected by the Valley Tailings is the headwaters area of Flat Creek. Recent synoptic sampling of Flat Creek has shown elevated zinc concentrations in Flat Creek in the area where tailings impacted flow would be expected to enter Flat Creek (Interralogic 2011), with zinc concentration of 0.24 mg/L in Flat Creek adjacent to the VTF. Even with the vast majority of the tailings entirely removed from the drainage, such as is contemplated in Alternative 3, it likely that dispersed tailings in Flat Creek drainage that are downgradient of Tailings Dam 3 will limit the recovery of the zinc concentration in this area to achieve water quality goals in a rapid time frame. It is likely that with effective diversions that prevent tailings contact of Flat Creek water with the VTF that in time sediment from the hillside will cover some of the dispersed tailings and limit contact of these dispersed tailings with Flat Creek water. However, during a flood event erosion of the stream channel and exposure of previously buried tailings could realistically cause a temporary or sustained spike in metal (especially zinc) concentrations. Consequently, it should not be expected that Flat Creek zinc concentrations will provide a rapid response variable to determine how effective the tailings closure is on improving water quality in Flat Creek.

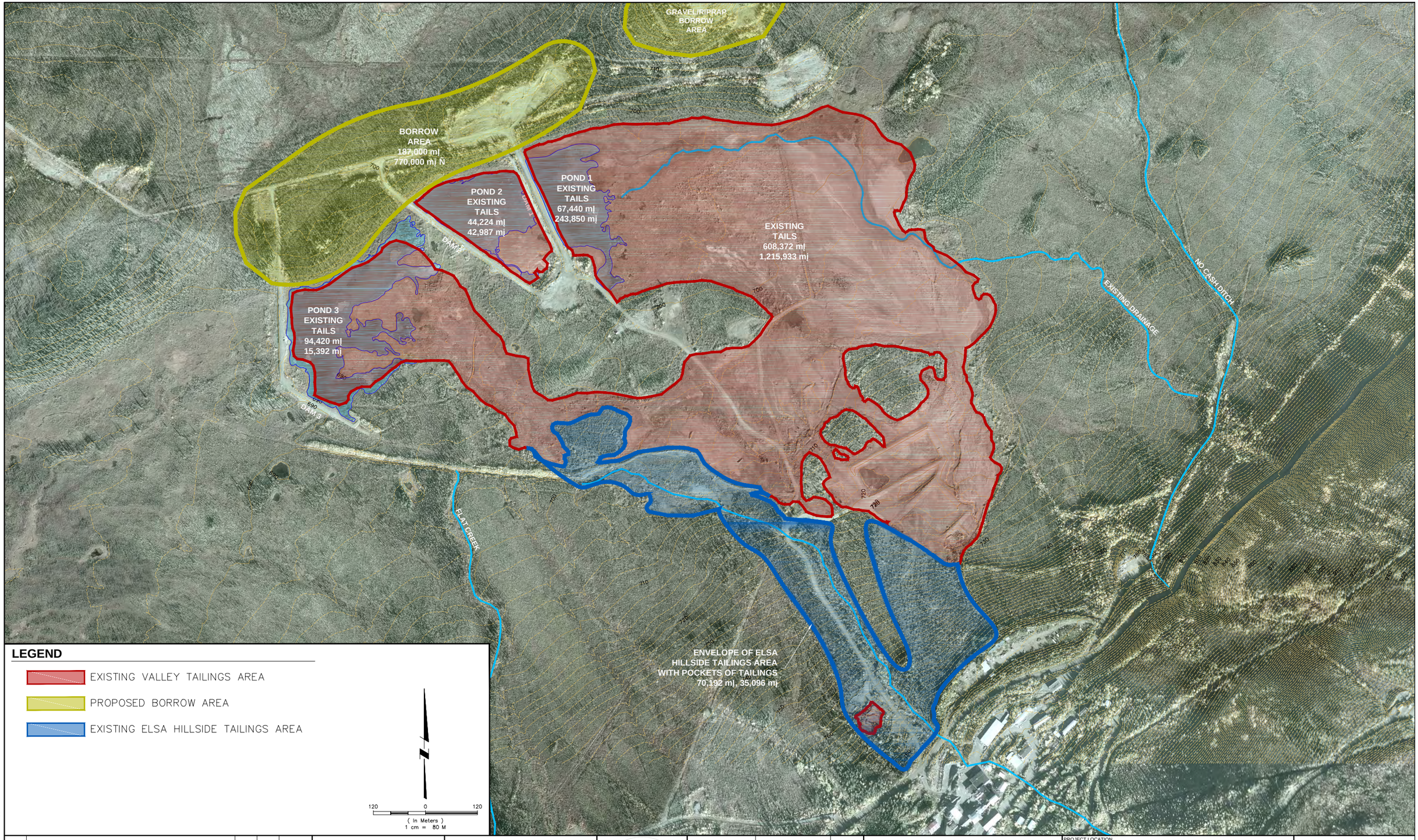
However, Porcupine Creek diversion, with its current contact with the VTF is producing a significant portion of the zinc load in Flat Creek. Recent concentrations in this drainage have often ranged up to 0.4 to 0.5 mg/L zinc, and creating a clean diversion channel will cause a benefit in Flat Creek. Effective construction sediment control during tailings closure work will be difficult but necessary to prevent a short term increase resulting from mobilization of tailings material in this area.

This analysis indicates that once an alternative is selected, that improvements if determined to be required will likely be refinements of the implemented alternative but will not result in a second alternative being implemented. Example refinements could include additional erosion control features in the area of the diversion discharge to limit erosion within Flat Creek, or extension of the construction diversion further down valley to get farther past the dispersed tailings area. Additional field study is planned for 2011 to refine the understanding of the dispersed tailings area in Flat Creek.

	Alternative 1 Cover in Place (limited relocation)	Alternative 2A Relocation-Consolidation of Shallow Tailings and Cover Dams No.1, No. 2, and No. 3 remain	Alternative 2B Relocation-Consolidation of Shallow Tailings and Cover Dams No.1, No. 2, and No. 3 removed	Alternative 3 Relocation-Consolidation of All Tailings to Synthetic Lined Facilities
Components and Remedial Methods				
Tailings Relocation	Tailings relocation is minimal and limited to areas needed for stabilization of diversions; tailings along Porcupine Creek and area of thicker tailings on the northeast side of Elsa hillside would be consolidated with existing tailings on the north side of the south diversion	Tailings from the Elsa hillside; area between the hillside and valley bottom, and unsubmerged portions of Ponds 2 and 3 are relocated and consolidated behind Pond 1	Tailings from the Elsa hillside; area between the hillside and valley bottom, and unsubmerged portions of Ponds 2, and 3 are relocated and consolidated behind Pond 1; tailings in the submerged and unsubmerged portions of Ponds 1, 2, and 3 are drained and left in place.	All tailings are removed by excavation and hauling for dry tailings and slurry pumping/dredging for wet tailings; removed tailings are placed in two new storage facilities with synthetic liners located outside of the Flat Creek valley bottom
Cover	1-m cover is placed over the valley floor tailings with amendments for vegetation; areas of the Elsa hillside tailings from which tailings are removed are covered with 0.3 m; other areas already vegetated are closed without cover; direct seeding and amendments used where possible on the Elsa hillside for non-vegetated areas	Area of consolidated tailings is covered with 1 m with amendments for vegetation; Areas of removed tailings are covered with 0.3 m with amendments for vegetation	Area of consolidated tailings is covered with 1 m with amendments for vegetation; Areas of removed tailings are covered with 0.3 m with amendments for vegetation; tailings in Ponds 1, 2, and 3 are covered in place with 1 m and graded to slope toward to the east	Areas of removed tailings are covered with 0.3 m with amendments for vegetation; areas of removed tailings are graded to drain to diversions; lined storage facilities covered with 1 m and re-vegetated
Lime Amendment	Lime added to the tailings surfaces in the valley bottom prior to cover placement; limited surface disruption reduced potential for metal release by oxidation processes compared to other alternatives	Lime is added to the volume relocated tailings and to the surfaces of existing and consolidated tailings areas; large amount of added lime may reduce short-term metal mobilization prior to establishment of vegetated cover		Lime is added to all of the removed tailings placed in the synthetic lined facility; metal mobilization and transport to Flat Creek eliminated
Surface Water Management	North and south diversions are constructed to keep surface water from covered tailings; both diversions end in a sediment pond; the south diversion is directed to the existing Porcupine Diversion; the Porcupine diversion is rehabilitated; additional sediment pond constructed on Flat Creek near the Silver King highway to reduce suspended loads downstream in Flat Creek and the Porcupine diversion			A north drainage way is constructed to follow the historic path of Flat Creek; a south drainage way is constructed to drain Elsa hillside to a rehabilitated Porcupine Diversion; both diversions end in a sediment pond
Dams and Ponds	The dams and ponds are retained in their current configuration; Dams No. 1, No. 2, and No. 3 are fortified		All dams are breached with center portions filled with gravel for drainage; ponds drained, covered, and graded for drainage	All dams are removed, ponds drained, and areas graded for drainage and reclamation
Water Treatment	Water treatment required during construction and in future; Pond 3 used as a storage reservoir for water treatment plant; water treatment for metal removal and clarification prior to discharge to Flat Creek		Water treatment required during construction and for short-term future; a collection pond constructed below the current location of Dam No. 3 for storage for the treatment plant; water treatment for metal removal and clarification prior to discharge to Flat Creek	Water treatment required during construction and until all onsite surface exposed to tailings treated and discharged; water treatment expected to end after all tailing are removed
Post-construction requirements	Dam inspection; groundwater and surface water monitoring; vegetation monitoring; general maintenance of diversions		Groundwater and surface water monitoring; vegetation monitoring; general maintenance of diversions	Groundwater and surface water monitoring; vegetation monitoring; general maintenance of diversions; maintenance of lined facilities

Estimated Costs				
Total Cost (present-day actual cost without inflation)	$21,200,000	$23,000,000	$26,500,000	$54,100,000
Risks				
Performance of covers and reclamation	Largest area of cover increases potential for failure; direct revegetation of tailings in the Elsa hillside may be difficult	Poor cover performance may result in erosion of tailings and transport to Flat Creek and failure of re-vegetation		Liner may leak or water buildup may overflow and be released to downgradient areas above Flat Creek; removal of wet tailings may be difficult
Dams	Dam failure due to intense freshet or precipitation event; inspections required	Dam failure due to intense freshet or precipitation event: inspections required	Not applicable (dams removed)	
Ponds	Ponds are retained and are potential transport pathways for metal uptake by wildlife	Ponds are retained and are potential transport pathways for metal uptake by wildlife	Not applicable (ponds removed)	
Water treatment performance	Improvements in water quality unlikely, resulting in long-term operation of a water treatment plant; Plant failure would discharge poor water quality to Flat Creek	Plant failure would discharge poor water quality to Flat Creek		
Metal mobilization	Limited amount of lime addition may not appreciable improve metal release from current rates; failure of containment by peat may result in metal release to groundwater	Large amount of surface disruption may result in short-term release of metals; failure of containment by peat may result in metal release to groundwater		Metals may be released from the lined facility due to liner failure or buildup of water in the lined facility, overflowing to downgradient area
Aesthetics	All manmade structures left in place in the valley bottom results in unnatural landscape; water treatment plant increases traffic; consolidated tailings areas and areas of tailings relocation may have unnatural appearance until vegetation is established		Consolidated tailings may have unnatural appearance until vegetation is established; loss of historical mining facility	Consolidated tailings may have unnatural appearance until vegetation is established; loss of historical mining facility; previously unaffected area is disrupted to construct lined facility; upper Flat Creek is returned to natural stream course
Cost Increases	Unknown longevity of water treatment; erosion of tailings from Elsa hillside and poor cover performance may require repair and maintenance; inflationary cost increases for labour, equipment, repair, and inspection and maintenance of structures	Poor cover performance may require repair and maintenance; inflationary cost increases for labour, equipment, repair, and inspection and maintenance of structures		Difficulties in removing wet tailings may take longer and be more difficult than expected; poor cover performance may require repair and maintenance; inflationary cost increases for labour, equipment, repair, and inspection and maintenance of structures

Table 6-2. Summary of VTF Closure Alternatives, Methods, Costs, and Risks



LEGEND

- EXISTING VALLEY TAILINGS AREA
- PROPOSED BORROW AREA
- EXISTING ELSA HILLSIDE TAILINGS AREA

120 0 120
(In Meters)
1 cm = 80 M

ISSUE / REV	DESCRIPTION	TECH	ENG	DATE
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DATUM: NAD83

SCALE: 1 cm = 80 cm

DESIGNED BY	T. EARY	3-25-2011
DRAWN BY	C. WELKEN	3-25-2011
CHECKED BY	B. CARLSON	3-25-2011
APPROVED BY		
PROJECT MANAGER		
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
HISTORIC VALLEY TAILINGS

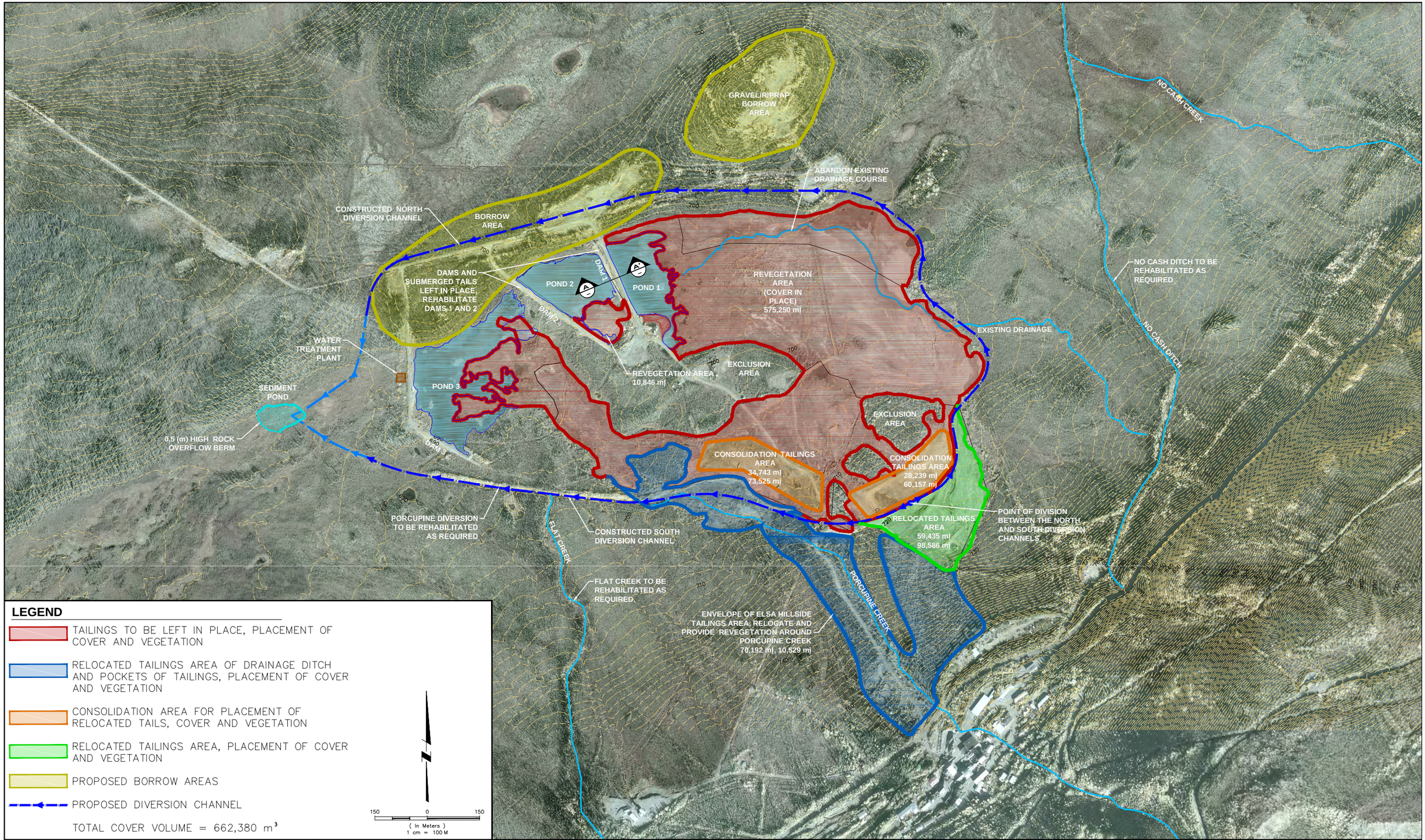
INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING
FIGURE 6-1

REVISION

FILE NAME
Tailings Exhibit_Areas

DRAWING FILENAME: X:\Projects\120209 - Keno-Hood\Keno Civil\Exhibits\Tailings Exhibit_Areas.dwg LAYOUT NAME: HISTORIC_VALLEY DATE: Mar 25, 2011 - 4:49pm CAD OPERATOR: mcohen
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GRAVEL/RIPRAP BORROW AREA
CONSTRUCTED NORTH DIVERSION CHANNEL
BORROW AREA
ABANDON EXISTING DRAINAGE COURSE
NO CASH CREEK
DAMS AND SUBMERGED TAILS LEFT IN PLACE, REHABILITATE DAMS 1 AND 2
DAM 1
DAM 2
POND 2
POND 1
REVEGETATION AREA (COVER IN PLACE) 575,250 m²
NO CASH DITCH TO BE REHABILITATED AS REQUIRED
EXISTING DRAINAGE
NO CASH DITCH
WATER TREATMENT PLANT
SEDIMENT POND
POND 3
DAM 3
REVEGETATION AREA 10,846 m²
EXCLUSION AREA
EXCLUSION AREA
CONSOLIDATION TAILINGS AREA 34,743 m² 73,525 m²
CONSOLIDATION TAILINGS AREA 28,239 m² 60,157 m²
0.5 (m) HIGH ROCK OVERFLOW BERM
PORCUPINE DIVERSION TO BE REHABILITATED AS REQUIRED
CONSTRUCTED SOUTH DIVERSION CHANNEL
FLAT CREEK
FLAT CREEK TO BE REHABILITATED AS REQUIRED
RELOCATED TAILINGS AREA 59,435 m² 98,586 m²
POINT OF DIVISION BETWEEN THE NORTH AND SOUTH DIVERSION CHANNELS
PORCUPINE CREEK
ENVELOPE OF ELSA HILLSIDE TAILINGS AREA, RELOCATE AND PROVIDE REVEGETATION AROUND PORCUPINE CREEK 70,192 m², 10,529 m²
A
A'
700
710
720
730
740
750
760
770
780
790
800
810
820
830
840
850
860
870
880
890
900
910
920
930
940
950
960
970
980
990
1000
1010
1020
1030
1040
1050
1060
1070
1080
1090

GRAVEL/RIPRAP BORROW AREA

CONSTRUCTED NORTH DIVERSION CHANNEL

ABANDON EXISTING DRAINAGE COURSE

DAMS AND SUBMERGED TAILS LEFT IN PLACE, DAMS 1 AND 2 TO BE REHABILITATED

BORROW AREA

POND 2

POND 1

DAM 1

DAM 2

REVEGETATION AREA (COVER IN PLACE) 175,124 m|

INTERCEPTION POINT OF EXISTING DRAINAGE COURSE BY CONSTRUCTED DIVERSION CHANNEL

NO CASH DITCH TO BE REHABILITATED AS REQUIRED

NO CASH CREEK

NO CASH DITCH

EXISTING DRAINAGE

WATER TREATMENT PLANT

SEDIMENT POND

POND 3

DAM 3

CONSOLIDATION AREA FOR RELOCATED TAILINGS 158,922 m| TAILINGS = 389,439 m| OVER EXCAVATION = 148,148 m|

EXCLUSION AREA

RELOCATED TAILINGS AREA 10,850 m|, 5,425 m| (ASSUMING TOP 0.5M HAUL, REMAINING SUBMERGED STAY IN PLACE)

0.5 (m) HIGH ROCK OVERFLOW BERM

RELOCATED TAILINGS AREA 296,295 m| 337,278 m| (HAUL)

EXCLUSION AREA

EXCLUSION AREA

POINT OF DIVISION BETWEEN THE NORTH AND SOUTH DIVERSION CHANNELS

PORCUPINE DIVERSION TO BE REHABILITATED AS REQUIRED

RELOCATED TAILINGS AREA 38,820 m|, 11,646 m| (ASSUMING TOP 0.3m HAUL, REMAINING SUBMERGED STAY IN PLACE)

FLAT CREEK

CONSTRUCTED SOUTH DIVERSION CHANNEL

INTERCEPTION POINT OF EXISTING DRAINAGE COURSE BY CONSTRUCTED DIVERSION CHANNEL

EXCLUSION AREA

PORCUPINE CREEK

FLAT CREEK TO BE REHABILITATED AS REQUIRED

ENVELOPE OF ELSA HILLSIDE TAILINGS AREA, PROVIDE REVEGETATION AROUND PORCUPINE CREEK AND OTHER POCKETS OF TAILINGS TO BE DELINEATED AT A LATER DATE 70,192 m|, 35,096 m|

LEGEND

- CONSOLIDATION AREA FOR PLACEMENT OF RELOCATED TAILINGS, COVER AND VEGETATION
- RELOCATED TAILINGS AREA, PLACEMENT OF COVER AND VEGETATION
- RELOCATED TAILINGS AREA OF DRAINAGE DITCH AND POCKETS OF TAILINGS, PLACEMENT OF COVER AND VEGETATION
- RELOCATED UNSUBMERGED TAILINGS AREA, PLACEMENT OF COVER AND VEGETATION
- TAILINGS TO BE LEFT IN PLACE, PLACEMENT OF COVER AND VEGETATION
- PROPOSED BORROW AREA
- PROPOSED DIVERSION CHANNEL

TOTAL VOLUME OF COVER = 443,992 m^3

N

150 0 150
(In Meters)
1 cm = 100 M

ISSUE REV	DESCRIPTION	TECH	ENG	DATE
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DATUM: NAD83 SCALE: 1 cm = 100 cm

DESIGNED BY	C. GREEN	3-25-2011
DRAWN BY	C. WELKEN	3-25-2011
CHECKED BY	B. CARLSON	3-25-2011
APPROVED BY		
PROJECT MANAGER		
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
VALLEY TAILINGS ALT-2A

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-3 REVISION

FILE NAME VTF-CLOSURE-ALTERNATIVE-2

DRAWING PLOTTED: V:\Projects\VTF0000 - Keno-Hoodoo Exp\Admin\VTF-CLOSURE-ALTERNATIVE-2.dwg LAYOUT PLOTTED: ALT-2A DATE: Mar 24, 2011 - 4:43pm CAD OPERATOR: cadman
LIST OF XREFS: [VTF0000_xTOPO] [VTF0000_xPOND] [VTF0000_xPOND] [VTF0000_xPOND

GRAVEL/RIPRAP BORROW AREA

NO CASH CREEK

FILL OVER TAILINGS IN PONDS WITH BORROW MATERIAL 86,395 m| 172,790 m| (2m DEEP)

REESTABLISH NATURAL DRAINAGE PATTERNS IN BOTTOM OF REVEGETATED AREA

WATER TO BE PUMPED AND TREATED, DAMS TO BE BREACHED

BORROW AREA

CONSTRUCTED NORTH DIVERSION CHANNEL

B'

REVEGETATION AREA (COVER IN PLACE) 175,124 m|

POND 2

POND 1

DAM 1

NO CASH DITCH TO BE REHABILITATED AS REQUIRED

INTERCEPTION POINT OF EXISTING DRAINAGE COURSE

NO CASH DITCH

FILL OVER TAILINGS IN PONDS WITH BORROW MATERIAL 65,670 m|, 131,340 m| (2m DEEP)

EXISTING DRAINAGE

WATER TREATMENT PLANT

DAM 2

CONSOLIDATION AREA FOR RELOCATED TAILINGS 158,922 m| TAILINGS = 389,439 m| OVER EXCAVATION = 148,148 m|

RELOCATED TAILINGS AREA 10,850 m|, 5,425 m| (ASSUMING TOP 0.5m HAUL, SUBMERGED TO REMAIN)

SEDIMENT POND

POND 3

B

EXCLUSION AREA

0.5 (m) HIGH ROCK OVERFLOW BERM

DAM 3

EXCLUSION AREA

RELOCATED TAILINGS AREA 296,295 m| 337,278 m|

POINT OF DIVISION BETWEEN THE NORTH AND SOUTH DIVERSION CHANNELS

WATER TO BE PUMPED AND TREATED, DAMS TO BE BREACHED

PORCUPINE DIVERSION TO BE REHABILITATED AS REQUIRED

RELOCATED TAILINGS AREA 38,820 m|, 11,646 m| (ASSUMING TOP 0.3m HAUL, SUBMERGED TO REMAIN)

CONSTRUCTED SOUTH DIVERSION CHANNEL

FLAT CREEK

EXCLUSION AREA

PORCUPINE CREEK

FLAT CREEK TO BE REHABILITATED AS REQUIRED

ENVELOPE OF ELSA HILLSIDE TAILINGS AREA, PROVIDE REVEGETATION AROUND PORCUPINE CREEK AND OTHER POCKETS OF TAILINGS TO BE DELINEATED AT A LATER DATE 70,192 m|, 35,096 m|

LEGEND

- CONSOLIDATION AREA FOR PLACEMENT OF RELOCATED TAILINGS (HAUL), COVER AND VEGETATION
- RELOCATED TAILINGS AREA, PLACEMENT OF COVER AND VEGETATION
- RELOCATED TAILINGS AREA OF DRAINAGE DITCH AND POCKETS OF TAILINGS, PLACEMENT OF COVER AND VEGETATION
- TOP 1 m TAILINGS REMOVED. RELOCATED PUMPED TAILINGS PLACED 1 M DEEP, PLACEMENT OF COVER AND VEGETATION.
- RELOCATED TAILINGS VIA HAUL, ASSUMED 0.3 M THICK, PLACEMENT OF COVER AND VEGETATION
- PROPOSED BORROW AREA
- FILL POND VOLUME WITH GRAVEL BORROW MATERIAL (REPLACING WATER VOLUME IN POND), ASSUME 2.0 M THICK, COVER AND VEGETATION
- PROPOSED DIVERSION CHANNEL

TOTAL VOLUME OF COVER = 748,122 m^3

N

150 0 150

(In Meters)
1 cm = 100 M

ISSUE REV	DESCRIPTION	TECH	ENG	DATE
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DATUM: NAD83

SCALE: 1 cm = 100 cm

DESIGNED BY	C. GREEN	3-25-2011
DRAWN BY	C. WELKEN	3-25-2011
CHECKED BY	B. CARLSON	3-25-2011
APPROVED BY		
PROJECT MANAGER		
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
VALLEY TAILINGS ALT-2B

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-4

REVISION

FILE NAME VTF-CLOSURE-ALTERNATIVE-2

DRAWING PLOTTED: S:\Projects\VTF\2010 - Misc-Keno\Keno Cad\Exhibits\VTF-CLOSURE-ALTERNATIVE-2.dwg LAYOUT PLOTS: ALT-2B DATE: Mar 24, 2011 - 4:47pm CAD OPERATOR: andrew
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PLACEMENT AREA FOR RELOCATED TAILINGS
76,000 m²
20 m HIGH
TAILS-685,115 m³
OVER EX-MAT.-407,228 m³
(HAUL)

PLACEMENT AREA FOR RELOCATED TAILINGS
POND-210,575 m³
POND-1,117,487m³
TAILS POND-868,143 m³
BORROW
BERM-170,922 m³
7 m DEEP
6 m HIGH BERM
(PUMP)

GRAVEL/RIPRAP BORROW AREA

RELOCATED SUBMERGED TAILINGS AREA
33,374 mł, 35,472 mł (PUMP)

WATER TO BE PUMPED AND TREATED, DAMS TO BE REMOVED

RELOCATED SUBMERGED TAILINGS AREA
67,440 mł
243,850 mł
(PUMP)

REESTABLISH NATURAL DRAINAGE PATTERNS IN BOTTOM OF REVEGETATED AREA

NO CASH CREEK

NO CASH DITCH TO BE REHABILITATED AS REQUIRED

BORROW AREA

POND 1

POND 2

DAM 1

DAM 2

RELOCATED DEEP TAILINGS AREA
324,010 mł
906,995 mł-ALL UNSUBMERGED
1 m THICK
(HAUL & PUMP)

EXISTING DRAINAGE

NO CASH DITCH

RELOCATED SUBMERGED TAILINGS AREA
55,600 mł, 1,589 mł (PUMP)

WATER TREATMENT PLANT

SEDIMENT POND

POND 3

RELOCATED TAILINGS AREA
10,850 mł, 7,515 mł
ALL UNSUBMERGED
0.5 m THICK
(HAUL & PUMP)

EXCLUSION AREA

EXCLUSION AREA

REESTABLISH NATURAL DRAINAGE PATTERNS IN BOTTOM OF REVEGETATED AREA

0.5 (m) HIGH ROCK OVERFLOW BERM

DAM 3

PORCUPINE DIVERSION

RELOCATED SHALLOW TAILINGS AREA
284,362 mł
308,938 mł
(HAUL)

EXCLUSION AREA

WATER TO BE PUMPED AND TREATED, DAMS TO BE REMOVED

RELOCATED TAILINGS AREA
38,820 mł, 13,803 mł
ALL UNSUBMERGED
0.3 m THICK (HAUL & PUMP)

FLAT CREEK

PORCUPINE DIVERSION TO BE REHABILITATED AS REQUIRED

EXCLUSION AREA

PORCUPINE CREEK

FLAT CREEK TO BE REHABILITATED AS REQUIRED

ENVELOPE OF ELSA HILLSIDE TAILINGS AREA, PROVIDE REVEGATATION AROUND PORCUPINE CREEK AND OTHER POCKETS OF TAILINGS TO BE DELINEATED AT A LATER DATE
70,192 mł, 35,086 mł

LEGEND

TOTAL COVER VOLUME = 686,111 m³

- CONSOLIDATION AREA FOR PLACEMENT OF RELOCATED TAILS, COVER AND VEGETATION
- RELOCATED DEEP TAILINGS AREA, PLACEMENT OF COVER AND VEGETATION
- RELOCATED SHALLOW TAILINGS AREA, PLACEMENT COVER AND VEGETATION
- RELOCATED SUBMERGED TAILINGS AREA (PUMPED), PLACEMENT COVER AND VEGETATION
- RELOCATED UNSUBMERGED TAILINGS AREA (HAUL AND PUMPED), PLACEMENT COVER AND VEGETATION
- RELOCATED TAILINGS AREA OF DRAINAGE DITCH AND POCKETS OF TAILINGS, PLACEMENT OF COVER AND VEGETATION
- PROPOSED BORROW AREA
- PROPOSED DIVERSION CHANNEL

150 0 150
(In Meters)
1 cm = 100 M

ISSUE/REV	DESCRIPTION	TECH	ENG	DATE
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DATUM: NAD83 SCALE: 1 cm = 100 cm

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APPROVED BY		
PROJECT MANAGER		
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

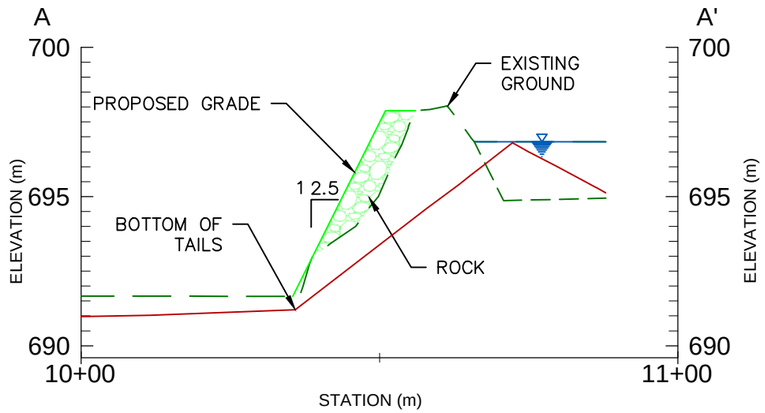
TITLE
VALLEY TAILINGS
ALT-3

INTERRA
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DRAWING FIGURE 6-5 REVISION

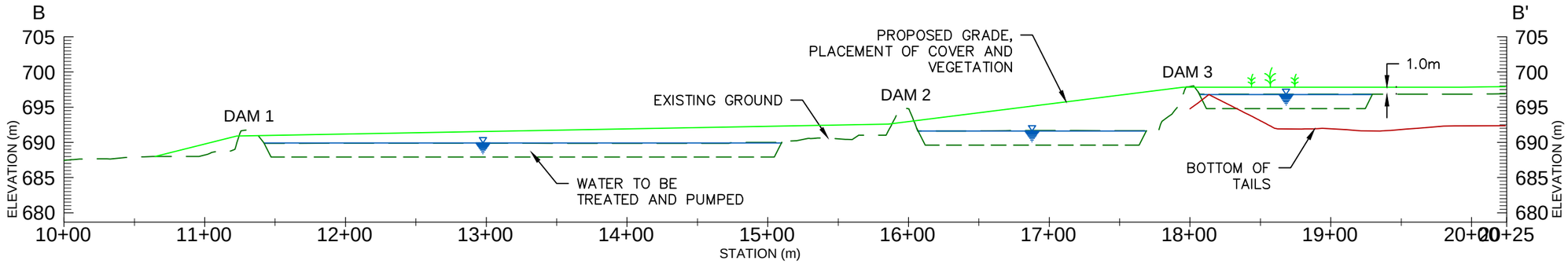
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LIST OF XREFS: [120000_xrfVTF] [120000-Aftershade-xs-base-Model] [120000_xrefs]



DAM REHABILITATION - SECTION A-A'

SCALE: 1cm = 10m (5 VERTICAL EXAGGERATION)



PLACEMENT OF BORROW MATERIAL AND COVER OVER DRAINAGE PONDS (ALT 2B ONLY) - SECTION B-B'

SCALE: 1cm = 33.3m (5 VERTICAL EXAGGERATION)

ISSUE / REV	DESCRIPTION	TECH	ENG	DATE
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CLIENT REFERENCE NO.		

PROJECT LOCATION: KENO,YUKON, CANADA

PROJECT: KENO

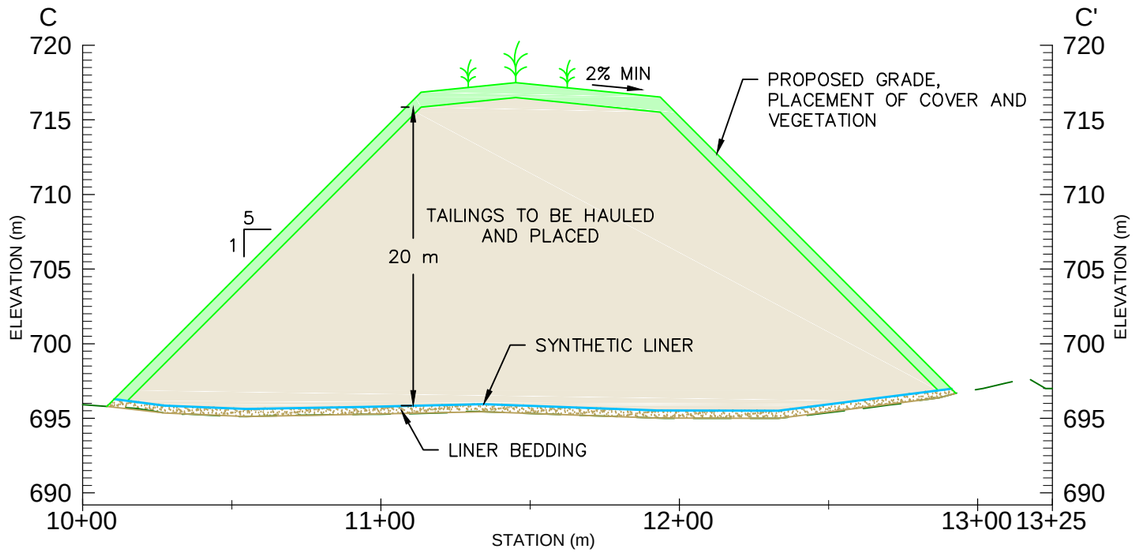
TITLE: VALLEY TAILINGS PROFILES

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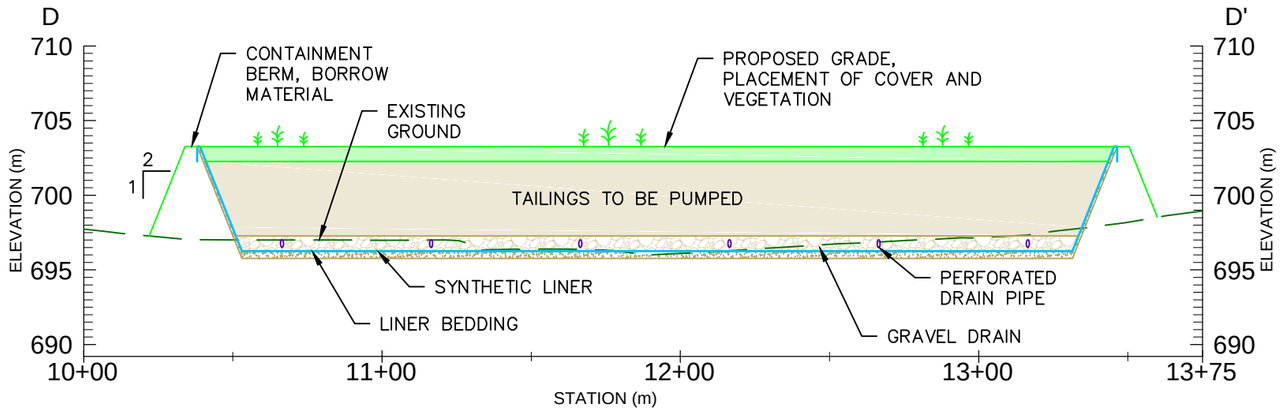
DRAWING: FIGURE 6-6

REVISION:

FILE NAME: VTF-CLOSURE-SECTIONS



HAULED AND PLACED TAILINGS
(ALT 3 ONLY) - SECTION C-C'
SCALE: 1cm = 20m (5 VERTICAL EXAGGERATION)



PUMPED-SLURRY TAILINGS
(ALT 3 ONLY) - SECTION D-D'
SCALE: 1cm = 20m (5 VERTICAL EXAGGERATION)

ISSUE / REV	DESCRIPTION	TECH	ENG	DATE
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CLIENT APPROVAL		
CLIENT REFERENCE NO.		

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
VALLEY TAILINGS
PROFILES

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Fort Collins, Co 80525
970.225.8222

DRAWING: FIGURE 6-7
REVISION:
FILE NAME: VTF-CLOSURE-SECTIONS

6.3 **Adit/Shaft Water Treatment**

It is useful to classify adit systems as "high flow, high concentration" systems, "high flow, low concentration" systems, "low flow, high concentration" system, and "low flow, low concentration" systems. In general, the high flow, high concentration systems will require an active treatment technology, where lower flow and lower concentration systems are candidates for more passive treatment approaches. Tables 6-3 through 6-5 summarize metal loads from the key adits in the KHSD.

	Annual average of continuous flowmeter measurement					
	2006	2007	2008	2009	2010	2011
Galkeno 300	348,375	349,091	344,520	386,043	331,073	274,637
Galkeno 900	118,781	104,182	90,592	86,077	80,914	87,985
Silver King 100	245,197	186,632	215,103	239,710	170,640	127,217
	Average of 5 years quarterly field measurements					
No Cash 500	173,567					
Onek 400	66,587					
Keno 700	107,296					
Bermingham 200	60,906					
Ruby 400	30,611					
Husky SW Shaft	13,254					
Sadie Ladue Adit	241,100					
LES-66 Natural Spring	78,894					

* Continuous flow meter measurements
** Averaged manual field measurements

Table 6-3. Annual Adit Discharge in Keno Hill District.

	Total Zinc (mg/L)					Loading (kg)				
	2007	2008	2009	2010	2011	2007	2008	2009	2010	2011
Galkeno 300	112.7	99.9	103.3	93.9	82.8	39,359	34,425	39,864	31,082	22,746
Galkeno 900	5.46	5.55	6.09	5.87	5.50	569	503	524	475	484
Silver King 100	0.925	0.846	0.907	0.797	0.853	173	182	217	136	109
	Average of 2006-2010 data					Average of 2006-2010 data				
No Cash 300	11.04					1916				
Onek 400	78.6					5234				
Keno 700	1.41					151				
Bermingham	3.41					208				
Ruby	1.47					45				
Husky SW Shaft	1.02					13				
UN Adit	0.396					5				
Sadie Ladue Adit	0.737					178				
LES-66 Natural Spring	0.110					9				

Table 6-4. Zinc concentration and loading from adits in the KHSD

	Total Cadmium (mg/L)	Annual Loading (kg)
	Average of 2006-2010 data	Average of 2006-2010 data
Galkeno 300	0.309	107.65
Galkeno 900	0.0014	0.17
Silver King 100	0.0098	2.41
No Cash 500	0.124	21.54
Onek 400	1.474	98.15
Keno 700	0.012	1.29
Bermingham	0.166	10.12
Ruby	0.0163	0.50
Husky SW Shaft	0.0141	0.19
UN Adit	0.002	0.03
Sadie Ladue Adit	0.0045	1.08
LES-66 Natural Spring	0.00087	0.07

Table 6-5. Cadmium concentration and loading from adits in the KHSD

Five approaches for adit water treatment are considered viable for consideration for each individual mine drainage locations, which are:

1. Managed natural attenuation, where water is discharged from the adit through engineered structures into the natural environment; treatment is accomplished through natural physical, chemical and biological processes in the environment; monitoring is performed to demonstrate that treatment is occurring in a sustainable manner prior to water reaching the receiving stream.
2. Bioreactor with sulphate-reducing processes, where water is discharged from the adit into a lined facility; treatment is accomplished by passage of the water through the bioreactor which contains permeable substrate to sustain sulphate reducing processes, and metal precipitation as metal sulphides, with an option to add a soluble carbon source to also sustain sulphate reducing processes; an aeration polishing step to remove residual carbon is sometimes required; monitoring is performed at the discharge location.
3. Mine pool treatment with alkaline or sulphate-reducing processes, where an injection location is established, and water is recirculated within the mine workings to distribute an organic carbon substrate to cause sulphate reduction and metal precipitation as metal sulphides; treatment is typically accomplished in a single annual cycle of injections; an aeration polishing step to remove residual carbon is sometimes required; monitoring is performed at the discharge location of the adit or the aeration step.
4. Active water treatment, typically with lime precipitation or other metals precipitation process; water is discharged from the adit into an equalization or storage basin, drawn into a rapid mix tank with the selected reagents, and precipitates are separated by a clarifier/sludge thickener process; sludge could returned to the mine pool, or pressed to make a sludge cake which would be placed in a landfill on site. Two location-based variants of this approach are considered:
    a. Individual treatment facility located near a single adit source.
    b. Combined treatment facility located in a common area.

5. Reclamation only, where surface reclamation activities alone result in prevention of source material leaching, making additional treatment unnecessary; in this case reclamation activities are implemented to prevent infiltration through mine workings to the extent practical through the backfilling of open pits to create free draining backfill zones with a cover layer that has fine grained properties to support revegetation.

6.3.1 **Alternatives Considered But Not Advanced**

The following alternatives were considered but not advanced for further analysis at this time:

1. Addition of solid phase iron to mine drainage water to enhance natural attenuation in mine drainage waters that are low in iron, such as Keno 700. This alternative was considered potentially viable as a way to enhance natural attenuation, because the primary removal mechanism documented at No Cash is the coprecipitation of metals with iron and manganese hydroxides. However, there are aesthetic concerns about adding iron which will create staining and sludge buildup in the drainage. In addition, in an active stream where deposition and burial of iron hydroxides is likely to occur, it is possible that these iron oxides will not be stable and metal re-release could occur.
2. Constructed wetlands treatment of mine drainage water utilizing plant-based removal mechanisms. This was tested at Galkeno 900 in 1995, with decent removal in the summer months, but essentially no removal of metals in cold months. Consequently, this is viewed at best as a potential seasonal polishing treatment used in conjunction with other alternatives and not as a stand along treatment technology.
3. Passive chemical reactors, such as with zero valent iron (ZVI), have been used effectively to treat mine waters for metals including zinc. However, the treatment is not as effective in higher sulphate waters, due to surface

passivation of the ZVI. It is also a relatively high cost per unit of treatment making it a less attractive option.

4. As discussed below, treatment approaches that are considered viable for some sites are not considered viable for others and therefore were not advanced at specific sites. For example, passive treatment approaches may not be appropriate for high flow high concentration adit systems.

6.3.2 **Managed Natural Attenuation**

Natural attenuation has been studied extensively in the No Cash drainage. This drainage receives inputs from No Cash 500 adit, Ruby adit, and Bermingham adit. In-stream concentrations are reduced by >99.9% for zinc and cadmium along the flow path in this stream, and more conservative elements show very limited dilution, indicating that physical, chemical, or biological processes are effectively removing these metals from the drainage (Interralogic 2010 and references contained within; Interralogic 2011). The very high efficiency of metals removal by this drainage, and the apparent robustness of the treatment mechanisms makes this technology have promise for long term closure of water draining from old mines in a passive configuration.

6.3.2.1 Natural Attenuation Treatment Processes

The treatment processes responsible for the water quality improvements are largely sustainable processes; these processes include:

- Aeration of the water leading to metal hydroxide or metal oxide precipitation and co-precipitation removing zinc and cadmium as part of the iron or manganese minerals (the sustainable process relies on oxygen in the atmosphere to continue to be present, iron and/or manganese present in the mine discharge, and sufficient alkalinity to keep the pH above approximately pH 5 to allow insoluble iron-based metal precipitates to form).

- Sorption of the metals to peat and vegetative materials in the bog area (the sustainable processes relies on continued vegetation growth and peat deposition in the bog area).
- Sulphide-based precipitation, where sulphate in the mine drainage is reduced by microbes to produce aqueous sulphide, which forms authigenic sulphide minerals in the bog area (the sustainable process relies on continued vegetation growth and peat deposition in the bog area, which are sources of organic carbon for microbial sulphate reduction).

These three processes act in concert, where the bulk of the metals are precipitated by the aeration process on the hill side, and the vegetative and microbial processes act to polish the remaining metals not removed by the aeration processes in the boggy area.

The application of the natural attenuation process relies on the following geographic or physical setting requirements:

- A physical configuration that supports aeration and settling of precipitates formed from aeration of mine waters, which could be in an engineered setting such as a buried aeration cascade and settling basin.
- Contact with vegetative materials especially peat-forming vegetation where metals can be adsorbed.
- Contact with potentially anaerobic sediment or wetland areas where sulphate reduction can occur and metal sulphides can be formed.
- A sufficient monitoring zone to document that these processes are occurring in a stable configuration.

6.3.2.2 Potential Treatment Locations Utilizing Managed Natural Attenuation

The adit locations where the above requirements appear to be possible include the No Cash drainage sites (No Cash 500, Ruby, and Bermingham); Flat Creek drainage sites

(Silver King 100 and Husky SW), and the Ladue River drainage site at Sadie Ladue 600. The locations where it appears there is a limiting factor that makes Managed Natural Attenuation not possible are the Christal Creek sites (Galkeno 300, Galkeno 900, and Onek 400), and the Lightning Creek site at Keno 700.

Galkeno 300 has a very high initial concentrations and a short flow path to the receiving environment (Christal Creek) with a lack of a boggy polishing area which eliminates this technology for consideration. Galkeno 900 lacks sufficient room to perform natural attenuation prior to flow into Christal Lake/Christal Creek. Onek 400 has a very high initial concentration of both cadmium and zinc, and infiltrates to ground at least seasonally. Kwong (1997) studied the attenuation of metals from this drainage, and documented extensive natural attenuation but not to a level great enough to assure sufficient metals reduction prior to reaching the surface receiving environment. In addition, there is a risk of contamination of the local groundwater which is used as a water supply for Keno City by the waters infiltrating from the Onek adit. Keno 700 discharges through waste rock and rapidly into gravels that are in the headwaters of Lightning Creek. There is room for aeration, but there is little potential for polishing in a boggy setting as there is little vegetative area in this location. Analysis of the mass balances of zinc leaving the Keno 700 mine and in the headwaters of Lightning Creek shows that little attenuation is occurring in the existing configuration.

6.3.2.3 Adaptive Management of Natural Attenuation

In the No Cash drainage, monitoring is readily available in the stream channel at the Silver Trail highway to document metals concentrations prior to entering the bog area. This provides a good check to ensure that primary attenuation by the aeration processes continues during closure. A surface pond that is the low point of the bog also provides a "terminus point" for monitoring prior to apparent infiltration of the water into gravels at a central moraine, long before any potential for surface water impacts (which would

occur at some downgradient location on the South McQuesten River). Monitoring of seasonal trends indicates that attenuation reactions are occurring during all seasons that have been measured (winter, summer, and fall), and additional freshet monitoring is planned in 2011 to provide further documentation of the robustness of the natural attenuation processes on a year-round basis especially during freshet.

If managed natural attenuation were selected for the mine sites in the No Cash drainage, there are many opportunities for adaptive management. Source area monitoring at the No Cash 500, Ruby, and Bermingham adits could be used to determine if increased source loads or changes in water chemistry were responsible for changes in treatment efficiency. If a single site were to become substantially changed in water chemistry a backup treatment process such as a bioreactor or mobile lime treatment process could be implemented to pre-treat the water from the problematic adit.

Reclamation activities in the No Cash drainage are also expected to have a positive impact on water quality in the adits that comprise the sources of metals. For instance, berms and water diversions around the Bermingham pit and Ruby waste rock areas will tend to limit the amount of water flow through mine areas and should limit the flushing of metals from the mines into the No Cash Creek. Additional reclamation activities could have benefits to No Cash 500 adit drainage such as diversions in the No Cash 100 area to limit infiltration in the No Cash mine area. This will be investigated in 2011 or 2012 by the injection of dye containing water into the mine and evaluation of the timing of dye release from the No Cash 500 adit.

In other drainages where managed natural attenuation might be chosen as the preferred closure option, adaptive management could involve similar implementation of a more active treatment technology to reduce metal loading to the natural attenuation

zone, or maintenance of the reclamation components of the mine site to minimize loading of metals from the mine into the treatment zone.

6.3.3 **Sulphate Reducing Bioreactor**

Alexco Environmental Group (2011) has operated a test bioreactor at the Galkeno 900 mine site. In general, once the onset of sulphate reducing conditions occurred after a commissioning period, effective treatment was accomplished with a test flow rate range of 0.5-1.0 l/s. The primary failure mode of the bioreactor was failure of the pumping systems due to power outages, which happened several times per year. The configuration of the current bioreactor is not sub-optimal due to the very limited footprint available at Galkeno 900 and the regulatory requirement to operate the bioreactor upstream of the lime treatment system. However, the objectives of the test were accomplished, specifically that sulphate reducing rates were established for year-round operation, and it was demonstrated that the sulphate bioreactor technology could achieve discharge water quality standards as set forth under the existing water licence QZ06-074.

6.3.3.1 Sulphate Reducing Bioreactor Treatment Processes

The sulphate reduction bioreactor treatment process which is responsible for the water quality improvements requires the availability of a carbon source, which can be supplied in the form of biomass, such as peat, wood chips, compost, or in a dissolved form such as sugar solutions or alcohols. It also requires a permeable matrix to allow the mine water to be treated to flow through the matrix, and the matrix must also be suitable for sulphate-reducing microbes to colonize the matrix. In the Keno Hill environment, these requirements can be achieved by filling a pond with gravels and small amounts of biomass substrates, and continuing to supply a soluble carbon source at a rate stoichiometrically required for sufficient sulphate reduction to precipitate the metals in

the mine water. Burying the pond can be performed to maintain water flow in the cold wintertime conditions.

A common bioreactor approach that will not work in the Keno Hill environment utilizes biomass as the only carbon source. While this is commonly done in many bioreactor applications, it can lead to sulphate reduction beyond what is required for metals precipitation, with the potential for residual sulphide in the bioreactor discharge, and consequent possible toxicity to aquatic organisms. In addition, degradation of plant materials especially in the initial phases of bioreactor operation can produce an excess of organic acids and reduced nitrogen compounds (e.g. ammonia) which themselves can consume oxygen in surface water and also can be toxic to aquatic organisms. Toward the end of the biomass-based bioreactor useful operating life, the bioreactor can become less effective especially during cold temperature periods due to the slower degradation of biomass in cold temperatures, and the exhaustion of readily degraded carbon sources.

The problems encountered in biomass-based bioreactors will be avoided by using a small amount of biomass in the construction, and instead primarily relying on a regular supply of a carbon source. During the Galkeno 900 bioreactor testing, the addition of a carbon source as infrequently as every two weeks provided sufficient treatment. This will either require small amounts of power or regular operator visits, which make this bioreactor design not completely passive, but will lead to acceptable discharge from the bioreactor. A small amount of biomass will aid the stability of the anaerobic conditions which will help prevent upset conditions from forming due to variable carbon loading if it were to occur.

6.3.3.2 Potential Sites Utilizing Bioreactor Treatment

The adit locations where a bioreactor appears to be a feasible technology to be implemented include the No Cash drainage sites (No Cash 500, Ruby, and Bermingham)

Flat Creek drainage sites (Silver King 100 and Husky SW), the Ladue River drainage site at Sadie Ladue 600, the Christal Creek sites (Galkeno 900, and Onek 400), and the Lightning Creek site at Keno 700.

In several of these cases, the primary limitation will be the availability of stable ground from a geotechnical perspective upon which a bioreactor can be constructed. This may necessitate in some cases a buried pipeline to transmit the water from the adit to the bioreactor location. In the case of Galkeno 300 it is possible that a bioreactor could accomplish the treatment, but the principal limitation in that location beside stable ground is the uncertainty about the long term permeability and the replacement rate of the media due to loss of available pore space from metal precipitation. No noticeable loss of permeability was observed at the Galkeno 900 bioreactor, however the relative concentration of metals requiring treatment was more than 20 times less than what is in the Galkeno 300 discharge. Bioreactors, where high concentration water has been treated successfully, often have special designs where bioreactor effluent is recycled to the front of the bioreactor for a pre-treatment step, but in those cases the bioreactor becomes similar to an active treatment plant.

6.3.3.3 Adaptive Management of Bioreactor Systems

Since the bioreactor design being contemplated here has active components, adaptive management can be readily performed in several ways. A primary management technique will be adjusting the application rate of the soluble carbon source. If additional treatment is required, additional bioreactor cells can be added in series or in parallel. If excessive sulphide or residual organic carbon is present, an aeration system can be added, either an active bubbling system or a buried passive tumbling system.

6.3.4 **Mine Pool Treatment**

Alexco Resource US Corp (2009) reviewed underground mine workings in the Keno district that had water discharge, and made recommendations about potential sites that could be candidates for underground mine pool treatment.

Mine pool treatment technology is similar to the bioreactor technology in that it relies on the formation and maintenance of sulphate reducing microbes in the mine pool through the addition of a carbon source, which may be coupled with the addition of alkaline reagents such as lime, sodium hydroxide, or residual water treatment sludge.

A handful of sites have been operated in full scale using underground mine pool technology, which provides source control or mitigation prior to water leaving the mine. For example, Alexco has treated the underground mine pool at the Platoro site in Colorado for over 10 years, where initial concentrations of zinc (over 20 mg/L) and arsenic (over 50 mg/L) have been reduced by over 90% and in many cases over 99% by the annual recirculation of water and the addition of a carbon source into the mine pool.

6.3.4.1 Mine Pool Treatment Processes

The principal treatment process utilized in mine pool treatment is microbial sulphate reduction. The addition of a soluble organic carbon source, such as alcohol, sugar syrups, or starches, leads to the growth of microbes that create anaerobic conditions within the mine pool and adjacent mine workings. The organic carbon source is transformed into inorganic carbon, which partitions into bicarbonate alkalinity and carbon dioxide. The formation of an anaerobic mine pool and carbon dioxide off-gassing leads to reduced metal leaching in the zone immediately around the pool, which results in lower mass loading from the mine. In a situation where sufficient residence time is available in the underground workings further improvements in water quality can be achieved by the sulphate reduction reactions described for the bioreactor, where

metal sulphides precipitate throughout the mine pool, coating the wall rocks of mine. Residual iron in host rocks reacts with sulphide forming an iron sulphide coating in the mine, which acts as an anaerobic buffer in the mine pool, and providing treatment in the periods of time when the added carbon source is exhausted. In the case of Platoro, for instance, a single annual dose maintains >90% metal reduction throughout the year, while the carbon source is completely consumed in less than 6 months.

Alkaline reagents such as lime or sodium hydroxide can also be added to the mine pool, and water quality improvements associated with raising the pH is attributed to the precipitation of metal hydroxides such as iron or manganese hydroxides, and the co-precipitation or sorption of other metals with the iron or manganese hydroxides. The adits in the Keno district typically do not have low pH water, and many adit discharges are near neutral with some alkalinity present. However, unlike the formation of iron sulphides in the mine which are relatively compact and stick to the walls of the mine, metal hydroxide sludges are not very dense with many waters of hydration incorporated into the sludge. Consequently, alkaline reagent addition alone is not proposed. Recycling of anaerobic sludge back into the mine workings will be considered for the benefits of the residual alkalinity from the sludge, as well as the permanent storage of the metals in the sludge below the phreatic surface.

6.3.4.2 Potential Sites Utilizing Mine Pool Treatment Technology

There are only a few mine pools in the KHSD. Hector Calumet mine pool (which is inferred to be the source of the Galkeno 300 discharge) and possibly the Galkeno 900 discharge, are both sites with substantial mine pools. Keno 700 discharges from a mine pool, as does Silver King 100. Bermingham has a small pit lake/mine pool that is drained from the Bermingham 200 adit. Husky SW shaft is understood to be connected to the Husky shaft and through underground connections also receives drainage from the Elsa mine.

During the initial risk assessment process, installing high pressure bulkheads to create mine pools was discussed and recommended against. The performance of the Galkeno 900 high pressure adit plug was part of the basis of this recommendation, in that leakage was not substantially stopped (~4 l/s continues to come from leakage around the plug) and seepage of zinc containing water on Galena Hill increased possibly due to leakage to surface from the mine pool. The possibility of high pressure adit plugs creating fugitive flow through seeps was considered high enough and an undesirable outcome that the decision was made to not propose any high pressure adit plugs.

Low pressure adit plugs, where only the level containing the plug is allowed to flood, but not to pressurize, would result in benefits by from creating flexibility of storage in the mine for temporary periods. It will also decrease oxygen flow through the mine, which may decrease metals loading from the mine by decreasing oxidation reactions and associated metals leaching. There are several candidate locations where a low pressure plug is considered part of water treatment solution; however, only a few sites have sufficient potential storage to create residence time to allow for treatment in the mine pool that could be created on the level where the adit plug would be located. Two sites where this is considered possible are the No Cash 500 and Ruby 400 adits, which both have long adits where a plug could allow the adit to fill and create a few weeks of storage in the resulting shallow mine pool.

6.3.4.3 Adaptive Management of Mine Pool Treatment

Several adaptive management techniques are considered possible for mine pool treatment approaches. Similar to the bioreactor technology, adjusting the application rate of the soluble carbon source can be used to adjust the amount of sulphate reduction achieved. If excessive treatment results in excess sulphide, delaying the retreatment of the mine pool will be done. If excessive sulphide or residual organic carbon is present in the mine pool drainage, an aeration system can be added. Either an active bubbling system or a buried passive tumbling system will be used. If the mine

pool drainage is being actively treated, such as by lime-based water treatment, a standard aeration step may be required to oxidize the reduced iron to create ferric iron. Adjusting the pH of the mine pool to greater than pH 7 will also enhance iron sulphide formation, which will tend to have many trace metals coprecipitate within the iron sulphide matrix.

6.3.5 **Active Water Treatment Mechanical Plants**

Lime treatment facilities have been operated successfully in the KHSD at four adit treatment sites: Galkeno 300; Galkeno 900; Silver King 100; and Bellekeno 625. With the upgrades that have been implemented since ERDC purchased the property, the lime treatment sites now have a high rate of compliance with the water quality standards in the WUL QZ06-074. Where out-of-compliance results occur, they are typically due to elevated suspended solids of lime precipitates that have not been settled or filtered out. The existing plants also sometimes have difficulty with pH control due to the variability of influent metal loads, variability of lime quality and reactivity, or spikes of water flow rates.

Lime-based water treatment processes are effective and have the most extensive track record of any treatment process being considered in the KHSD. The drawbacks of lime treatment application across the KHSD include the following:

- KHSD is spread out, which either necessitates long pipelines to collect and transport water to a centralized treatment plant, or else multiple treatment plants spread across the district.
- Lime treatment produces a relatively high volume of sludge compared to any other treatment technology, due to unreacted lime, gypsum, and a sludge that doesn't readily densify without additives.
- Lime treatment plants require operator care and maintenance. Some aspects of the plant can be automated, but often at a significant cost; and the reliability of

power and mechanical systems in remote sites that have weather extremes is a drawback that affects the feasibility of lime treatment at KHSD.

Because of the proven nature of lime treatment, it is seen as the default treatment approach for high flow, high concentration sites, specifically Galkeno 300, and possibly Onek 400. It can also serve as an adaptive management mechanism for sites such as Galkeno 900, No Cash 500, and Keno 700, especially if the plant for other sites is located nearby where a pipeline could feasibly provide access for an upset condition for a more passive treatment site.

6.3.5.1 Active Water Treatment Processes

Lime treatment involves the addition of lime to water to raise the pH and induce metal precipitation by metal hydroxide formation. Typical pH of the water treatment plants in the KHSD is pH 9 to 9.5. At this pH, all the regulated metals are precipitated from solution, though only partial removal of manganese is achieved.

For some water chemistry observed in the KHSD, addition of polymers and/or ferric iron is necessary to achieve sludge settling. These reagents are removed as part of the sludge, and their utilization is somewhat dependent on the separation approach utilized in the treatment process design.

Typical configurations for lime treatment include:

- an equalization basin which helps moderate rapid changes in flow rates,
- a rapid mix tank where the reagents are added to the water and the treatment precipitates are formed,
- a clarifier and/or thickener where the solids are settled from the water,
- an optional recycle line where sludge is returned to the rapid mix tank to provide sites for larger precipitates to form,

- an optional filtration system to remove fine particles that were insufficiently removed by the clarification/thickener process,
- a sludge press to make a drier sludge product which could be placed in a landfill.

Alternative reagents to lime are under consideration for water treatment, and bench scale and field scale tests are planned for the 2011/12 Fiscal Year.

- Sodium hydroxide is an alternative treatment reagent that was tested at Silver King treatment system with good results. It appears that the reagent cost would be somewhat higher, but sludge production rates would decrease, and sludge handling costs would consequently be lower. Bench scale tests to evaluate reagent utilization rates for different sites and potential mixed adit flows are planned.
- Sulphide-based reagents can be used to selectively remove metals, and the key metals of concern in the KHSD, zinc and cadmium, are readily removed in a sulphide-based treatment system. The chief advantage of sulphide-based water treatment is that it only removed metals, making the sludge production very minimal, and what sludge is produced may have economic value. Bench scale tests to evaluate reagent utilization rates for different sites and potential mixed adit flows are planned.
- Electrocoagulation is a treatment technology that also has proven effective for metal removal from mine waters. This process creates a hydrophobic sludge that can easily be collected and transported for disposal or futher re-processing. Preliminary bench-scale tests have shown promising results, and additional larger scale test are being planned.

6.3.5.2 Potential Sites for Active Water Treatment Mechanical Plants

All of the adit discharge sites with the exception of Sadie Ladue 600 are considered candidates for active treatment plants. The reason for this exception is the remoteness

of the site with no power and limited road access. Also, the water quality is very close to WUL QZ06-074 discharge standards already.

6.3.5.3 Adaptive Management of Active Water Treatment Mechanical Plants

Lime treatment mechanical plants as a closure alternative are being considered where a more passive approach is not considered likely to achieve the necessary treatment. Due to the high cost and other drawbacks of active mechanical plants the evaluation of the feasibility to apply more passive treatment approaches is conducted first. If passive systems are ruled out then the utilization active mechanical plants is considered. Some sites such as Galkeno 300 have a mechanical plant is considered to be the default option, due to the high loadings. For a site such as this, the closure options for consideration are related to the location and design of the plant. Where a treatment plant is installed, it will need to be operated in perpetuity or until the water quality entering the plant is improved enough to make other options feasible.

It is important to note that the Galkeno 300 site has shown a trend of decreasing daily adit discharge zinc loads from approximately 120 kg/day in 2007 down to approximately 80 kg/day in 2011. This decreasing trend in loading is consistant with flooding related water trends observed at other documented underground mine sites and at some point in the future will stabilize at a somewhat steady state base metal loading. The complexity of the underground workings at the Galkeno 300 site prevent any prediction of what the steady-state base metal loading from the site will be and when that loading scenario will be achieved. The knowledge that there will be some point in the future be a steady-state base loading at this site indicates there should be the future potential to optimize any active mechanical water treatment plant for this location.

Mine pool treatment upstream of a treatment plant is one approach that may provide a way to eventually eliminate the need to have active water treatment in mechanical plants. In those cases, the installation and operation of the treatment plant will provide

the stable operational situation that will provide certainty of water quality while this source control technology is implemented.

Another approach that may have application at the KHSD that could provide cost savings is through mine pool storage. This involves the utilization of underground workings for storage of water and allows for sizing of the treatment system to treat water at a rate such that all of the treatment could be accomplished from late spring through to fall. This provides a cost benefit through limiting operations to primarily the snow-free period of the year when site access and operating costs are lower. The mine pool can be drawn down and treated during the spring/summer/fall period and then treatment shutdown during the winter while the pool slowly refills.

Another option under consideration is the return of lime treatment sludge to the mine pool, where the residual lime provides an alkaline source of neutralization in the underground workings. This can be combined with a microbial carbon source to transform the metals in the sludge from a hydroxide form to a far denser sulphide form. This secondary microbial sludge densification process also helps release stored alkalinity in the sludge. Benefits of this approach include efficient use of alkalinity in the sludge, and return of iron hydroxides to the mine pool, which favours co-precipitation of other metals with the iron released from the sludge.

6.3.6 **Reclamation Only**

Reducing the amount of water that infiltrates the basin through surface source control measures would theoretically reduce the amount of water infiltrating into the workings and thus the amount of water available for metal leaching and subsequent discharge to the receiving environment.

6.3.6.1 Potential Sites Utilizing the Reclamation-Only Option

Sites such as Sadie Ladue 600 discharge several hundred kg of zinc per year, but due to the high flow rate of water leaving the mine, the concentration of the mine discharge is close to water discharge standards in WUL QZ06-074. If reclamation activities limited recharge through the mine workings even 50%, the same net runoff would still be expected in the receiving environment, and the loading and concentration might be decreased by something close to 50% as well.

For the above reasons, Sadie Ladue 600 is considered as a candidate for reclamation-only. Husky SW is also a candidate site, because the water leaving the shaft currently flows through waste rock that has visible sulphides and low pH. In the case of Husky SW, it is considered possible that the simple separation of the mine discharge from the waste rock materials, and installation of an effective cover over the sulphide-containing waste rock could sufficiently improve the water quality. Investigation of the mine pool chemistry in Husky SW is planned during 2011 or 2012 to further validate this possibility.

6.3.6.2 Adaptive Management of Reclamation-Only Option

Sites where it is reasonable to think that reclamation will have a significant positive impact on water quality should have the reclamation activities prioritized in the implementation of closure and reclamation activities. If water quality improvements are not identified within one annual cycle, it is not likely that these improvements will eventually show up many years later. If an improving trend is observed, implementation of other treatment approaches should be delayed until a stable water quality has been measured over at least one annual cycle.

6.4 **Waste Rock Storage Areas**

As shown in Table 6-6 and displayed on Figure 6-8, 68 Waste Rock Storage Areas (WRSA) sites have been identified within the KHSD, and of these, there are 16 sites associated

with open pits. The list does not include the Flame & Moth and Bellekeno 625 sites, which are Production Unit related operational facilities and not being considered for near-term reclamation of historic terrestrial liabilities under this closure and reclamation program.

Site Type	Site Name (b)	Waste Rock Tonnage (a)	Selected for WRSA Reclamation	Selected for Pit Safety Berm and/or Optional Backfill	Rationale
Pit	Bermingham pit and WRSA	1,500,000	X	X	WRSA: large, requires regrade, tension cracks. Possible pit recharge to Galkeno 900 adit
	Black Cap pit and WRSA	390,000	X		Large WRSA, visible (above tree line)
	Calumet Pit pit and WRSA	1,025,000	X	X	WRSA: large, requires regrade. Possible pit recharge to Galkeno 300 adit
	Cub & Bunny pit and WRSA	1,350			No obvious issues on Aerial
	Eagle pit and WRSA				No obvious issues on Aerial
	Galkeno 300 pits and WRSAs	450,000	X	X	WRSA: large, requires regrade. Possible pit recharge to Galkeno 300 adit
	Hector Pit pit and WRSA	110,000	X	X	WRSA: large, requires regrade
	Keno No. 9 System pit and WRSA	small piles			No obvious issues on Aerial
	Lake pit and WRSA	2,550			No obvious issues on Aerial
	Miller pit and WRSA	63,000		X	May require berm
	No Cash 100 pit and WRSA	6,500	X	X	WRSA: requires regrade. Possible pit recharge to No Cash 500 adit
	Onek pit and WRSA	600,000	X	X	WRSA: large, visible, requires regrade. Possible recharge to Onek 400 adit.
	Porcupine pit and WRSA (near Keno 700)	3,400			No obvious issues on Aerial
	Sadie Ladue (Wernacke) pit and WRSA	24,500	X		WRSA: requires regrade. Possible pit recharge to groundwater
	Shamrock pit and WRSA	9,000		X	Requires berm
	Silver King pit and WRSA	120,000	X	X	WRSA: large, requires regrade
Adit or Shaft	Apex adit and WRSA	trenching			No obvious issues on Aerial
	Bellekeno 100 (48 Vein) adit and WRSA	2,450			No obvious issues on Aerial
	Bellekeno 100 (50 Vein) adit and WRSA	500			No obvious issues on Aerial
	Bellekeno 200 adit and WRSA	13,000			No obvious issues on Aerial
	Bermingham adit and WRSA	7,000			No significant issues in 2007 Baseline Environmental Report
	Betty adit and WRSA	none			No obvious issues on Aerial
	Blue Bird adit and WRSA	minimal			No obvious issues on Aerial
	Christal (Dorothy) adit and WRSA	minimal			No obvious issues on Aerial
	Comstock 150 adit and WRSA	3,100			Listed as adits in 2007 Baseline Environmental Report
	Comstock 275 adit and WRSA	3,100			Listed as adits in 2007 Baseline Environmental Report
	Coral & Wigwam adit and WRSA	75,000			No obvious issues on Aerial
	Croesus No. 1 adit and WRSA	minimal			No obvious issues on Aerial
	Divide adit and WRSA	trenching			No obvious issues on Aerial
	Dixie adit and WRSA	19,800	X		Requires regrade, gullies
	Dragon (UN) adit and WRSA	3,200			No obvious issues based on 2007 B.E.R.
	Duncan Creek adit and WRSA	none			No obvious issues on Aerial
	Elsa +50 adit and WRSA	1,550	X		Confirmed collapsed 2007 Baseline Env. Rpt. Possible recharge at collapse feature
	Elsa 200 adit and WRSA	6,000			Confirmed gated and secure intrigue risk 2007 B.E.R.
	Elsa 400 adit and WRSA	44,100			Confirmed gated and secure 2007 B.E.R.
	Fox adit and WRSA	trenching			No obvious issues on Aerial
	Galkeno 300 adit and WRSA	150,000	X		Gullies on WRSA
	Galkeno 900 adit and WRSA	20,800	X		Settling pond constructed on waste rock, unstable with permafrost degradation
	Gerlitski adit and WRSA	10,281			No obvious issues on Aerial
	Gold Hill No. 2 adit and WRSA	100			No obvious issues on Aerial
	Hector 400 adit and WRSA	198,000	X		Large, requires regrade, visible, potential chemical source

	Highlander adit and WRSA	15,000			No obvious issues on Aerial
	Husky shaft and WRSA	4,600	X		Waste rock is a potential chemical source
	Husky SW shaft and WRSA	17,000	X		Waste rock is a potential chemical source
	Keno 200 adit and WRSA	14,600			Small site; very little waste rock
	Keno 700 adit and WRSA	27,500	X		Requires regrade. Adit discharge flows into waste rock
	Kijo adit and WRSA	minimal			No obvious issues on Aerial
	Klondike Keno adit and WRSA	2,000			No obvious issues on Aerial
	Lake View adit and WRSA	trenching			No obvious issues on Aerial
	Lucky Queen 500 adit and WRSA	61,900	X		Requires regrade, visible (above tree line)
	Lucky Queen shaft and WRSA	5,000			With Lucky Queen 500
	Mackeno adit and WRSA				No obvious issues on Aerial
	Monument & Ladue Fraction adit and WRSA	500			No obvious risks based on info in 2007 B.E.R.
	Nabob adit and WRSA	trenching			No obvious issues on Aerial
	Nabob No. 2 adit and WRSA	480			No obvious issues on Aerial
	No Cash 500 adit and WRSA	138,100	X		Large, requires regrade. Adit discharge may flow into waste rock
	Onek 400 adit and WRSA	7,500	X		Adit discharge flows onto waste rock
	Rico adit and WRSA	minimal			No obvious issues on Aerial
	Ruby adit and WRSA	28,900	X		Requires regrade. May require to diversion to keep surface water away from waste rock.
	Sadie Ladue shaft and WRSA				2007 B.E.R. shafts collapsed and backfilled
	Sadie Ladue 600 adit and WRSA	9,500	X		No obvious issues on Aerial. Possible pit recharge to groundwater
	Shamrock King adit and WRSA	16,200			No obvious issues on Aerial
	Shepherd adit and WRSA	minimal			No obvious issues on Aerial
	Silver Basin adit and WRSA	trenching			No issues raised in 2007 B.E.R
	Silver King 100 adit and WRSA	43,000	X		Requires regrade. Adit discharge may flow into waste rock
	Stone adit and WRSa	84,540			No obvious issues on Aerial
	Apex adit and WRSA	minimal			No obvious issues on Aerial
	Townsite adit and WRSA	14,300	X		WRSA: potential chemical source

(a) Tonnage – short tons (Source: Primary: Access, 1996 SCR, secondary PWGSC 2000 and estimates from SRK inspections)
(b) Bellekeno 625 and Flame and Moth are operating sites that are not being considered for near-term reclamation

Not applicable
Retained for cost analysis

Table 6-6. Keno District WRSA and Open Pit Sites

6.4.1 **Debris Removal and Site Cleanup**

It is recognized that disturbance associated with access will need to be balanced with the sites with only minimal debris or reclamation requirements. For purposes of costs, all 68 sites identified as having waste rock will be cleaned up. However, in practical application, a site inspection will be performed to determine which sites will require access in order to perform debris removal, and the amount of disturbance that creating access will cause. Based on this initial site inspection, debris removal will be performed as warranted at the identified mine sites. This will involve trash pickup and removal of old equipment, which will be disposed at the Elsa landfill. All WRSA sites will be cleaned up to improve the aesthetics of each site as the minimum standard of reclamation. To perform these minimal reclamation activities, heavy equipment will most often require access to these sites in order to perform the reclamation tasks.

6.4.2 **WRSA Reclamation Criteria**

A screening of the sites has been performed to determine which will be considered for additional reclamation of WRSAs and pits. The criteria for WSRA reclamation are:

- Unstable slopes showing signs of erosion or having the potential for movement.
- Significant gullying on steeper slopes.
- Waste rock areas directly adjacent to surface waters.
- Waste rock that is a potential chemical source to surface water.
- Adit discharge that may be migrating into or across waste rock.

The criteria for pit reclamation are:

- Safety hazard (pit wall heights greater than 5 meters).
- Potential sites of meteoric recharge to flowing adits (that is, not free-draining. and with a known or suspected connection to a flowing adit).

Sites meeting one or more of the above criteria are identified by an “X” in Table 6-6.

Table 6-7 summarizes the sites selected for reclamation and shows the activities being considered. An “X” indicates a required reclamation activity and “O” pertains to an optional activity that will be evaluated based on future environmental and engineering studies.

Site	Reference Figure	Waste Rock Storage Area (WRSA)					Pit Related		
		Tonnage (a)	Regrading to 2.5:1 Slopes	Stream Protection (rip-rap)	Diversions	Soil Cover	Safety Berms	Diversions	Pit Backfill with Cover
Bermingham pit and WRSA	6-9	1,500,000	X				X	X	
Black Cap pit and WRSA	6-12	390,000	X				X		
Calumet pit and WRSA	6-14	1,025,000	X				X	X	
Galkeno 300 area pits and WRSAs	6-15	450,000	X				X	X	
Hector pit and WRSA	6-18	110,000	X				X	X	
Miller pit and WRSA	6-20	63,000					X		
No Cash 100 pit	6-21	6,500	X	X			X	X	
Onek pit and WRSA	6-41	600,000	X				X	X	X
Sadie Ladue (Wernacke) pit and WRSA	6-24	24,500	X				X	X	
Shamrock pit and WRSA	6-26	9,000					X		
Silver King 100 pit and WRSA	6-27	120,000	X				X	X	X
Dixie adit and WRSA	6-29	19,800	X						
Elsa +50 adit and WRSA	6-31	1,550			X				
Galkeno 300 adit and WRSA	6-15	150,000	X						
Galkeno 900 adit and WRSA	6-32	20,800	X		X				
Hector 400 adit and WRSA	6-34	198,000	X			O			
Husky shaft and WRSA	6-35	4,600	O (c)			O			
Husky SW shaft and WRSA	6-36	17,000	O (c)			O			
Keno 700 adit and WRSA	6-37	27,500	X	X	X				
Lucky Queen 500 adit and WRSA	6-39	61,900	X						
No Cash 500 adit and WRSA	6-40	138,100	X	X (b)	X				
Onek 400 adit and WRSA	6-41	7,500	O (c)		X	O			
Ruby adit and WRSA	6-42	28,900	X		X				
Sadie Ladue 600 adit and WRSA	6-43	9,500			X				
Silver King 100 adit and WRSA	6-44	43,000	X	X	X				
Townsite adit and WRSA	6-45	14,300	X			O			

X Required
O Optional
(a) Tonnage – short tons (Source: Primary 1996 SCR, secondary PWGSC 2000 and estimates from SRK inspections)
(b) Will include placement of a clay liner
(c) Regarding will be performed only if a soil cover is placed

Table 6-7. Reclamation Activities

6.4.3 **Description of Reclamation Activities for WRSAs**

6.4.3.1 Regrading

For indicated WRSAs in Table 6-7, regrading will be performed on angle of repose slopes to achieve a stable permanent slope of 2.5:1. In certain circumstances, resloping may include mid-slope benching and short slopes sections steeper than 2.5:1, but with an overall 2.5:1 slope from crest to toe. Using a dozer, this will be performed by pushing waste rock from higher portions of the slope and filling on top of the lower portion of

the slope (cut-and-fill). The final surface will be smoothed and contoured to fit as much as possible with the adjacent existing topography. While most of the earth moving will be in a downhill direction, lateral movement will occur on some slopes to avoid waste rock encroachment into natural stream channels (e.g., Silver King 100 adit, No Cash 100 pit, and No Cash 500 adit).

6.4.3.2 Stream Protection

Rip-rap will be placed adjacent to stream channels where the toe of any regraded waste rock slope is close to the active channel. The rip rap will be designed by a professional engineer and keyed in to a sufficient depth below the water line as to prevent underming. Rip rap will be obtained from the existing bedrock quarry located north of the Valley Tailings Facility or from another suitable quarries which may be identified. Stream protection will not include diversions or significant relocation of existing channels. Stream protection is recommended for WRSAs at the No Cash 100 pit, Keno 700 adit, No Cash 500 adit, and Silver King 100 adit.

6.4.3.3 Diversions

The purpose of diversions is to reduce surface water and/or adit water flow onto waste rock in order to reduce erosion and limit chemical leaching of waste rock that could result in degraded water quality. Diversions are required to prevent erosion and gullying.

At the Ruby adit site, a surface water diversion channel will be constructed on the uphill (south) side of WRSA to intercept overland flow and divert this flow around the WRSA. This measure is intended to reduce the potential for gullying on sideslopes that are adjacent to an existing road.

At the Elsa +50, Galkeno 900, Keno 700, No Cash 500, Onek 400, Sadie Ladue 600, and Silver King 100 sites, there are adit discharges that have the potential to contact mineralized waste rock from the underground development. At each of these sites the water treatment design and waste rock closure will be coordinated to ensure that adit discharges will not result in erosion or chemical leaching of the waste rock materials. At a minimum, a channel will be constructed to divert the adit discharge away from the WRSA.

6.4.3.4 Optional Soil Covers

Soil covers are being considered for select WRSAs containing waste rock that has the potential to be a significant chemical source to surface water and groundwater. Two cover designs are proposed:

> Vegetation Cover is 0.5 m thick and consists of growth medium and seeding. The primary purpose of a vegetation cover is to reduce erosion and provide a nominal reduction in meteoric infiltration.
>
> Infiltration Cover is 1.0 m thick and consists of a lower soil layer that has been amended to reduce permeability and an overlying layer of seeded growth medium. The purpose of an infiltration cover is to greatly reduce meteoric infiltration into the WRSA and thereby minimize chemical loading from the WRSA to the environment.

The WRSAs being considered for soil covers are:

- Hector 400 adit;
- Husky shaft;
- Husky SW shaft;
- Onek 400 adit; and
- Townsite adit.

The decision to install soil covers on some or all of these WRSAs, and the type of cover utilized, will be based on future additional geochemical evaluations of the waste rock materials being conducted during 2011. Note that the regrading activities at Husky shaft, Husky SW shaft, and Onek 400 adit will only be performed if a decision is made to place covers on these WRSAs.

6.4.4 **Description of Reclamation Activities for Open Pits**

6.4.4.1 Safety Berms

To mitigate the fall hazard for people in vehicles, ATVs, and snow machines, double safety berms will installed along the perimeters of all pit walls that are higher than 5 m. The first berm will generally be located about 5-15 m from the top edge of the pit wall, constructed to a height of 3 m above grade, and have 1:1 side slopes. The second berm will be located adjacent to the primary berm (away from the pit wall) and have the same geometry.

6.4.4.2 Diversions

Surface diversions will be constructed upslope of most of the mine pits to reduce overland flow that currently reports to the pit and potentially become groundwater recharge to the underground workings associated with flowing adits. Reducing recharge at the Calumet pit, Hector pit, and Galkeno 300 area pits is particularly important because discharge from the nearby Galkeno 300 adit produces over 80 percent of the total known zinc loading within the District. In most cases, the surface diversions will be constructed parallel to portions of the safety berms, with the intent of routing surface water around the pit and discharging it downslope of the pit. Where there are several pits close together (e.g., Sime pits area), a single diversion channel will be constructed to route surface water away from all the pits.

6.4.4.3 Pit Backfill with Soil Cover

Two pits, Onek and Silver King, are not free draining and are located close to flowing adits (Onek 400 and Silver King 100, respectively). It is possible that ponded water in these pits (particularly during freshet) provides significant groundwater recharge that reports as discharge from the associated adits. A required reclamation activity for these pits is to place backfill and a soil cover to create a free draining conditions so that ponding is eliminated. In both pits, backfill will be placed in the bottom of the pit to create a smooth floor with a 2 to 5 percent grade and surface water discharge at one end of the pit. For both the Onek and Silver King pits, a 1-m vegetation cover will be placed to promote vegetation growth, reduce infiltration, and reduce groundwater recharge. The operational objective of the pit backfills is to decrease discharge at the Silver King 100 adit and Onek 400 adit to reduce the cost of long-term water treatment at these sites.

6.4.4.4 Cost Evaluation

A level 5 cost analysis, considered accurate to -50% / +100%, has been performed for all reclamation activities identified in Table 6-7.

Material quantities for regrading were estimated by constructing one or more topographic cross-sections across each of the reclaimed WRSAs. Site plans and cross-sections for the WRSAs are shown Figure 6-9 to Figure 6-45. In each section, the surface area of material to be moved downslope was measured using Autocad 3D. Each area was then multiplied by the perimeter distance associated with the section to compute the volume of material to be moved. If more than one section was generated for the

WRSA, the total volume was equal to the sum of the volumes associated with each section. A production rate was calculated for each site utilizing a D9 bulldozer, referencing the CAT handbook, and 2010/2011 BC Bluebook, to estimate the cost of moving the material. The average unit cost for regrading the slopes at all selected sites was $1.35/cubic meter.

Stream protection costs were evaluated by estimating the volume of rip-rap required to prevent waste rock encroachment into existing stream channels. A production rate was calculated for each site utilizing a 325 excavator, and a 740 haul truck, referencing the CAT handbook, and 2010/2011 BC Bluebook, to estimate the cost of loading hauling (assumed 5 km borrow site) and placing the material. A unit cost for blasting and screening the rip rap was included. The average unit cost for blasting, screening, hauling, and placing the rip rap was $33.17/cubic meter. The unit cost for material and placement of filter fabric was $5/square meter.

The cost of a diversion was estimated by developing a preliminary alignment of the diversion channel and estimating its length using Autocad. Preliminary alignments of diversions are shown on the site figures. Estimating costs for diversions were similar to stream protection costs as described above, except for the addition of a diversion berm. A production rate was calculated for each site utilizing a D6 bulldozer, 740 Haul Truck, and 980 Loader, and 325 excavator, referencing the CAT handbook, and 2010/2011 BC Bluebook, to estimate the cost of loading hauling (assumed 0.2 km distance to an appropriate borrow site assumed to be open pit waste rock) and placing the berms. The average unit cost for loading, hauling, and placing the channel/berm was $3.29/cubic meter.

Soil cover cost was estimated by determining the area to be covered (either WRSA or pit backfill) using Autocad. A production rate was calculated for each site utilizing a D6 bulldozer, 980 loader, and a 740 haul truck, referencing the CAT handbook, and 2010/2011 BC Bluebook, to estimate the cost of loading hauling (assumed 5 km borrow site) and placing the material. A unit cost for material and applications of seed was included. The average unit cost for the 0.5 m vegetation cover, including loading, hauling, placing the cover, and seeding was $9.71/square meter.

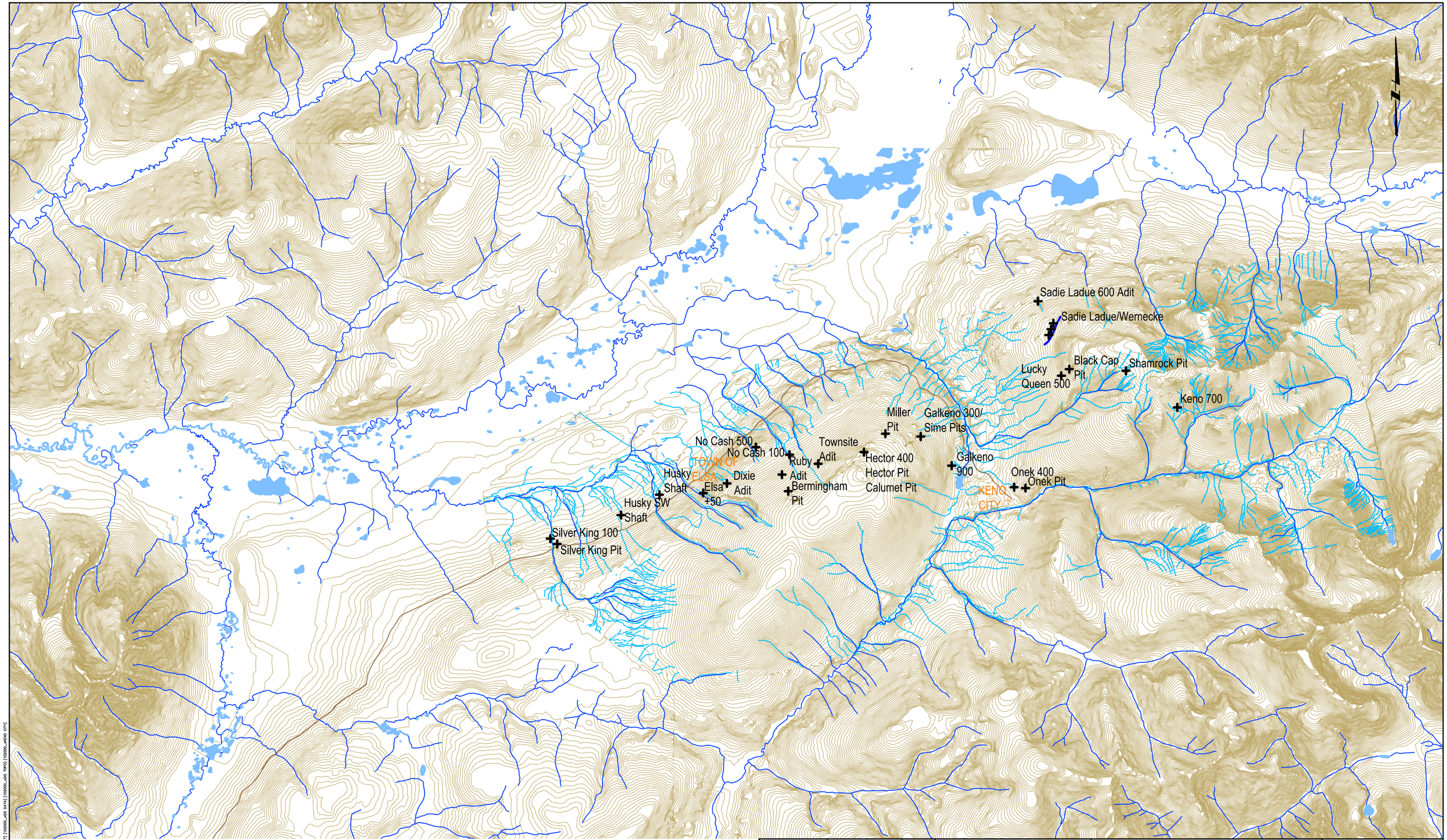
The method for estimating costs for the 1.0 m infiltration cover was similar to the vegetation cover, except for the added thickness and cost amending the soil to a lower

permeability. The average unit cost for the infiltration cover including loading, hauling, adding amendments, placing the cover, and seeding was $26.30/square meter.

Safety berm costs were estimated by drawing the berm alignments in Autocad and measuring the lengths. Each length was then multiplied by a material quantity per length. A production rate was calculated for each site utilizing a D6 bulldozer, 740 haul truck, and 980 loader, referencing the CAT handbook, and 2010/2011 BC Bluebook. The average unit cost for loading, hauling (assuming a 0.2 km distance to the borrow source), and placing the safety berms was $3.29/cubic meter. In most cases, berms will be constructed from nearby waste rock.

Backfill volumes for the Onek and Silver King pits were estimated by generating the backfill surface in Autocad 3D and using a utility in the program to compute the volume between the top of backfill and the current pit bottom. A production rate was calculated for each site utilizing a D9 bulldozer, 740 haul truck, and 980 loader referencing the CAT handbook, and 2010/2011 BC Bluebook, to estimate both the cost of loading, hauling, pushing in fill from the rim, and placing the fill. The average unit cost for backfill at the two sites was $5.40/cubic meter. The backfill for both pits will be obtained from WRSAs located near the pits; hence an assumed average distance of 0.2 km for backfill was used in the cost calculations.

After backfilling each pit to its design elevation, a 1 m soil cover will be placed on top of the backfill materials. A production rate for the infiltration cover installation was calculated for each site utilizing a D6 bulldozer, 740 haul truck, and 980 loader referencing the CAT handbook, and 2010/2011 BC Bluebook, to estimate the cost of loading, and hauling (assumed 5 km from borrow site), placing the cover, and seeding. Note that the backfill cover will not contain soil amendments to reduce permeability. The average unit cost of the cover for the pit backfill areas was $14.80/cubic meter.



300 0 300

(In Meters)
1 cm = 100 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED ____, 20__.

DATUM: NAD83

SCALE: 1 cm = 100 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
VICINITY MAP
OF SELECTED SITES FOR RECLAMATION

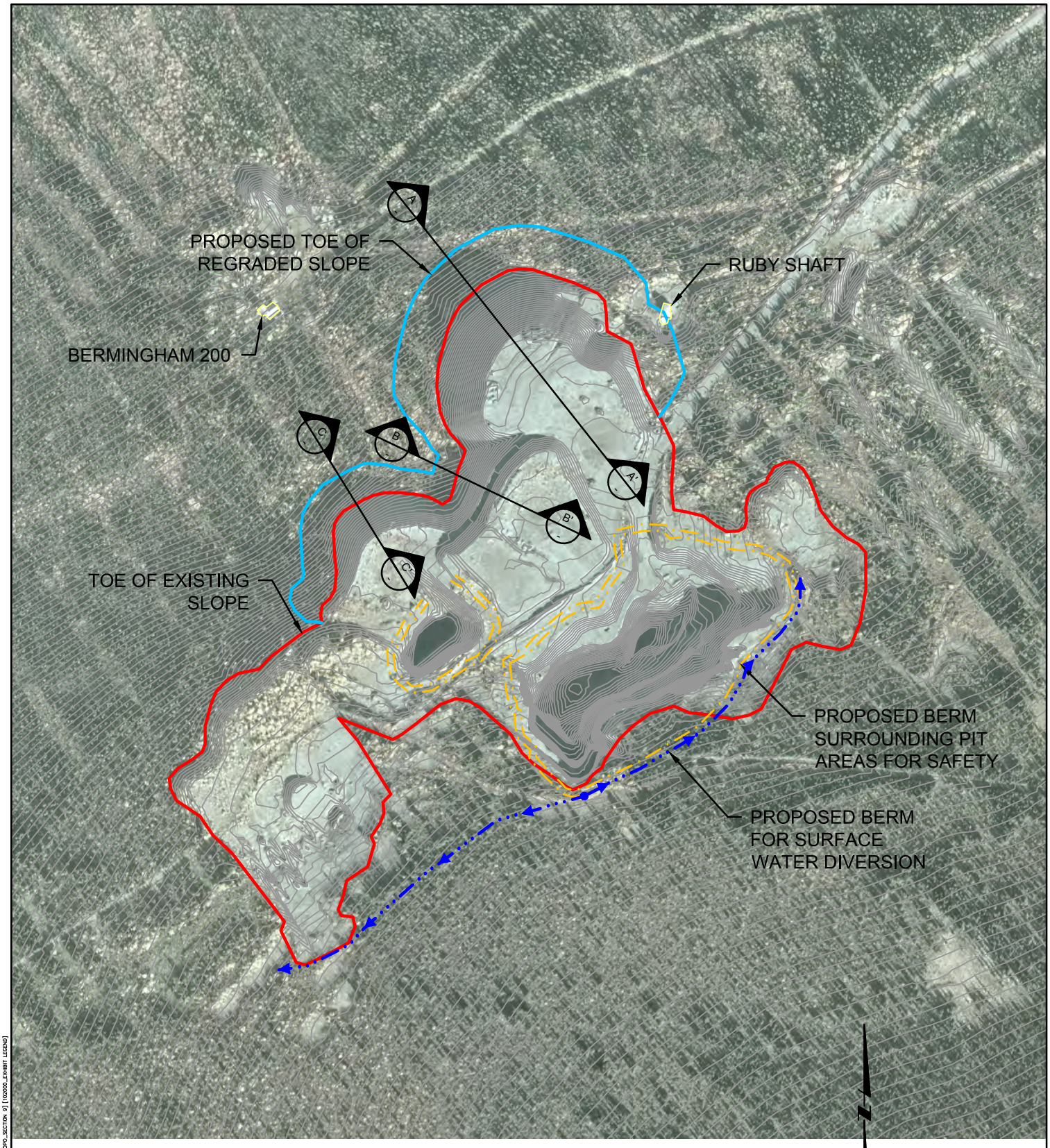
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DRAWING FIGURE 6-8

REVISION

FILE NAME 102000_Overall Map

DRAWING FILENAME: S:\Projects\102000 - Keno-Hexco\Mxds Cad\Cad\102000_Overall Map.dwg LAYOUT NAME: Overall DATE: Mar 31, 2011 - 4:32pm CAD OPERATOR: cwelken
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GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

N

120 0 120

(In Meters)
1 cm = 40 M

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DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____. RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 40m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

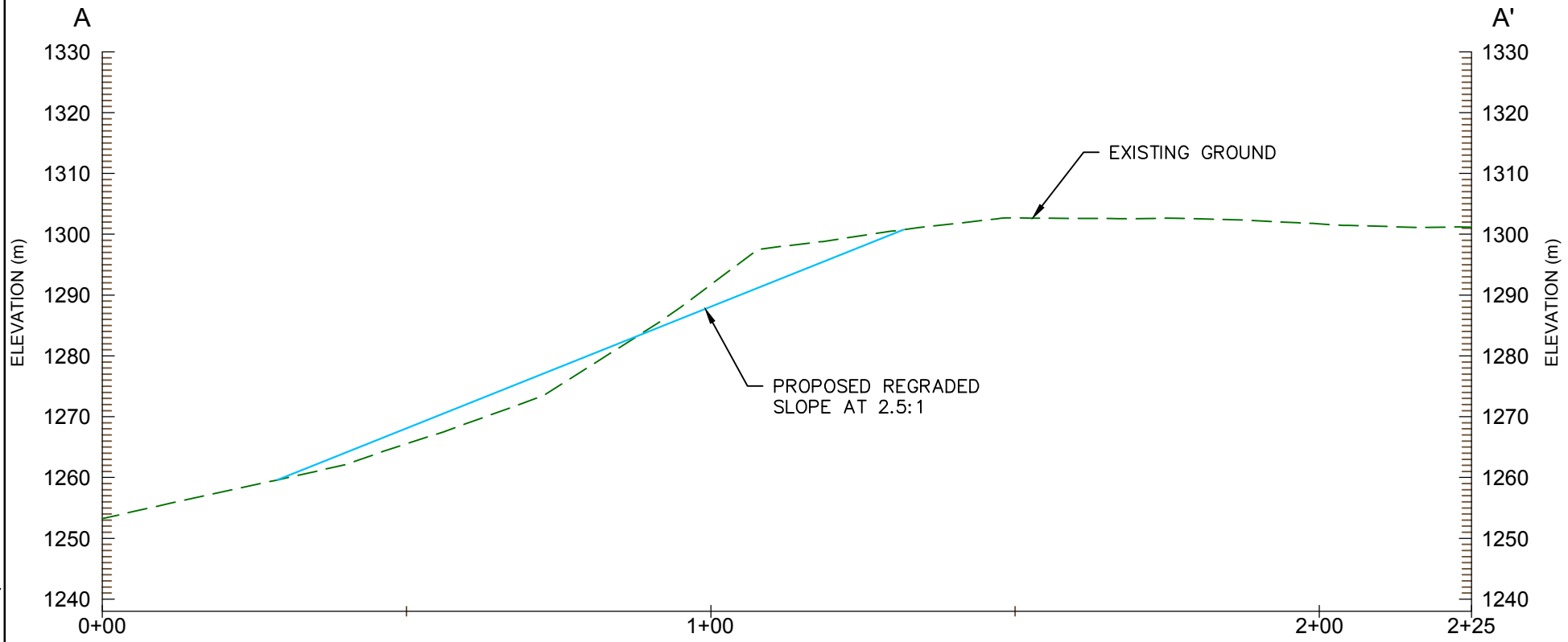
TITLE
BERMINGHAM PIT PLAN

INTERRA
4715 Innovation Drive, Suite 110
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DRAWING FIGURE 6-9 REVISION

FILE NAME 102000_Bermingham

DRAWING FILENAME: i:\Projects\102000 - Keno-Newco\Keno Coal\Graph\102000_Bermingham.dwg LAYOUT NAME: BERMINGHAM_PLAN DATE: Mar 29, 2011 - 2:31pm CAD OPERATOR: ACAD
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SECTION A-A'

30 0 30

(In Meters)
1 cm = 10 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED ____, 20__.

DATUM: NAD83

SCALE: 1 cm = 10m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
BERMINGHAM PIT
SECTION A

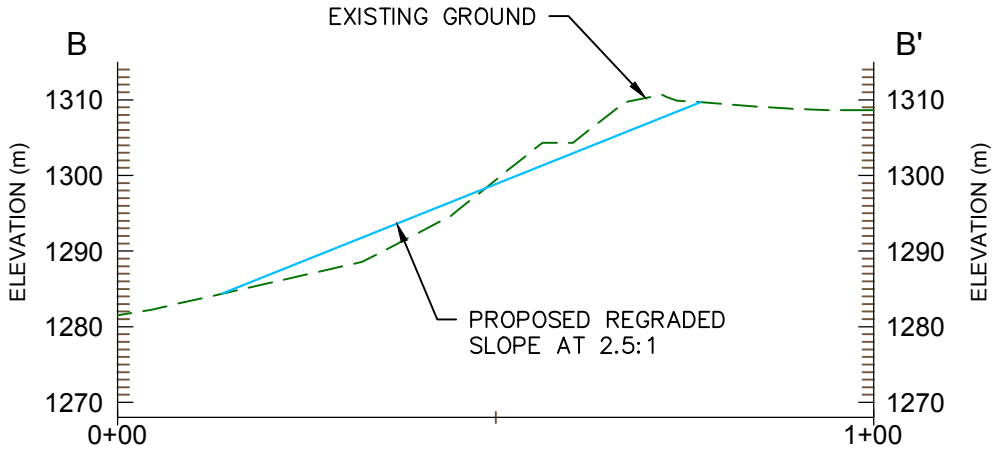
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DRAWING FIGURE 6-10

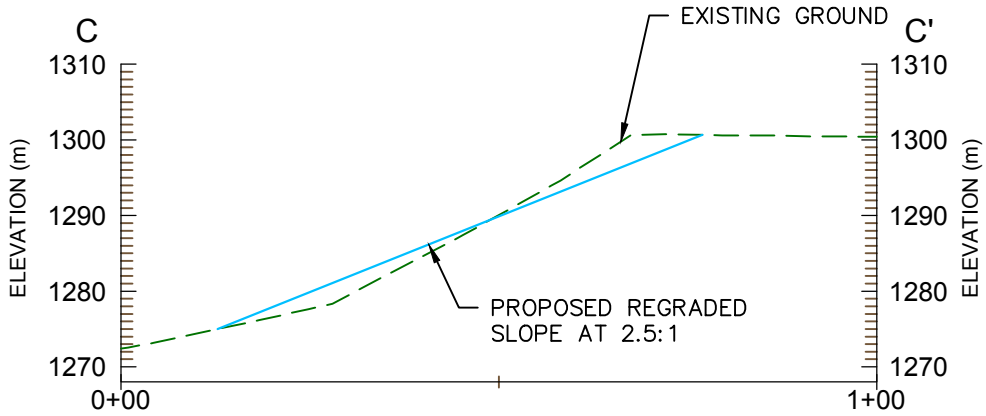
REVISION

FILE NAME 102000_Bermingham

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LIST OF XREFS: [b:\Terralogic-border-8x11.ctb][b:\Terralogic-border-8x11.ctb][102000_TOPO_SECTION 9][102000_EXHIBIT LEGEND]



SECTION B-B'



SECTION C-C'

30 0 30

(In Meters)
1 cm = 10 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 10m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

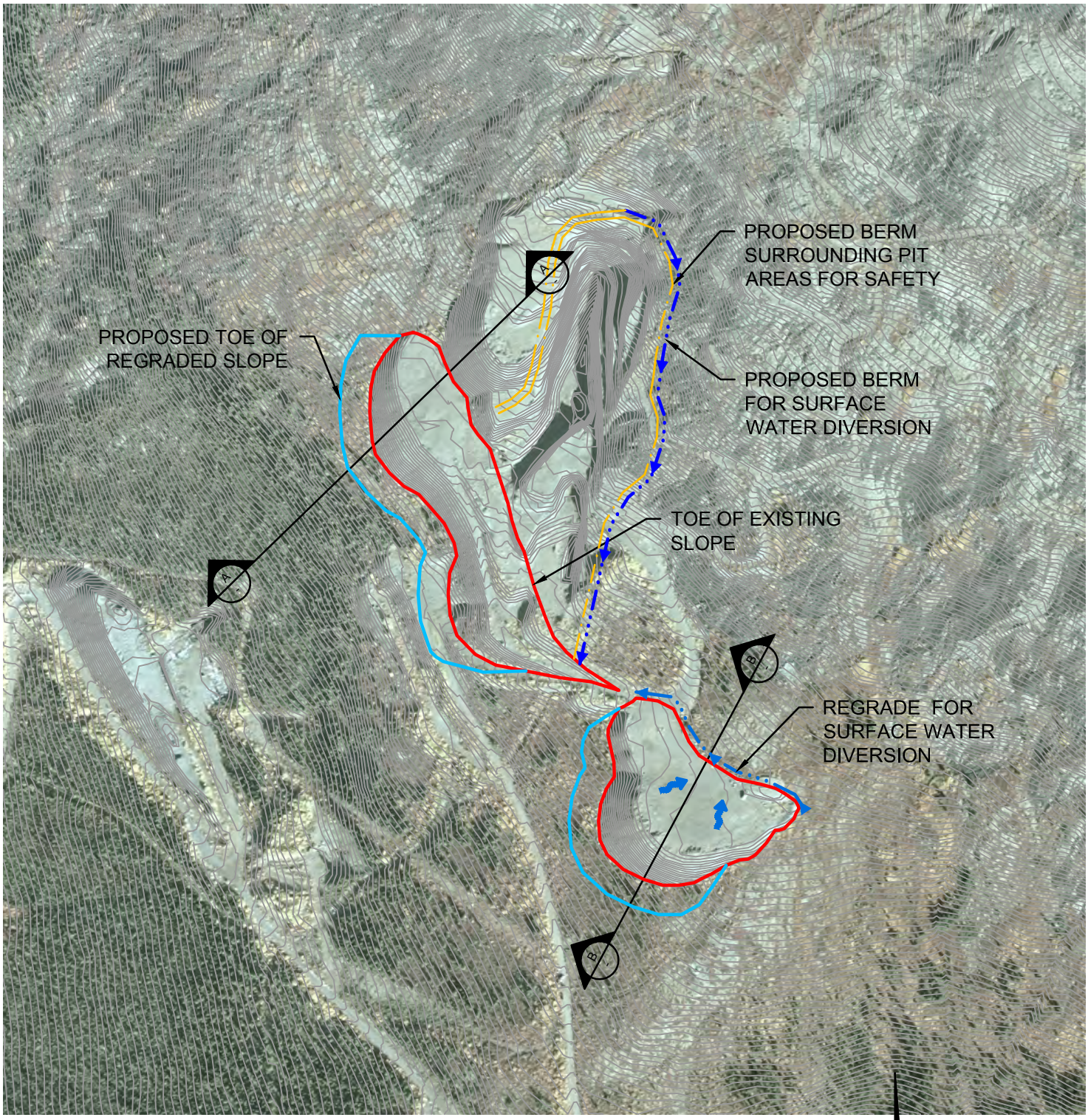
TITLE
BERMINGHAM PIT
SECTIONS B & C

INTERRA
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DRAWING FIGURE 6-11 REVISION

FILE NAME 102000_Bermingham

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GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

N

120 0 120

(In Meters)
1 cm = 40 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 40m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

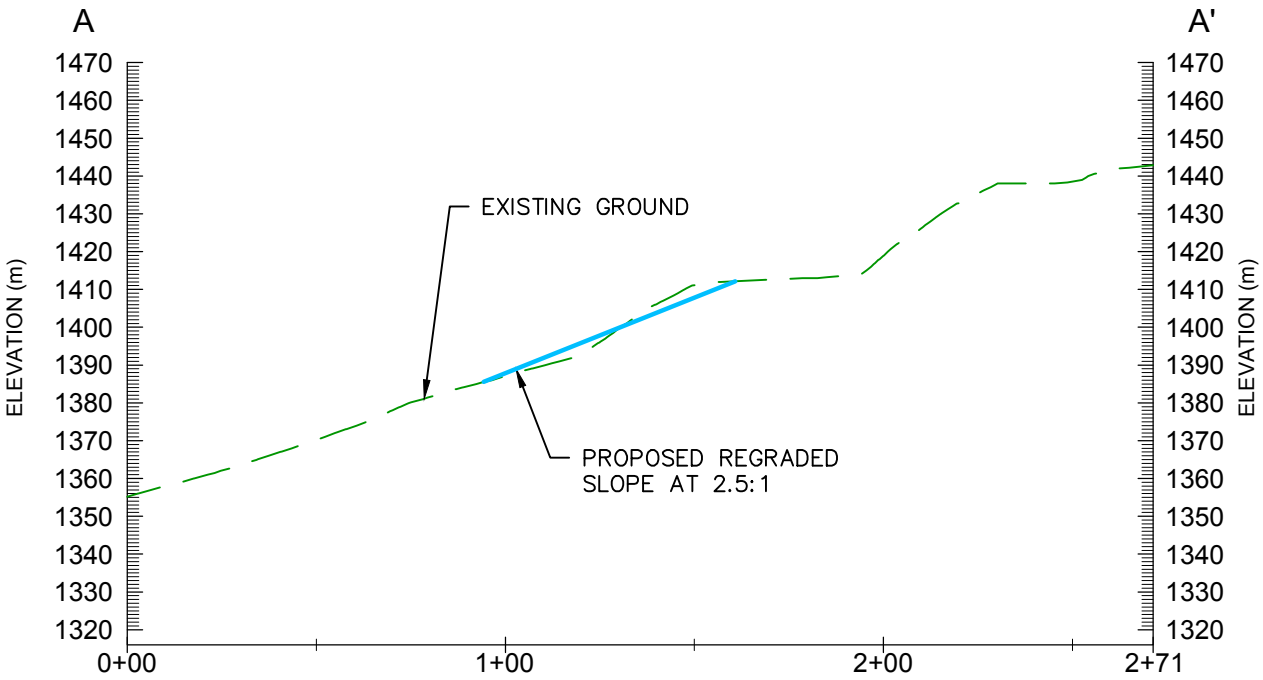
TITLE
BLACK CAP PIT
PLAN

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Fort Collins, Co 80525
970.225.8222

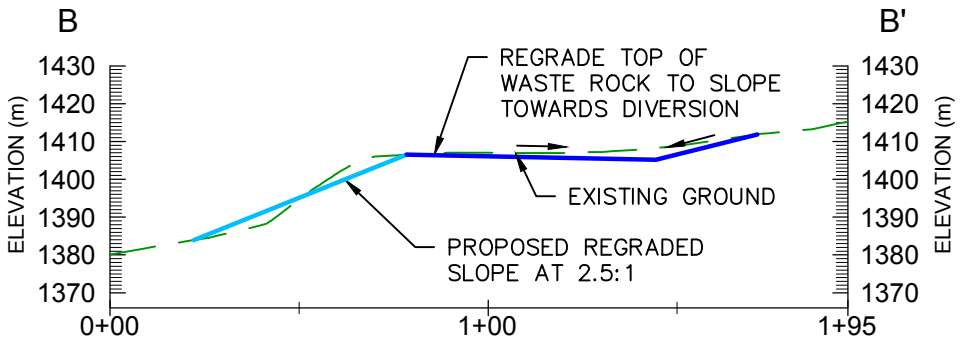
DRAWING FIGURE 6-12 REVISION

FILE NAME 102000_Black Cap

DRAWING FILENAME: C:\Users\cwelken\appdata\local\temp\AcPublish_4872\102000_Black Cap.dwg LAYOUT NAME: BLACK CAP PLAN DATE: Mar 30, 2011 - 9:25am CAD OPERATOR: cwelken
LIST OF XREFS: [nTerraLogo-border-8x11] [102000_xTOPO_SECTION 93] [102000_EXHIBIT LEGEND]



SECTION A-A'



SECTION B-B'

60 0 60

(In Meters)
1 cm = 20 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 20m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

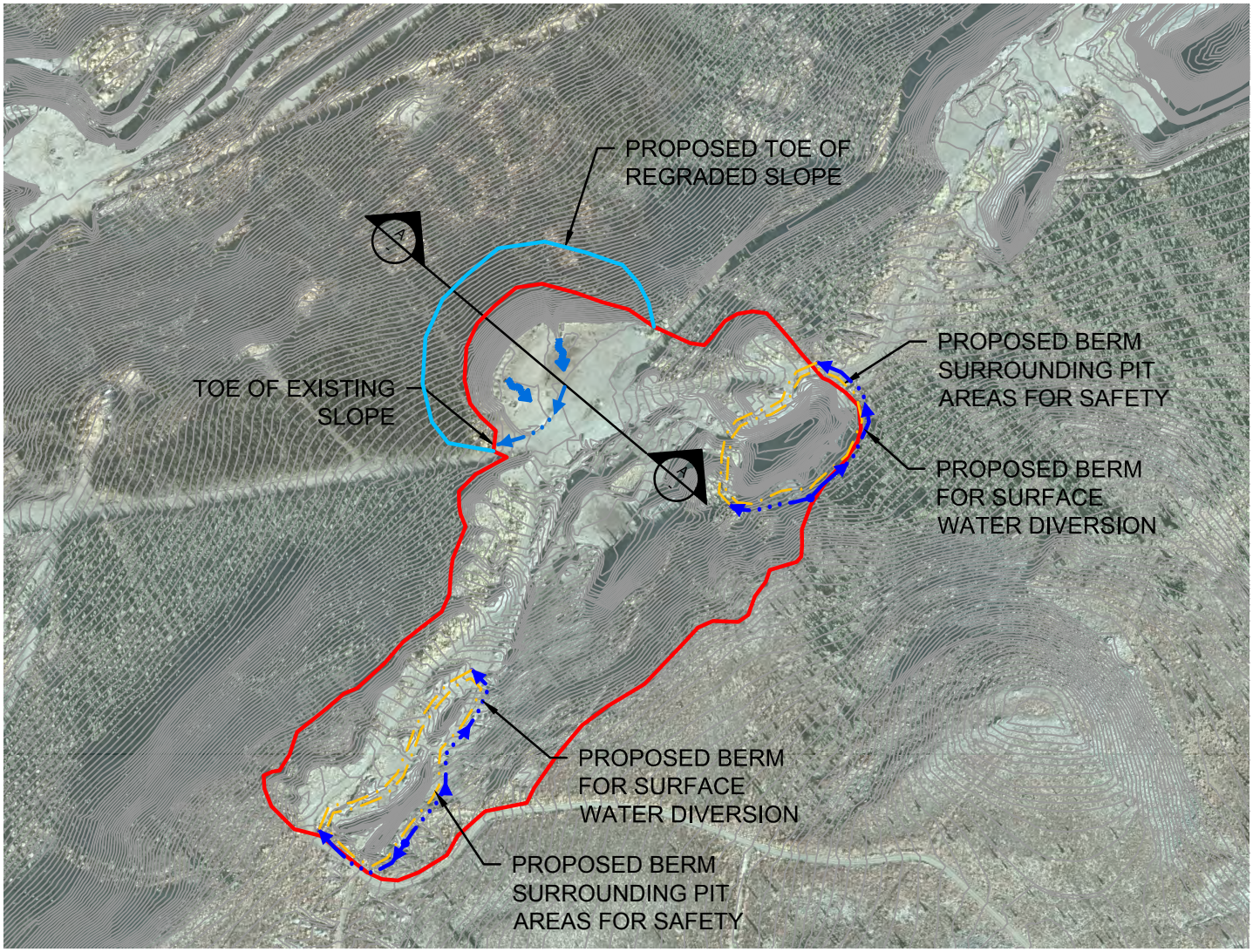
TITLE
BLACK CAP PIT
SECTIONS A & B

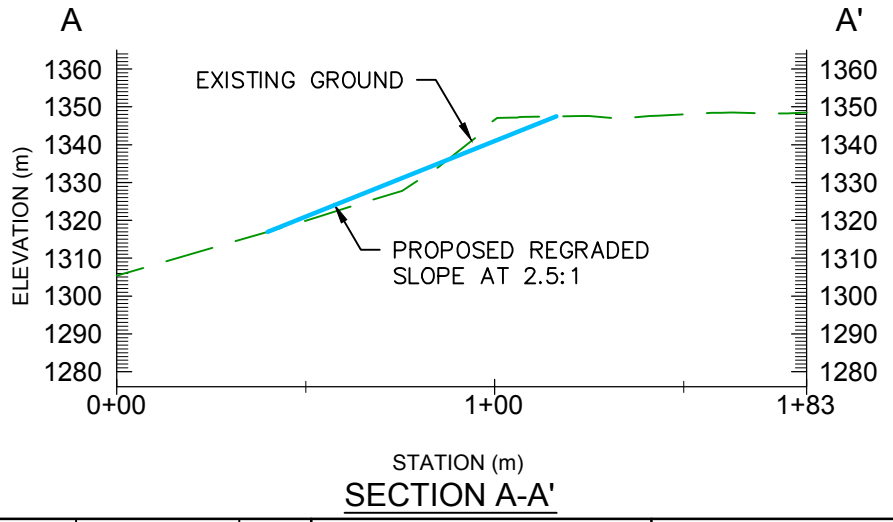
INTERRA
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DRAWING FIGURE 6-13 REVISION

FILE NAME 102000_Black Cap

DRAWING FILENAME: C:\Users\cwelken\appdata\local\temp\AcPublish_4872\102000_Black Cap.dwg LAYOUT NAME: BLACK CAP SECTION A B DATE: Mar 30, 2011 - 8:25am CAD OPERATOR: cwelken
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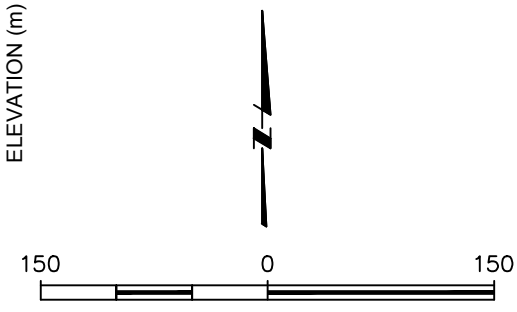




SECTION A-A'

GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.



DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____. RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 50 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

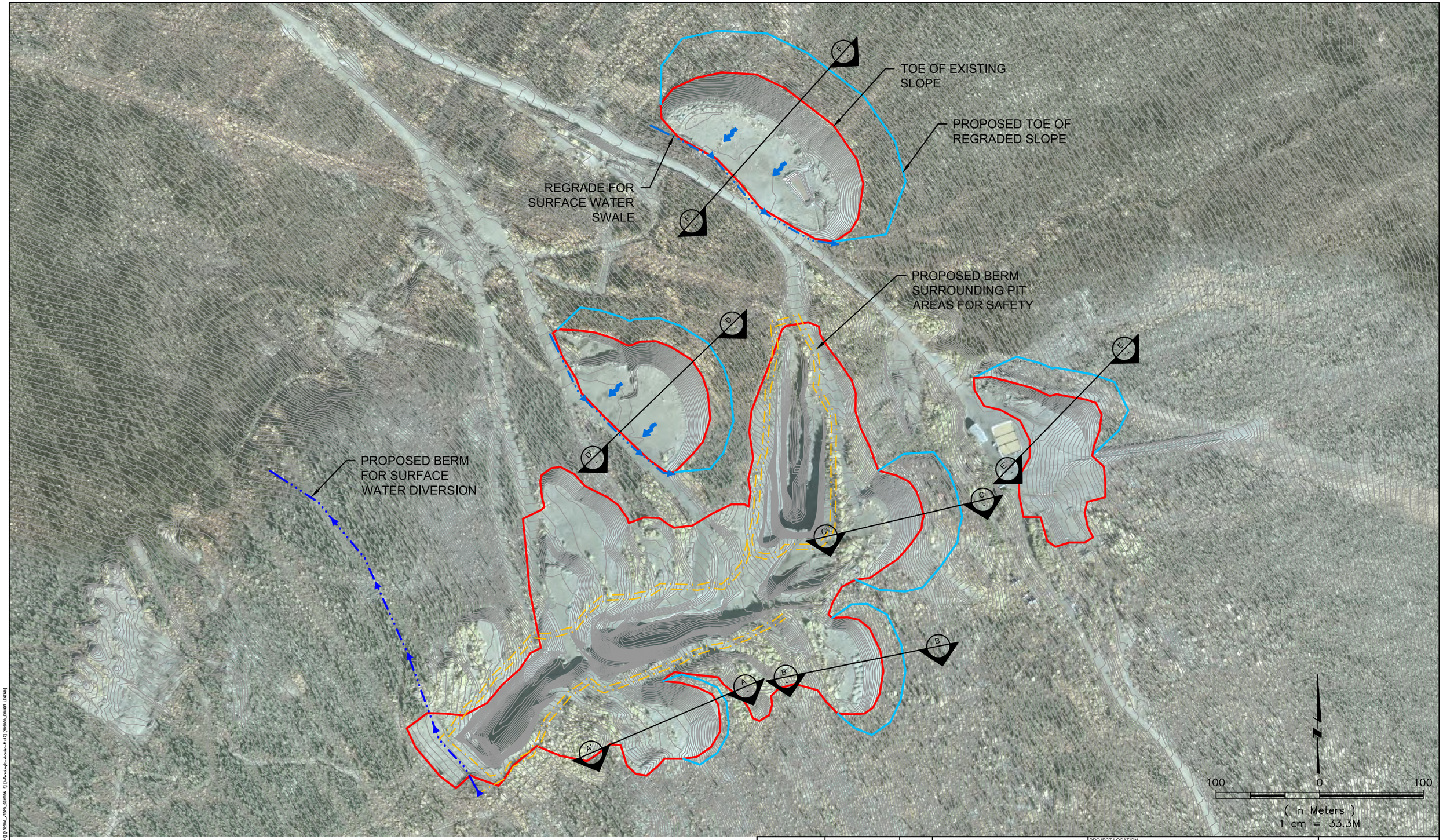
TITLE
CALUMET PIT
PLAN & SECTION A

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-14 REVISION

FILE NAME 102000_Calumet Pit

DRAWING FILENAME: i:\Projects\102000 - Keno-Nexco\Keno Coal\Grad\102000_Calumet Pit.dwg LAYOUT NAME: Calumet Pit Plan and Section DATE: Mar 29, 2011 - 2:42pm CAD OPERATOR: ACAD
LIST OF XREFS: [n:\terralogic-border-8x11] [102000_xTOPO_SECTION 5] [102000_EXHIBIT LEGEND]



GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____ 20__.

DATUM: NAD83 SCALE: 1 cm = 33 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

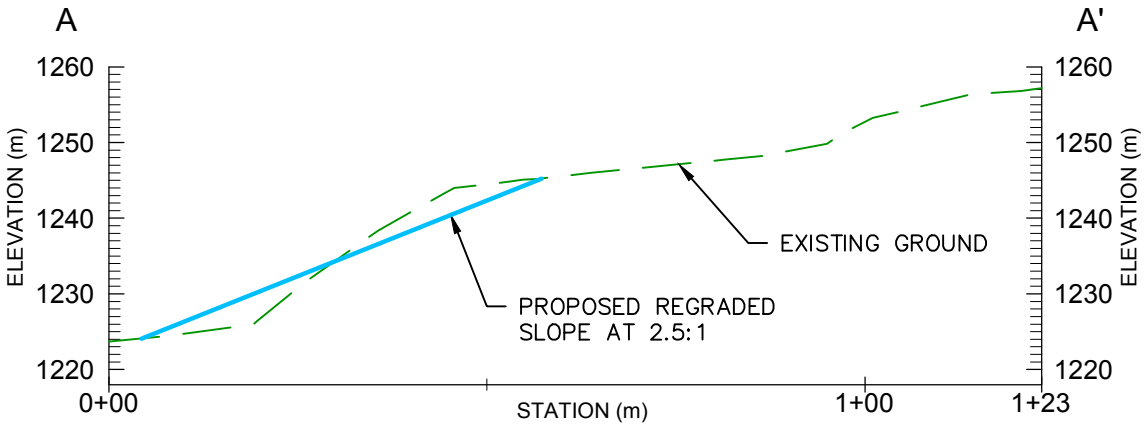
TITLE
GALKENO 300 AND SIME PITS
PLAN

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4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

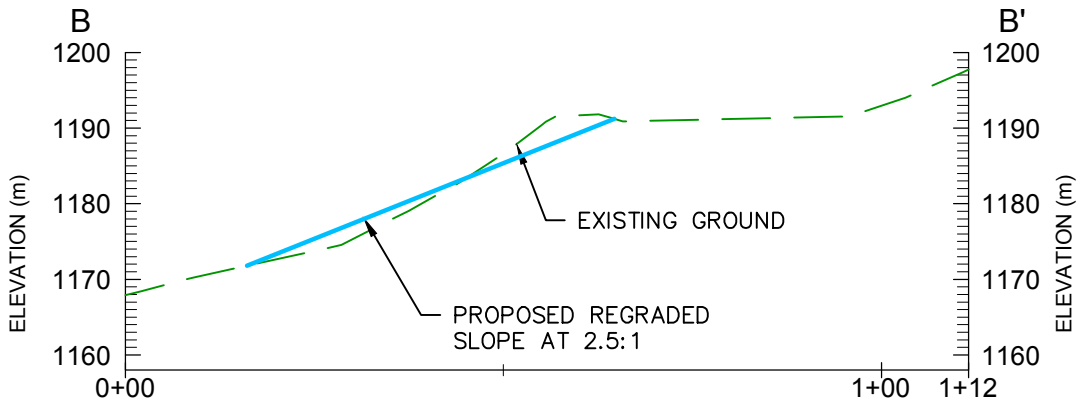
DRAWING FIGURE 6-15 REVISION

FILE NAME 102000_Galkeno 300

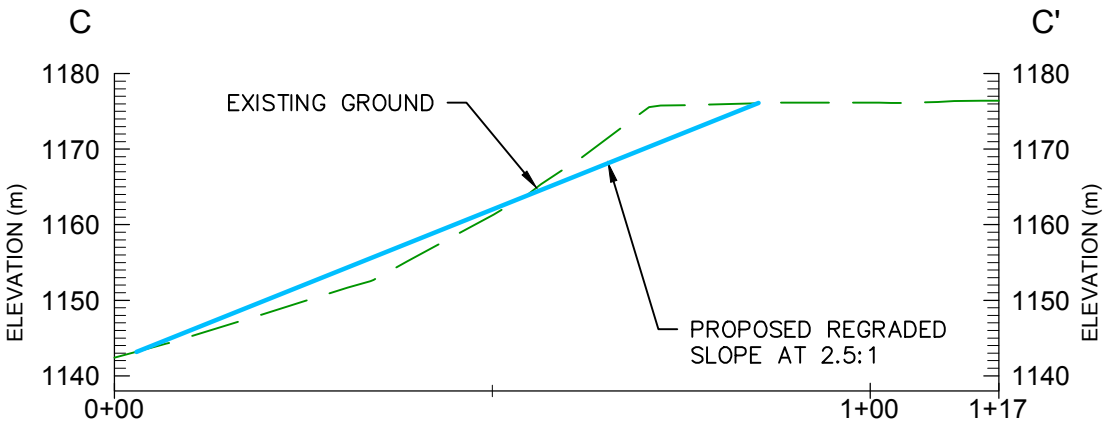
DRAWING FILENAME: L:\Projects\102000 - Keno-Hess\Keno Civil\Grad\102000_Galkeno 300.dwg LAYOUT NAME: Galkeno Plan and Section DATE: Mar 29, 2011 - 1:05pm CAD OPERATOR: cwelken
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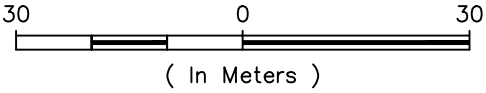
SECTION A-A'



SECTION B-B'



SECTION C-C'



(In Meters)
1 cm = 10 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____. RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 10 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

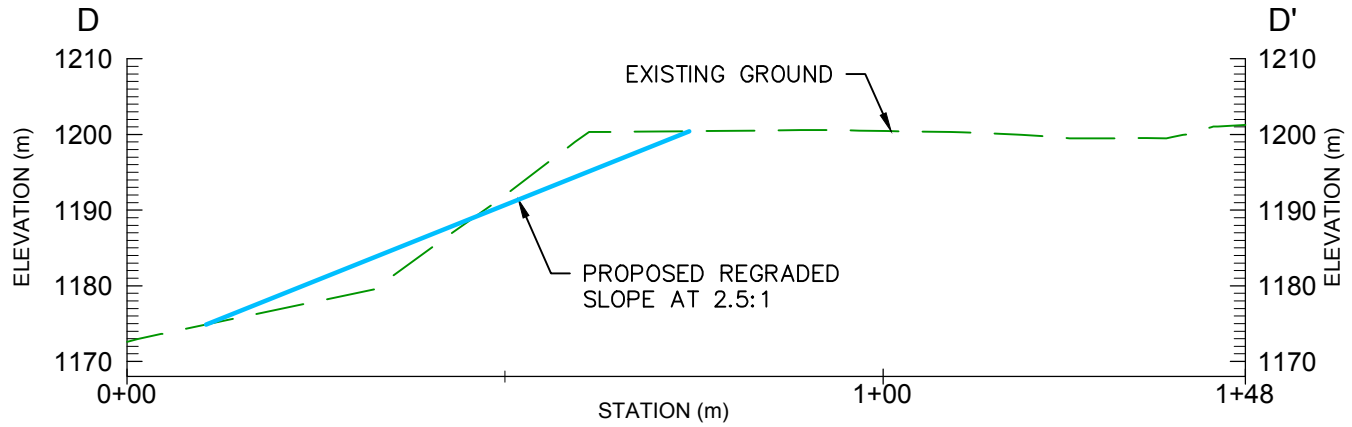
TITLE
GALKENO 300 AND SIME PITS
SECTIONS A, B & C

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

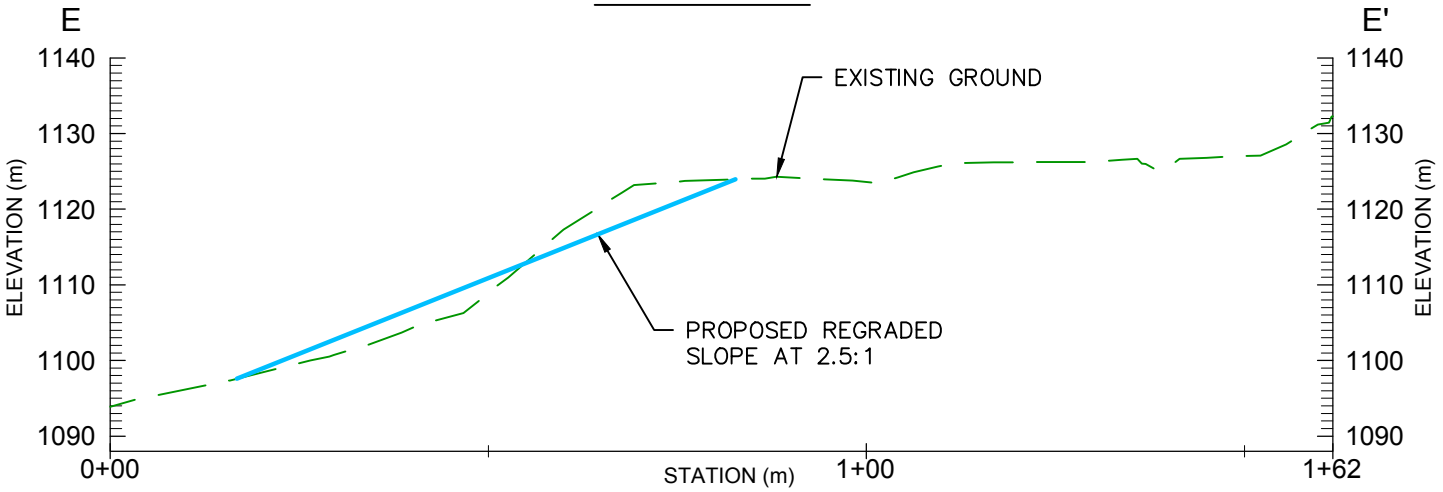
DRAWING FIGURE 6-16 REVISION

FILE NAME 102000_Galkeno 300

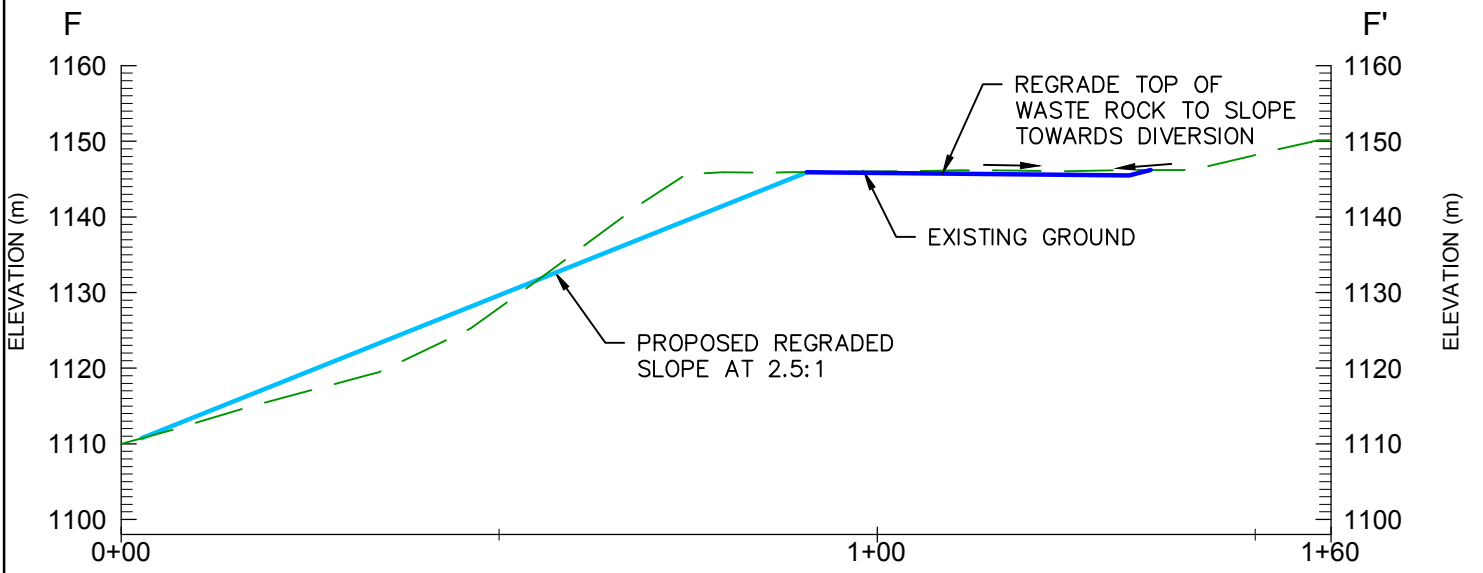
DRAWING FILENAME: i:\Projects\102000 - Keno-Hexco\Keno Coal\Grad\102000_Galkeno 300.dwg LAYOUT NAME: Galkeno Section A -C DATE: Mar 29, 2011 - 1:55pm CAD OPERATOR: cwelken
LIST OF XREFS: [n\TerraLogic-border-8x11] [102000_xTOPO_SECTION 5] [n\TerraLogic-border-11x17] [102000_EXHIBIT LEGEND]



SECTION D-D'



SECTION E-E'



SECTION F-F'

30 0 30

(In Meters)
1 cm = 10 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 10 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

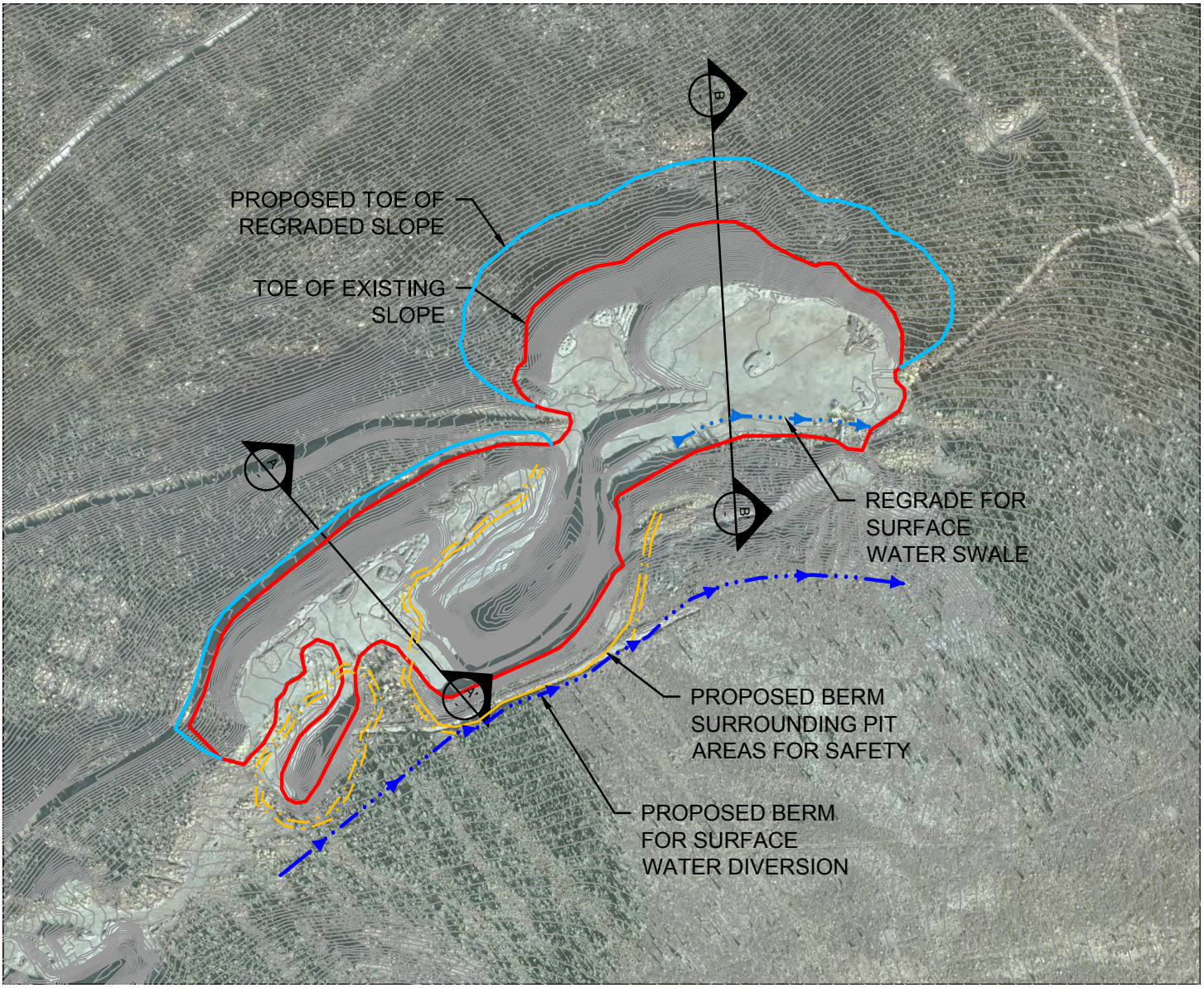
TITLE
GALKENO 300 AND SIME PITS
SECTIONS D, E & F

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-17 REVISION

FILE NAME 102000_Galkeno 300

DRAWING FILENAME: i:\Projects\102000 - Keno-Nexco\Keno Coal\Grad\102000_Galkeno 300.dwg LAYOUT NAME: Galkeno Section D-F DATE: Mar 29, 2011 - 1:55pm CAD OPERATOR: cwelken
LIST OF XREFS: [n\Terradigs--border-Bs11] [102000_xTOPO_SECTION 5] [n\Terradigs--border--11x17] [102000_EXHIBIT LEGEND]



GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

N

150 0 150

(In Meters)
1 cm = 50 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____. RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 50 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

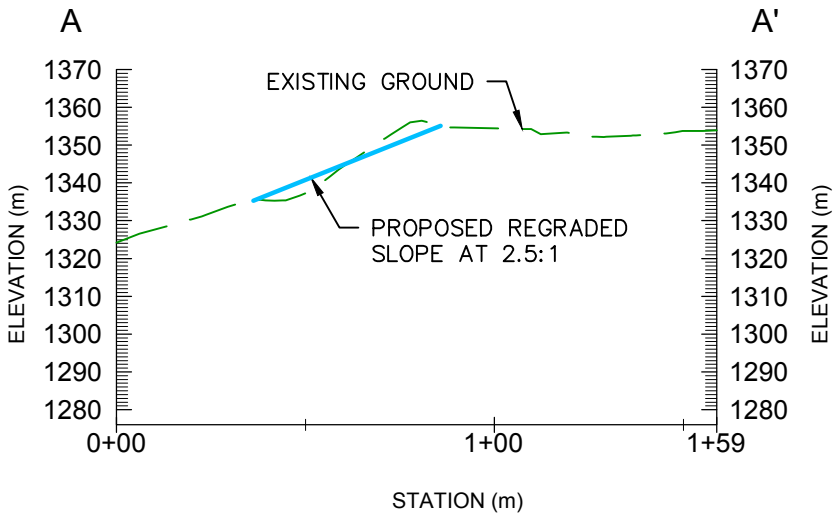
TITLE
HECTOR PIT PLAN

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

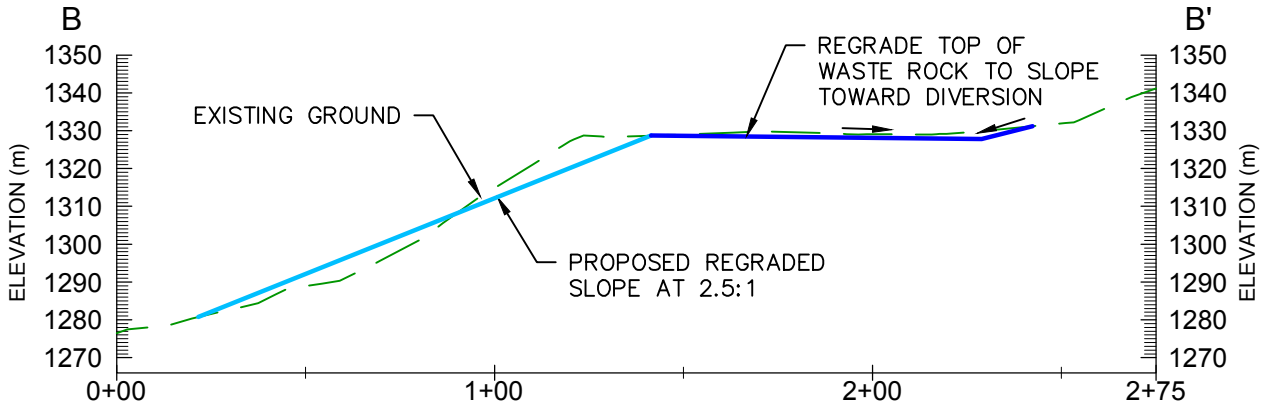
DRAWING FIGURE 6-18 REVISION

FILE NAME 102000_Hector Pit

DRAWING FILENAME: i:\Projects\102000 - Keno-Hector\Keno Coal\Graphics\102000_Hector Pit.dwg LAYOUT NAME: Hector Pit Plan and Section DATE: Mar 30, 2011 - 8:35am CAD OPERATOR: cwelken
LIST OF XREFS: [n:\terradyn-dundee-8x11\102000_xTOPO_SECTION V3.1\102000_EXHIBIT LEGEND]



SECTION A-A'



SECTION B-B'

60 0 60

(In Meters)
1 cm = 20 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 20 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
HECTOR PIT
SECTIONS A & B

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-19 REVISION

FILE NAME 102000_Hector Pit

DRAWING FILENAME: i:\Projects\102000 - Keno-Hance\Keno Coal\Grad\102000_Hector Pit.dwg LAYOUT NAME: Hector Pit Section A and B DATE: Mar 30, 2011 - 8:35am CAD OPERATOR: cwelken
LIST OF XREFS: [n:\terradyn-dunder-Bat\] [102000_xTOPO_SECTION A] [102000_EXHIBIT LEGEND]



N

60 0 60

(In Meters)
1 cm = 20 M

GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 20 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

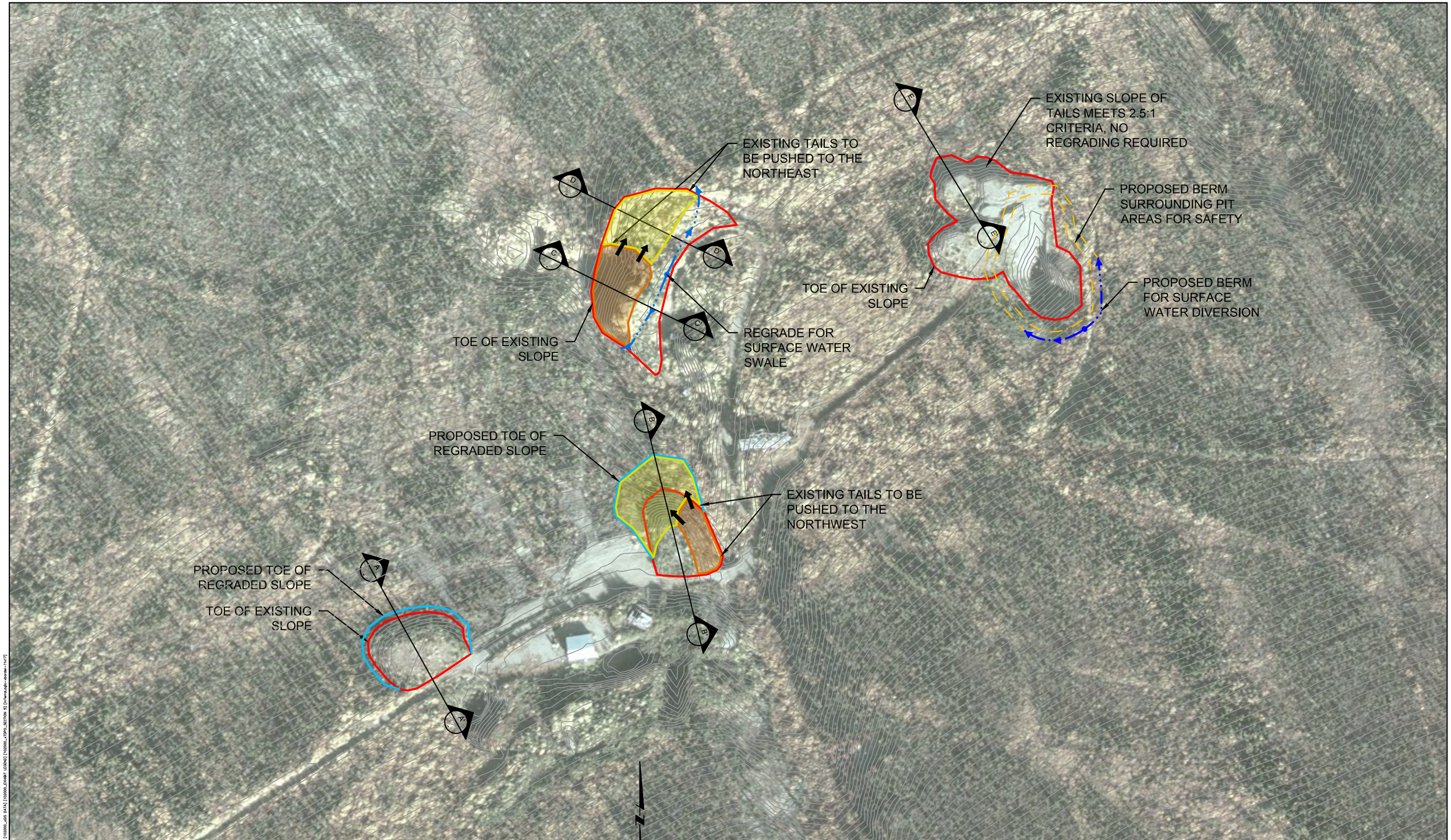
TITLE
MILLER PIT
PLAN

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-20 REVISION

FILE NAME 102000_Miller

DRAWING FILENAME: i:\Projects\102000 - Keno-Nexco\Keno Coal\Graphics\102000_Miller.dwg LAYOUT NAME: Miller Pit DATE: Mar 29, 2011 - 3:48pm CAD OPERATOR: ACAD
LIST OF XREFS: [n:\terralogic-border-8x11] [102000_xTOPO_SECTION 5] [102000_EXHIBIT LEGEND]



GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83

SCALE: 1 cm = 20 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
NO CASH 100 PIT PLAN

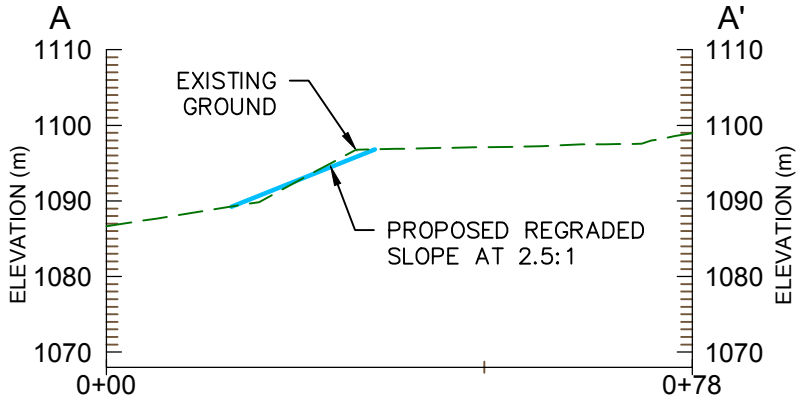
TERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-21

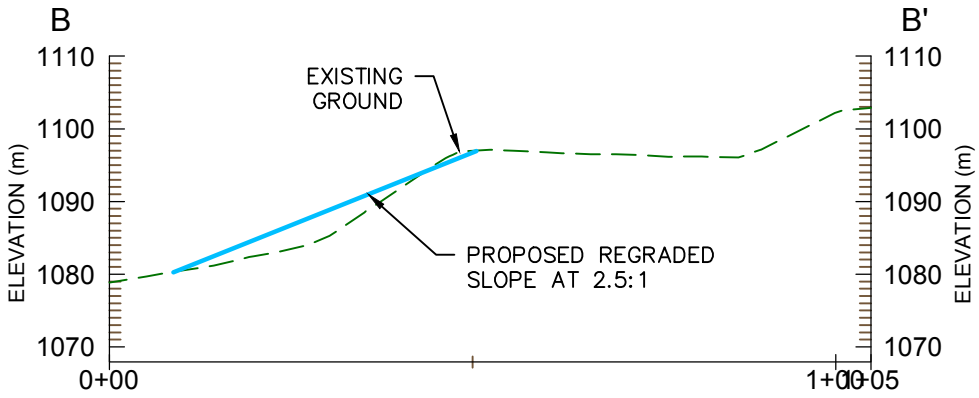
REVISION

FILE NAME 102000_No Cash 100

DRAWING FILENAME: L:\Projects\102000 - Keno-Hess\Vizmo Cad\Grad\102000_No Cash 100.dwg LAYOUT NAME: NO CASH 100_PLAN DATE: Mar 30, 2011 - 9:43am CAD OPERATOR: cwelken
LIST OF XREFS: [b:\terra\cgdc-aborder-8x11] [102000_GIS DATA] [102000_EXHIBIT LEGEND] [102000_xTOPO_SECTION 5] [b:\terra\cgdc-aborder-11x17]



SECTION A-A'



SECTION B-B'

30 0 30

(In Meters)
1 cm = 10 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 10 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

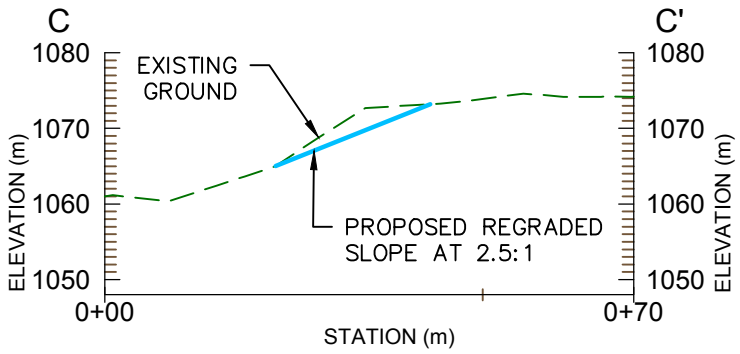
TITLE
NO CASH 100 PIT
PROFILES A & B

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

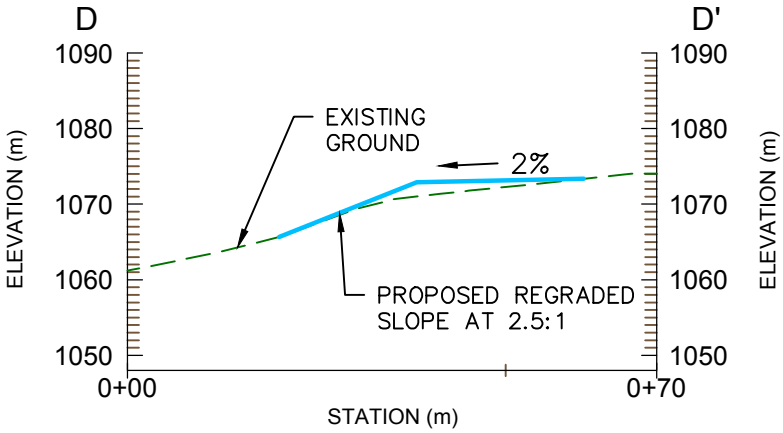
DRAWING FIGURE 6-22 REVISION

FILE NAME 102000_No Cash 100

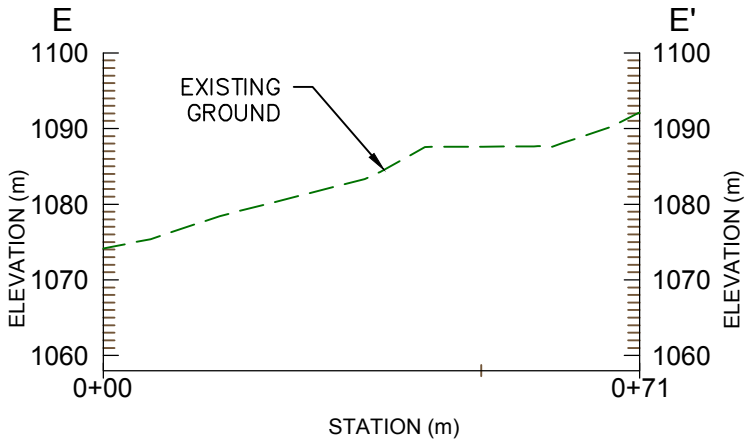
DRAWING FILENAME: L:\Projects\102000 - Keno-Hess\Keno Coal\Grad\102000_No Cash 100.dwg LAYOUT NAME: NO CASH 100_PROFILE DATE: Mar 30, 2011 - 8:43am CAD OPERATOR: cwelken
LIST OF XREFS: [n:\terradyn--border-8x11] [102000_GIS DATA] [102000_EXHIBIT LEGEND] [102000_xTOPO_SECTION A] [n:\terradyn--border-11x17]



SECTION C-C'



SECTION D-D'



SECTION E-E'

30 0 30

(In Meters)
1 cm = 10 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 10 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

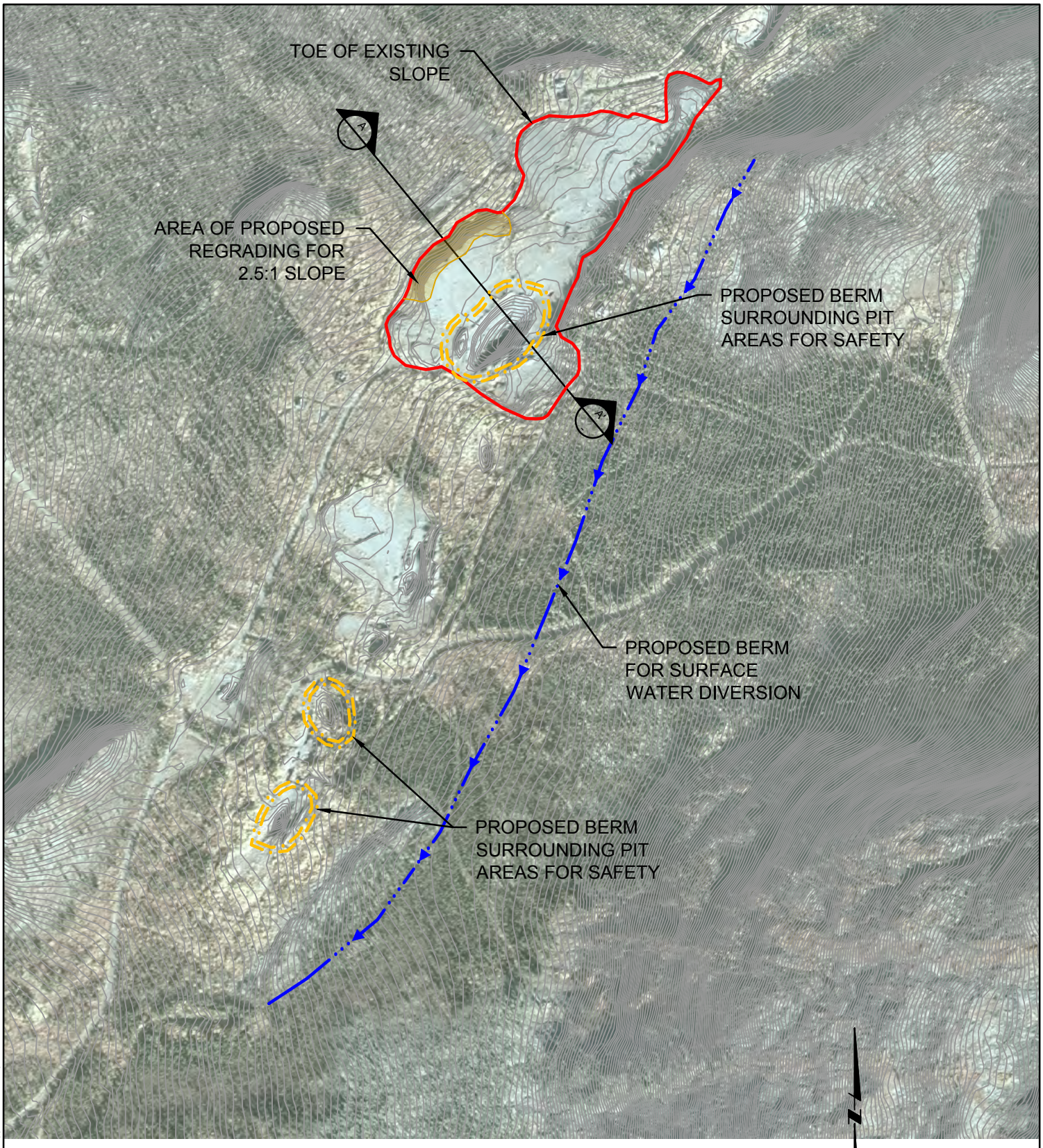
TITLE
NO CASH 100 PIT
PROFILES C, D & E

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-23 REVISION

FILE NAME 102000_No Cash 100

DRAWING FILENAME: i:\Projects\102000 - Keno-Hecla\Keno Coal\Grad\102000_No Cash 100.dwg LAYOUT NAME: NO CASH 100_PROFILE (2) DATE: Mar 30, 2011 - 8:43am CAD OPERATOR: cwelken
LIST OF XREFS: [b:\Terra\Logo--border-8x11] [102000_GIS DATA] [102000_EXHIBIT LEGEND] [102000_xTOPO_SECTION A] [b:\Terra\Logo--border--11x17]



GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

150 0 150

(In Meters)
1 cm = 50 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 50 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

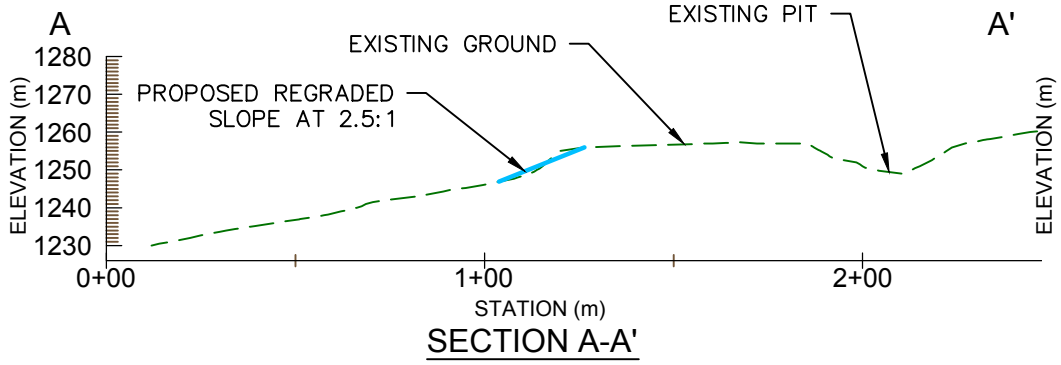
TITLE
SADIE LADUE AND WERNECKE PITS PLAN

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-24 REVISION

FILE NAME 102000_Sadie Ladue

DRAWING FILENAME: I:\Projects\102000 - Keno-Nexco\Keno Coal\Graphics\102000_Sadie Ladue.dwg LAYOUT NAME: Sadie Ladue_PLAN DATE: Mar 30, 2011 - 4:48pm CAD OPERATOR: cwelken
LIST OF XREFS: [InTerraLogo-Border-8x11] [102000_GIS DATA] [102000_TOPO_SECTION 5] [102000_EXHIBIT LEGEND]



SECTION A-A'

60 0 60

(In Meters)
1 cm = 20 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 20m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
SADIE LADUE AND WERNECKE PITS
SECTION A

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-25 REVISION

FILE NAME 102000_Sadie Ladue

DRAWING FILENAME: I:\Projects\102000 - Keno-Nexco\Keno Coal\Grad\102000_Sadie Ladue.dwg LAYOUT NAME: SADIE LADUE_SECTION A DATE: Mar 30, 2011 - 4:45pm CAD OPERATOR: cwelken
LIST OF XREFS: [InTerraLogo-Border-Bar1] [102000_GIS DATA] [102000_TOPO_SECTION 5] [102000_EXHIBIT LEGEND]



GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

N

60 0 60

(In Meters)
1 cm = 20 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 20m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

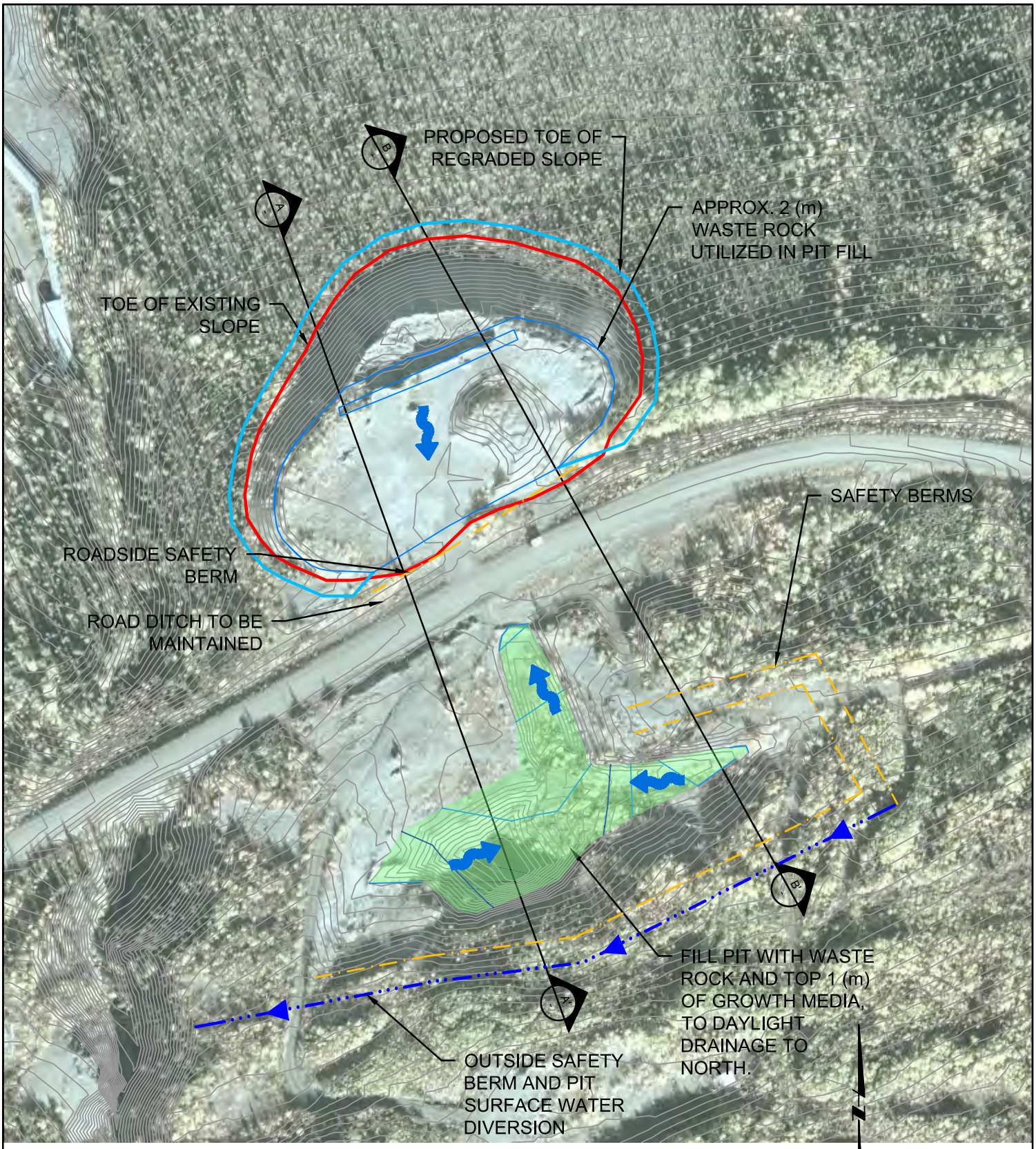
TITLE
SHAMROCK PIT
PLAN

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-26 REVISION

FILE NAME 102000_Shamrock

DRAWING FILENAME: i:\Projects\102000 - Keno-Nexco\Keno Coal\Graphics\102000_Shamrock.dwg LAYOUT NAME: SHAMROCK DATE: Mar 29, 2011 - 2:49pm CAD OPERATOR: ACAD
LIST OF XREFS: [n:\terralogic-border-8x11] [102000_xTOPO_SECTION 5] [102000_EXHIBIT LEGEND] [102000_xGIS DATA]



GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

60 0 60

(In Meters)
1 cm = 20 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____. RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 20 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

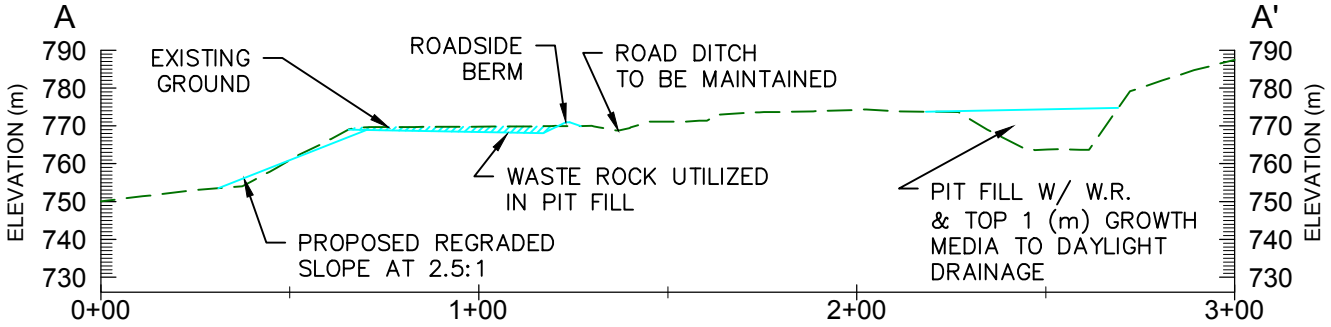
TITLE
SILVER KING PIT PLAN

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

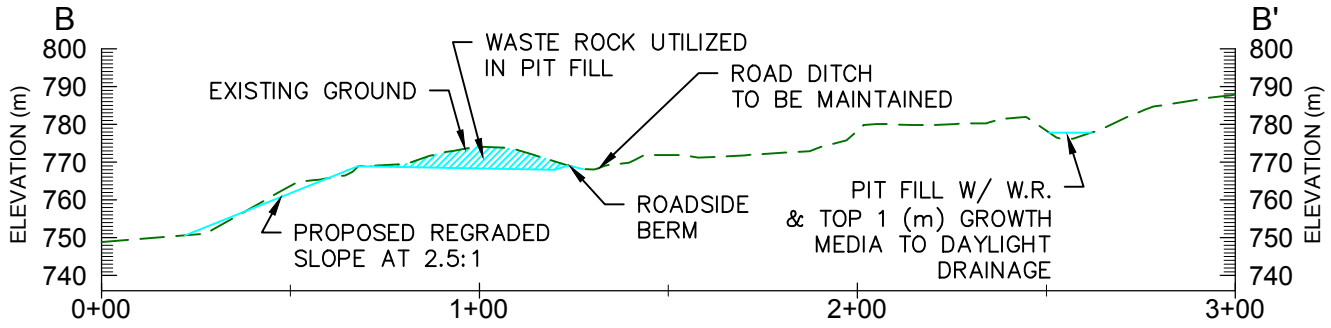
DRAWING FIGURE 6-27 REVISION

FILE NAME 102000_Silver King

DRAWING FILENAME: i:\Projects\102000 - Keno-Newco\Keno Coal\Graphics\102000_Silver King.dwg LAYOUT NAME: Silver King Plan DATE: Mar 29, 2011 - 4:03pm CAD OPERATOR: ACAD
LIST OF XREFS: [102000_TOPO_SECTION B] [xrefs:xplr-border-8x11] [102000_EXHIBIT LEGEND]



SECTION A-A'



SECTION B-B'

60 0 60

(In Meters)
1 cm = 20 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____. RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 20 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
SILVER KING PIT
SECTIONS A & B

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-28 REVISION

FILE NAME 102000_Silver King

DRAWING FILENAME: L:\Projects\102000 - Keno-Nexco\Keno Coal\Graphics\102000_Silver King.dwg LAYOUT NAME: Silver King Profile DATE: Mar 29, 2011 - 4:02pm CAD OPERATOR: ACAD
LIST OF XREFS: [102000_TOPO_SECTION B] [xrefs:xplc-xborder-8x11] [102000_EXHIBIT LEGEND]



GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

30 0 30

(In Meters)
1 cm = 10 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 10 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

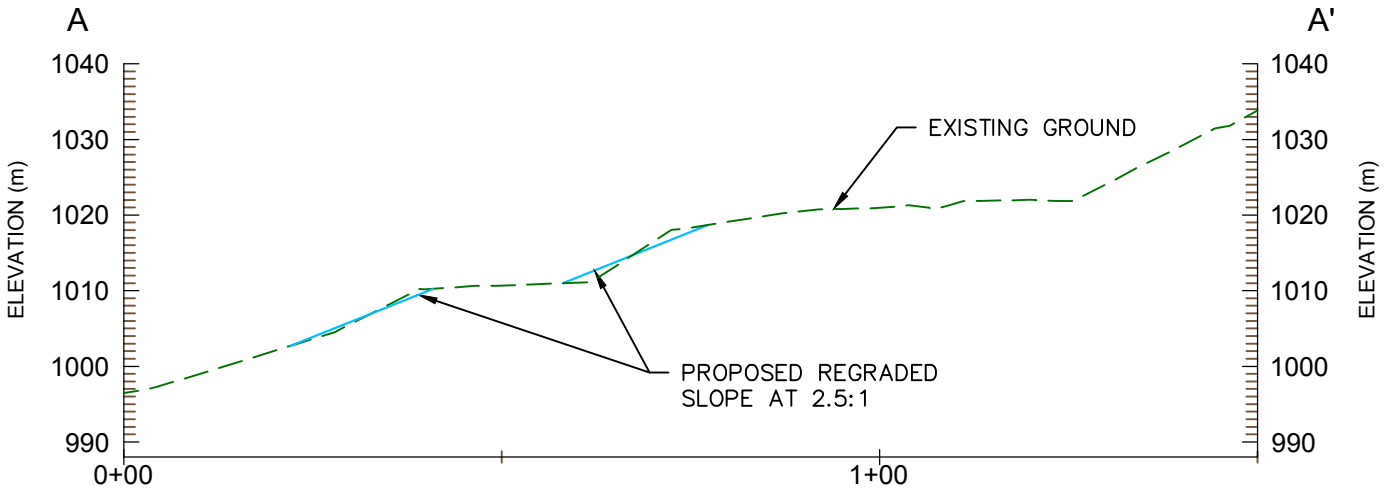
TITLE
DIXIE ADIT
PLAN

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-29 REVISION

FILE NAME 102000_Dixie

DRAWING FILENAME: C:\Users\cwelken\appdata\local\temp\VisPlaSet_4972\102000_Dixie.dwg LAYOUT NAME: DIXIE_PLAN DATE: Mar 30, 2011 - 9:05am CAD OPERATOR: cwelken
LIST OF XREFS: [InTrenEdge--Border-8x11] [102000_EXHIBIT LEGEND]



SECTION A-A'

30 0 30

(In Meters)
1 cm = 10 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83

SCALE: 1 cm = 10 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
DIXIE ADIT
SECTION A

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-30

REVISION

FILE NAME 102000_Dixie

DRAWING FILENAME: C:\Users\cwelken\appdata\local\temp\VisPlotSet_4872\102000_Dixie.dwg LAYOUT NAME: DIXIE_SECTION A DATE: Mar 30, 2011 - 8:05am CAD OPERATOR: cwelken
LIST OF XREFS: [nTerraLogo--border-8x11] [102000_EXHIBIT LEGEND]



GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

60 0 60

(In Meters)
1 cm = 20 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED ____, 20__.

DATUM: NAD83 SCALE: 1 cm = 20 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

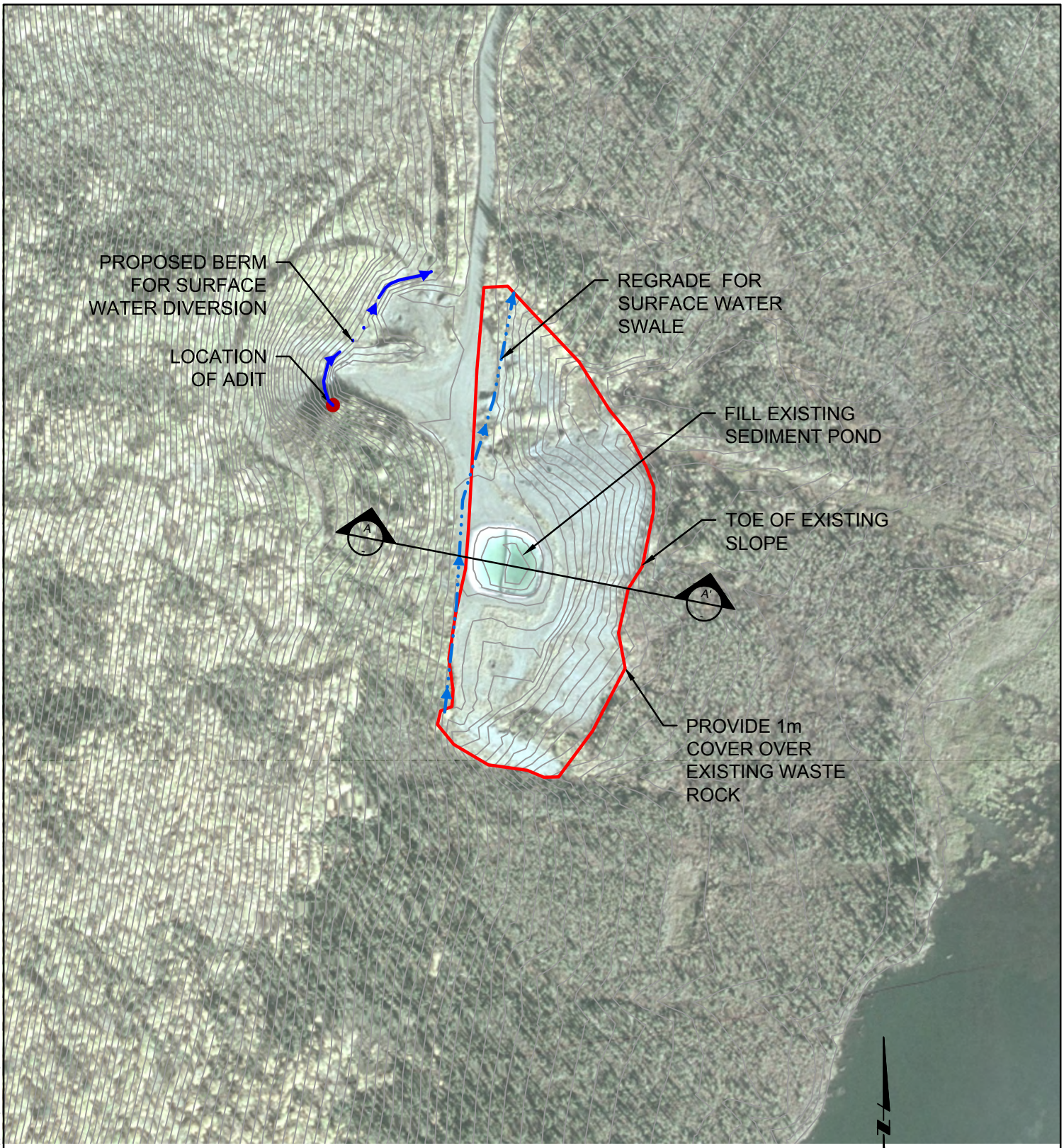
TITLE
ELSA +50 LEVEL ADIT PLAN

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-31 REVISION

FILE NAME 102000_Husky_Elsa

DRAWING FILENAME: i:\Projects\102000 - Keno-Nexco\Keno Coal\Grad\102000_Husky_Elsa.dwg LAYOUT NAME: ELSA +50 DATE: Mar 30, 2011 - 11:17am CAD OPERATOR: cwelken
LIST OF XREFS: [n:\terralogic-border-8x11] [102000_EXHIBIT LEGEND] [102000_ATOPO_SECTION B] [102000_GIS DATA]



GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____. RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 20 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

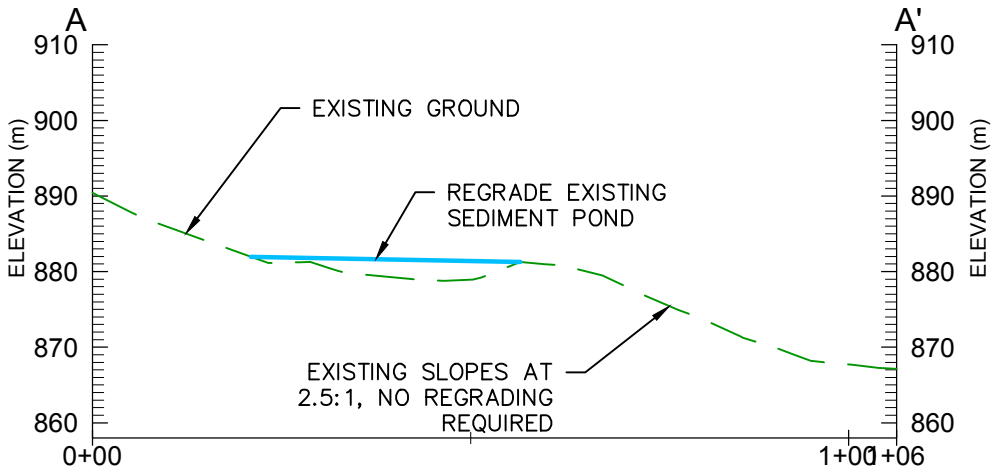
TITLE
GALKENO 900 ADIT PLAN

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-32 REVISION

FILE NAME 102000_Galkeno 900

DRAWING FILENAME: C:\Users\cwelken\appdata\local\temp\VarPlaSet_1252\102000_Galkeno 900.dwg LAYOUT NAME: Galkeno 900 DATE: Mar 30, 2011 - 3:19pm CAD OPERATOR: cwelken
LIST OF XREFS: [102000_TOPO_SECTION 5] [InTerra&gis-border-11x17] [102000_EXHIBIT LEGEND] [InTerra&gis-border-8x11]



SECTION A-A'

30 0 30

(In Meters)
1 cm = 10 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 10m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

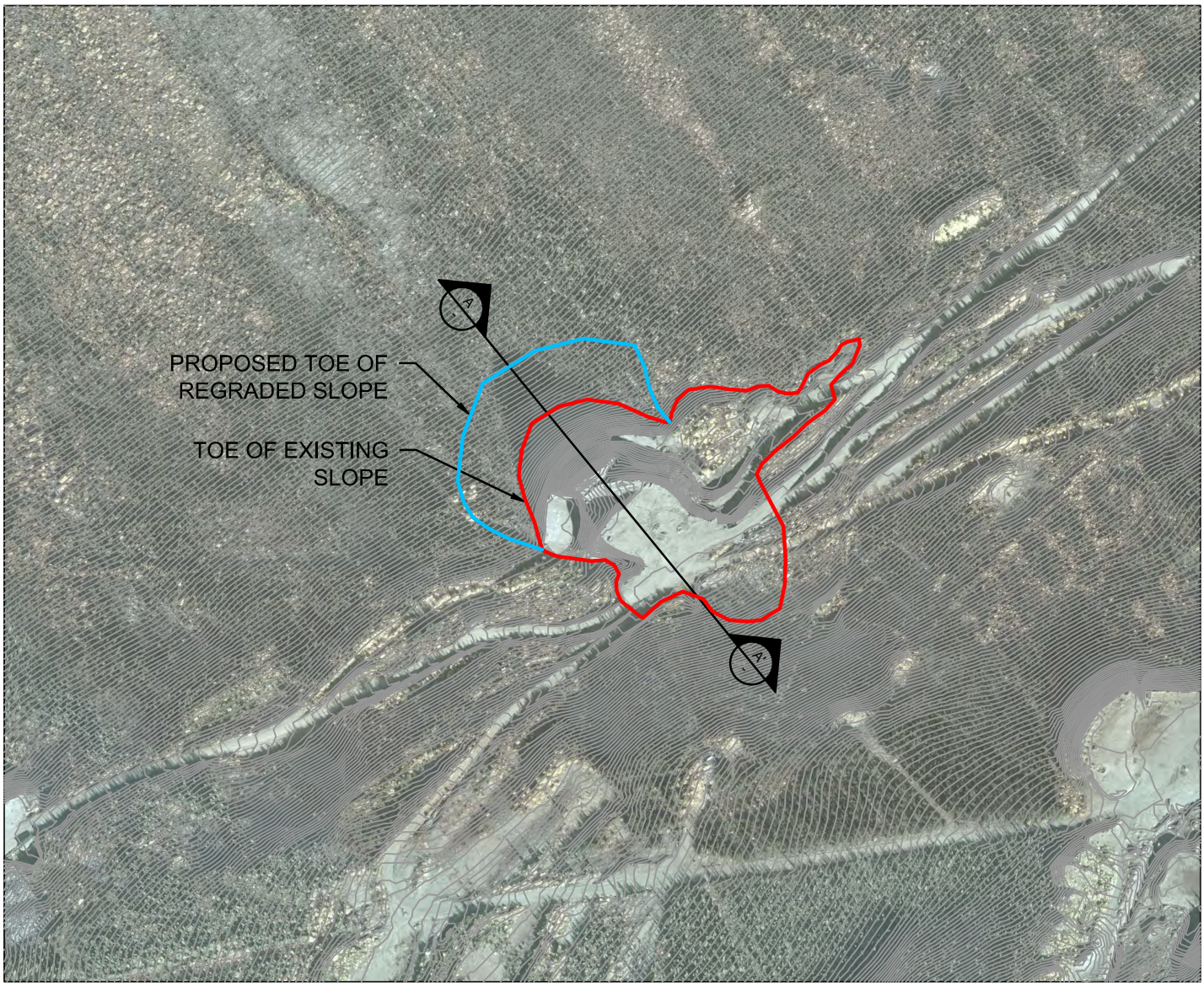
TITLE
GALKENO 900 ADIT
SECTION A

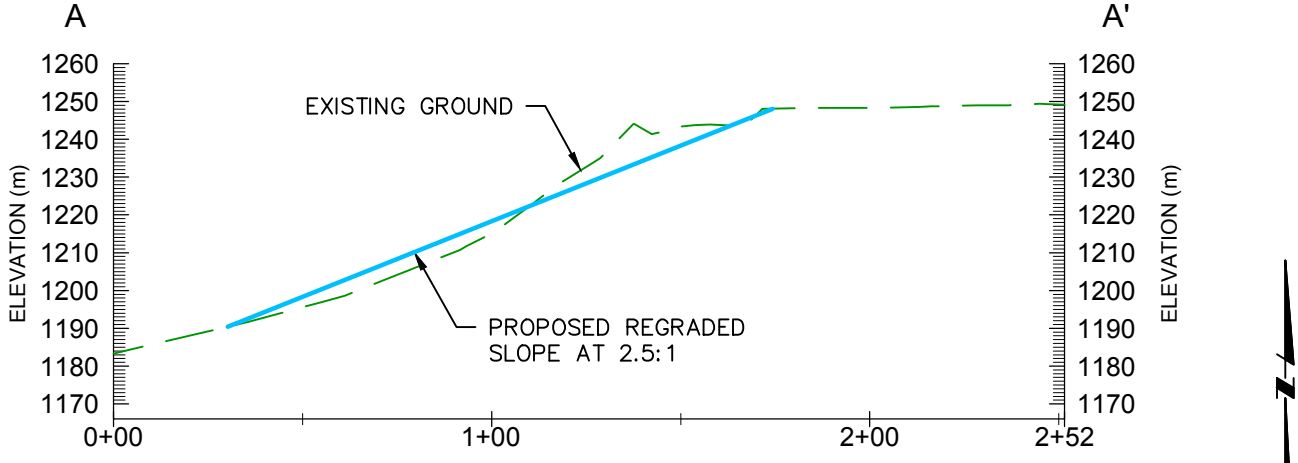
INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-33 REVISION

FILE NAME 102000_Galkeno 900

DRAWING FILENAME: C:\Users\cwelken\appdata\local\temp\AcePublish_1252\102000_Galkeno 900.dwg LAYOUT NAME: GALKENO_SECTION A DATE: Mar 30, 2011 - 3:18pm CAD OPERATOR: cwelken
LIST OF XREFS: [102000_TOPO_SECTION A] [m"terra\dgn~xborder~11x17] [102000_EXHIBIT LEGEND] [m"terra\dgn~xborder~Ar1]





GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

SECTION A-A'

150 0 150

(In Meters)
1 cm = 50 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 50 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
HECTOR ADIT
PLAN & SECTION A

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-34 REVISION

FILE NAME 102000_Hector Adit

DRAWING FILENAME: i:\Projects\102000 - Keno-Nexco\Keno Coal\Grad\102000_Hector Adit.dwg LAYOUT NAME: Hector Adit Plan and Section DATE: Mar 29, 2011 - 3:03pm CAD OPERATOR: ACAD
LIST OF XREFS: [n:\terralogic-border-8x11] [102000_xTOPO_SECTION v3] [102000_EXHIBIT LEGEND]



GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

60 0 60

(In Meters)
1 cm = 20 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 20 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

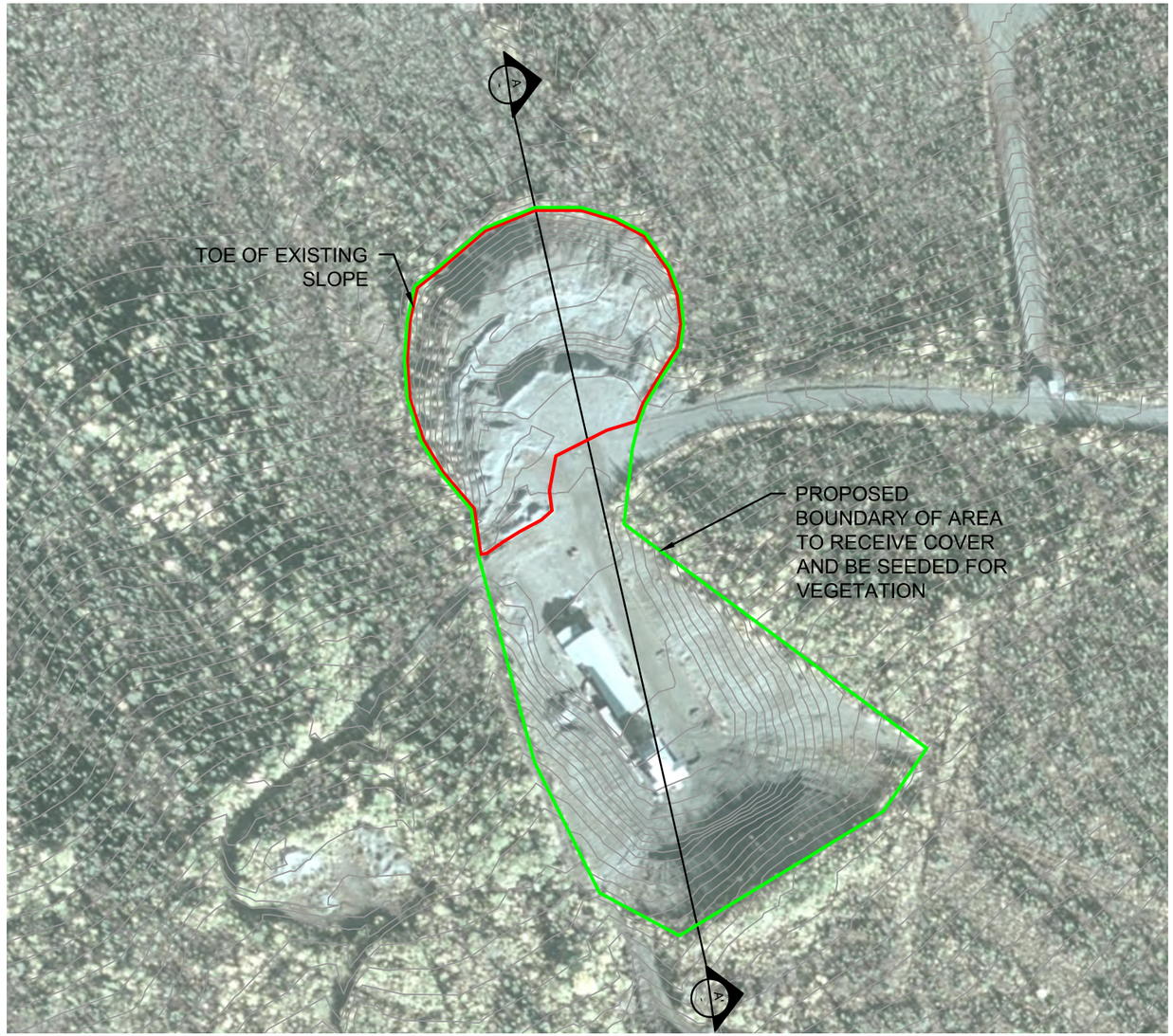
TITLE
HUSKY SHAFT PLAN

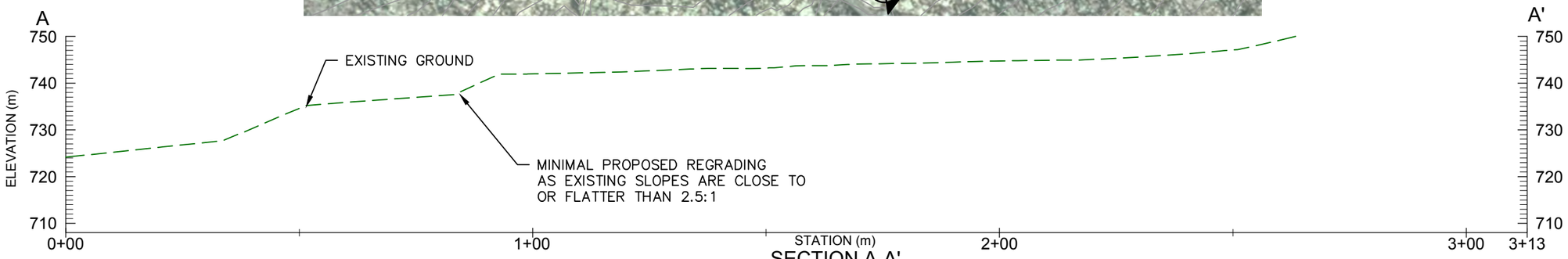
INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-35 REVISION

FILE NAME 102000_Husky_Elsa

DRAWING FILENAME: i:\Projects\102000 - Keno-Nexco\Keno Coal\Coal\102000_Husky_Elsa.dwg LAYOUT NAME: HUSKY PLAN DATE: Mar 29, 2011 - 3:17pm CAD OPERATOR: cwelken
LIST OF XREFS: [n:\terralogic-border-8x11] [102000_EXHIBIT LEGEND] [102000_2700_SECTION B] [102000_dGS DATA]





SECTION A-A'

GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

30 0 30
(In Meters)
1 cm = 10 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED ____ 20__

DATUM: NAD83 SCALE: 1 cm = 10 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

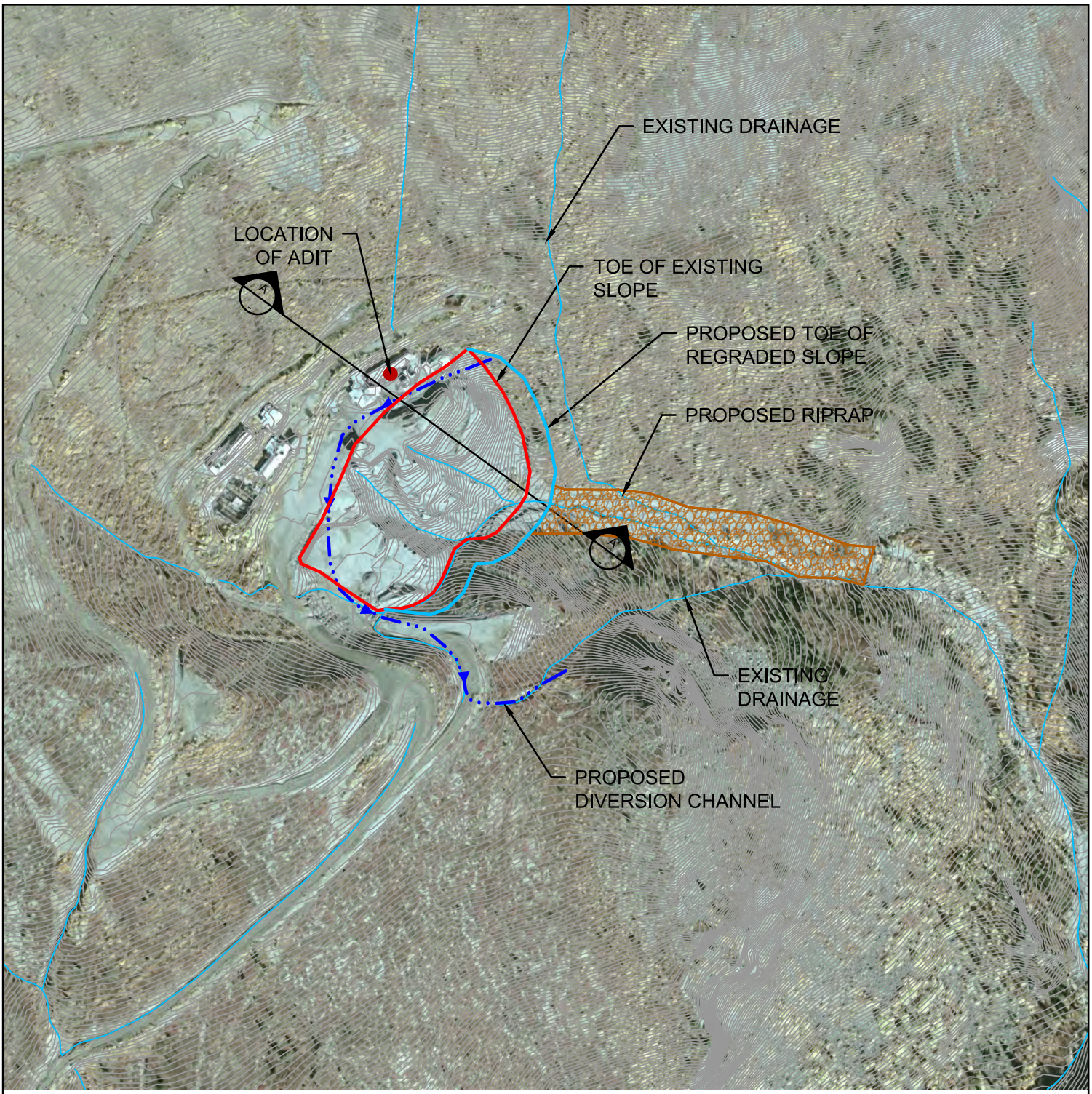
TITLE
HUSKY SW SHAFT
PLAN & SECTION A

TERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-36 REVISION

FILE NAME 102000_Husky SW

DRAWING FILENAME: L:\Projects\102000 - Keno-Hess\Mxds Cad\Grad\102000_Husky SW.dwg LAYOUT NAME: Husky SW Plan DATE: Mar 29, 2011 - 11:13am CAD OPERATOR: cwelken
LIST OF XREFS: [102000_TOPO_SECTION B] [102000_EXHIBIT LEGEND] [102000_GIS DATA] [xTerra-Logo-border-11x17]



GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

N

100 0 100

(In Meters)
1 cm = 33 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 33 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

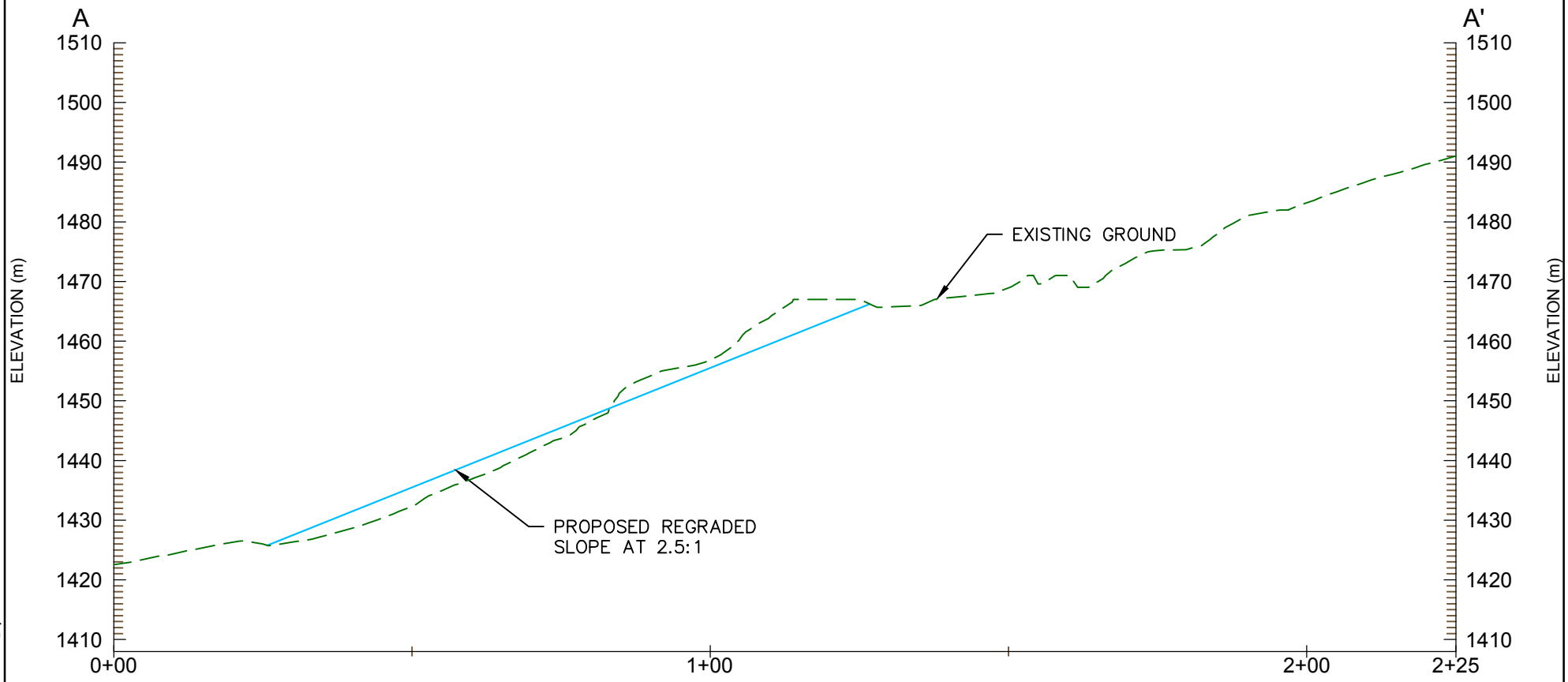
TITLE
KENO 700 ADIT PLAN

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-37 REVISION

FILE NAME 102000_Keno 700 Adit

DRAWING FILENAME: i:\Projects\102000 - Keno-Nexco\Keno Coal\Grad\102000_Keno 700 Adit.dwg LAYOUT NAME: Keno 700_PLAN DATE: Mar 30, 2011 - 2:48pm CAD OPERATOR: cwelken
LIST OF XREFS: [n\terra\dgn--border-8x11] [102000_GIS DATA] [102000_EXHIBIT LEGEND] [n\terra\dgn--border--8x11_ori]



SECTION A-A'

30 0 30

(In Meters)
1 cm = 10 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED ____, 20__.

DATUM: NAD83

SCALE: 1 cm = 10m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
KENO 700 ADIT
SECTION A

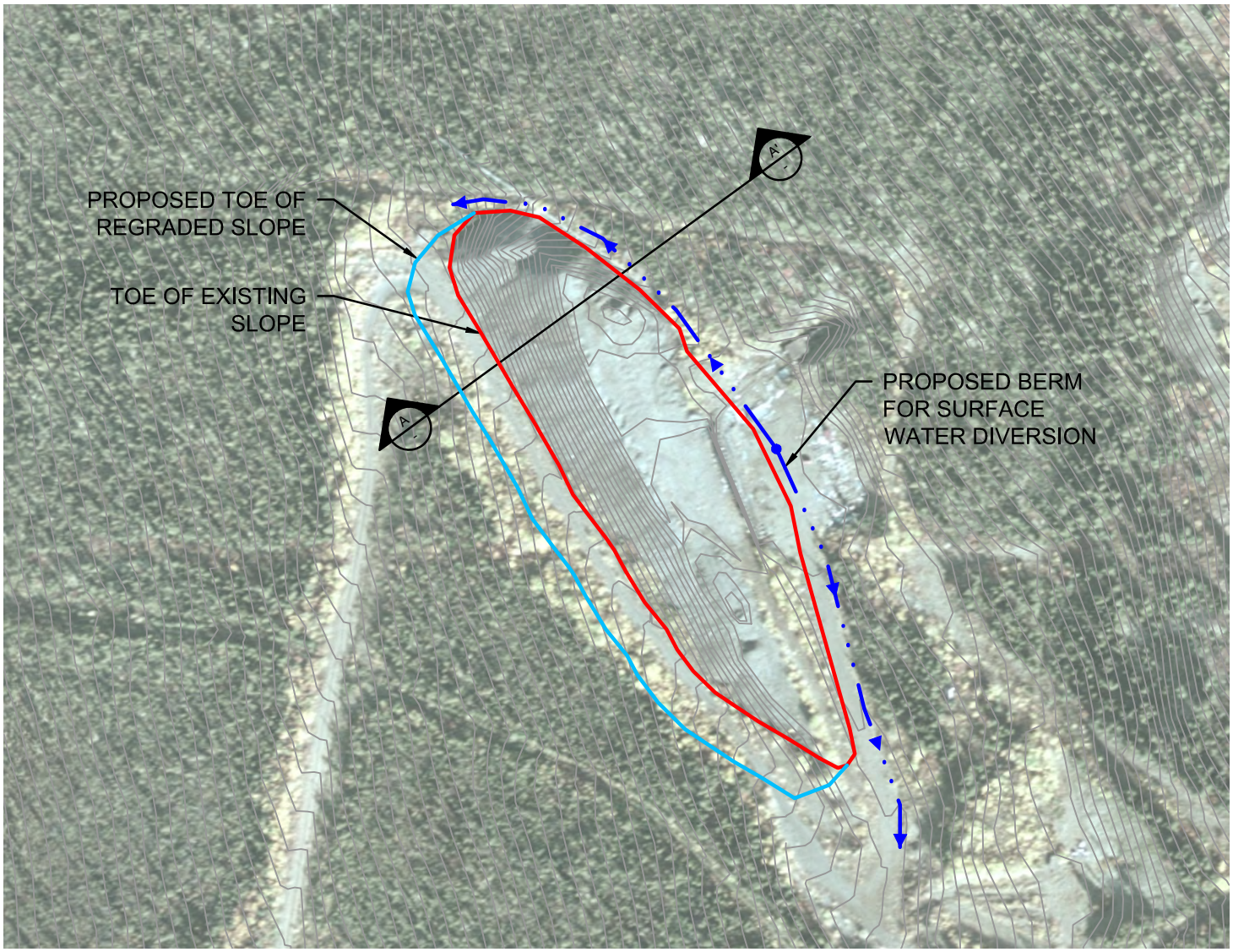
INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

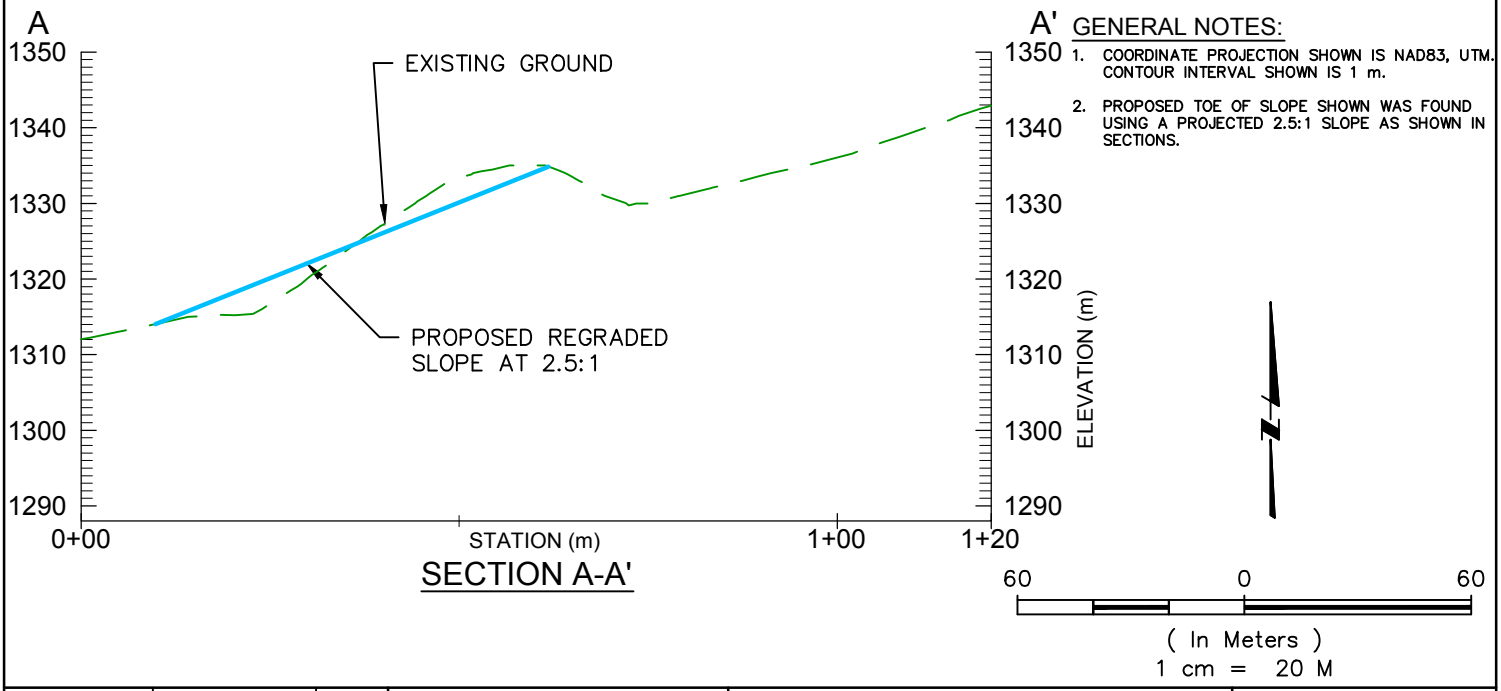
DRAWING FIGURE 6-38

REVISION

FILE NAME 102000_Keno 700 Adit

DRAWING FILENAME: s:\Projects\102000 - Keno-Anaco\Keno Gas\Grad\102000_Keno 700 Adit.dwg LAYOUT NAME: KENO 700_SECTION A DATE: Mar 30, 2011 - 2:48pm CAD OPERATOR: cwelken
LIST OF XREFS: [n:TerraLogic-border-8x11] [102000_GIS DATA] [102000_EXHIBIT LEGEND] [n:TerraLogic-border-8x11_ref]





GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____. RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 20m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

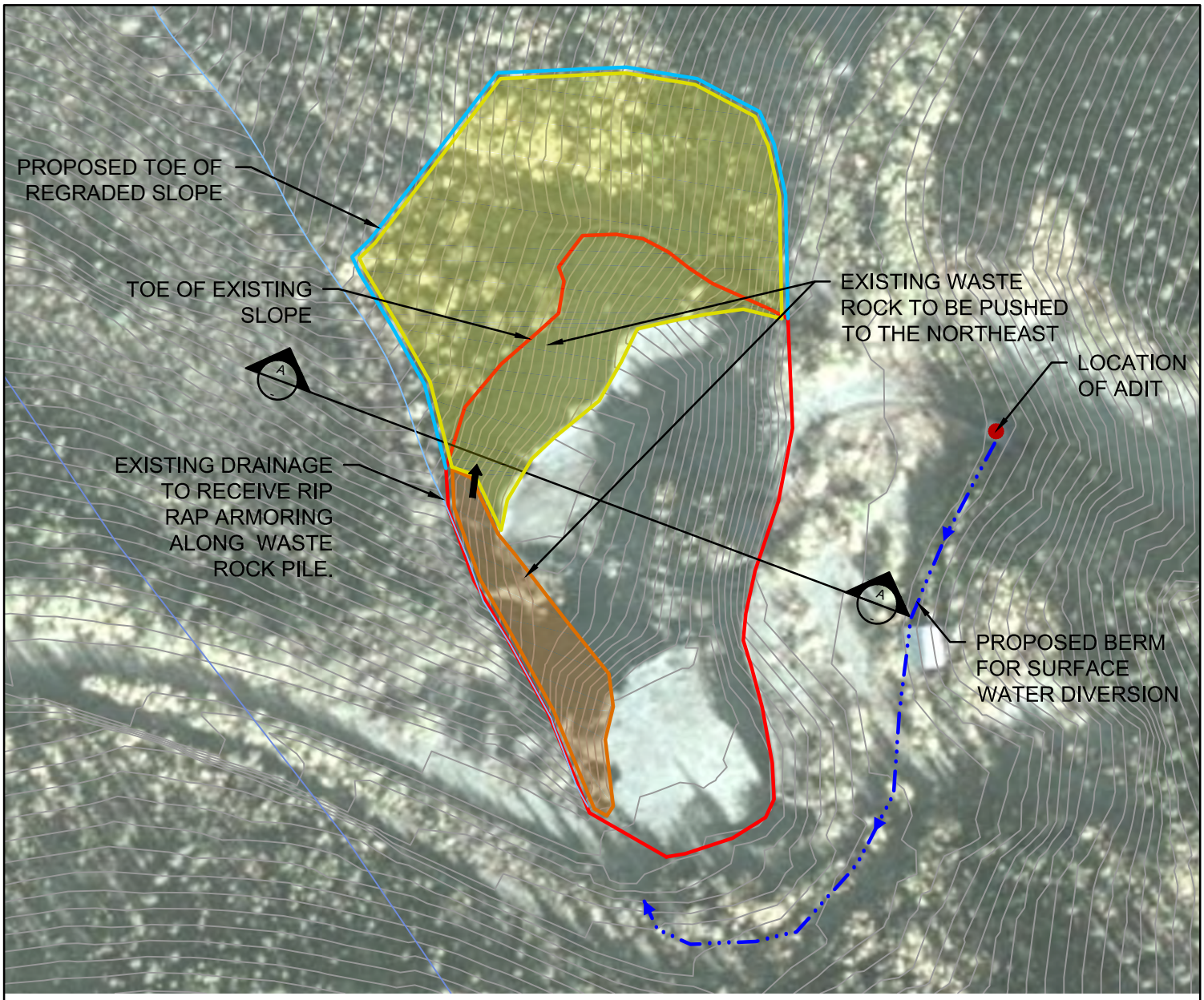
TITLE
LUCKY QUEEN 500 ADIT
PLAN & SECTION A

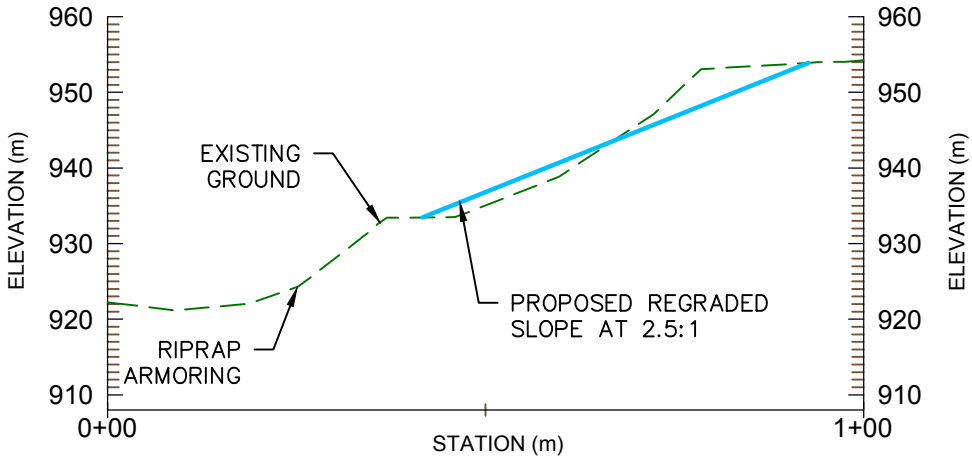
INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-39 REVISION

FILE NAME 102000_Lucky Queen

DRAWING FILENAME: i:\Projects\102000 - Keno-Nexco\Keno Coal\Grad\102000_Lucky Queen.dwg LAYOUT NAME: LUCKY QUEEN PLAN SECTION A DATE: Mar 30, 2011 - 8:38am CAD OPERATOR: cwelken
LIST OF XREFS: [n:\terrad\cgb--border-8x11] [102000_xTOPO_SECTION A] [102000_EXHIBIT LEGEND]

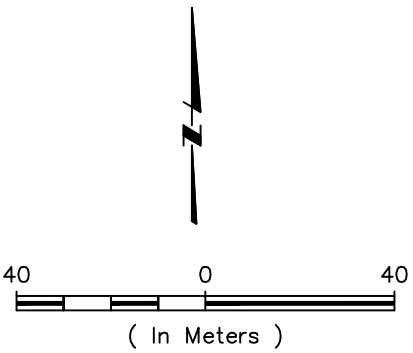




SECTION A-A'

GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.



DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____. RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 10 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
NO CASH 500 ADIT
PLAN & SECTION A

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-40 REVISION

FILE NAME 102000_No Cash 500

DRAWING FILENAME: i:\Projects\102000 - Keno-Mexco\Keno Coal\Grad\102000_No Cash 500.dwg LAYOUT NAME: NO CASH 500_PLAN DATE: Mar 30, 2011 - 11:45am CAD OPERATOR: cwelken
LIST OF XREFS: [n:\terradyn-border-8x11] [102000_EXHIBIT LEGEND] [102000_GIS DATA]



GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

60 0 60

(In Meters)
1 cm = 20 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 20 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

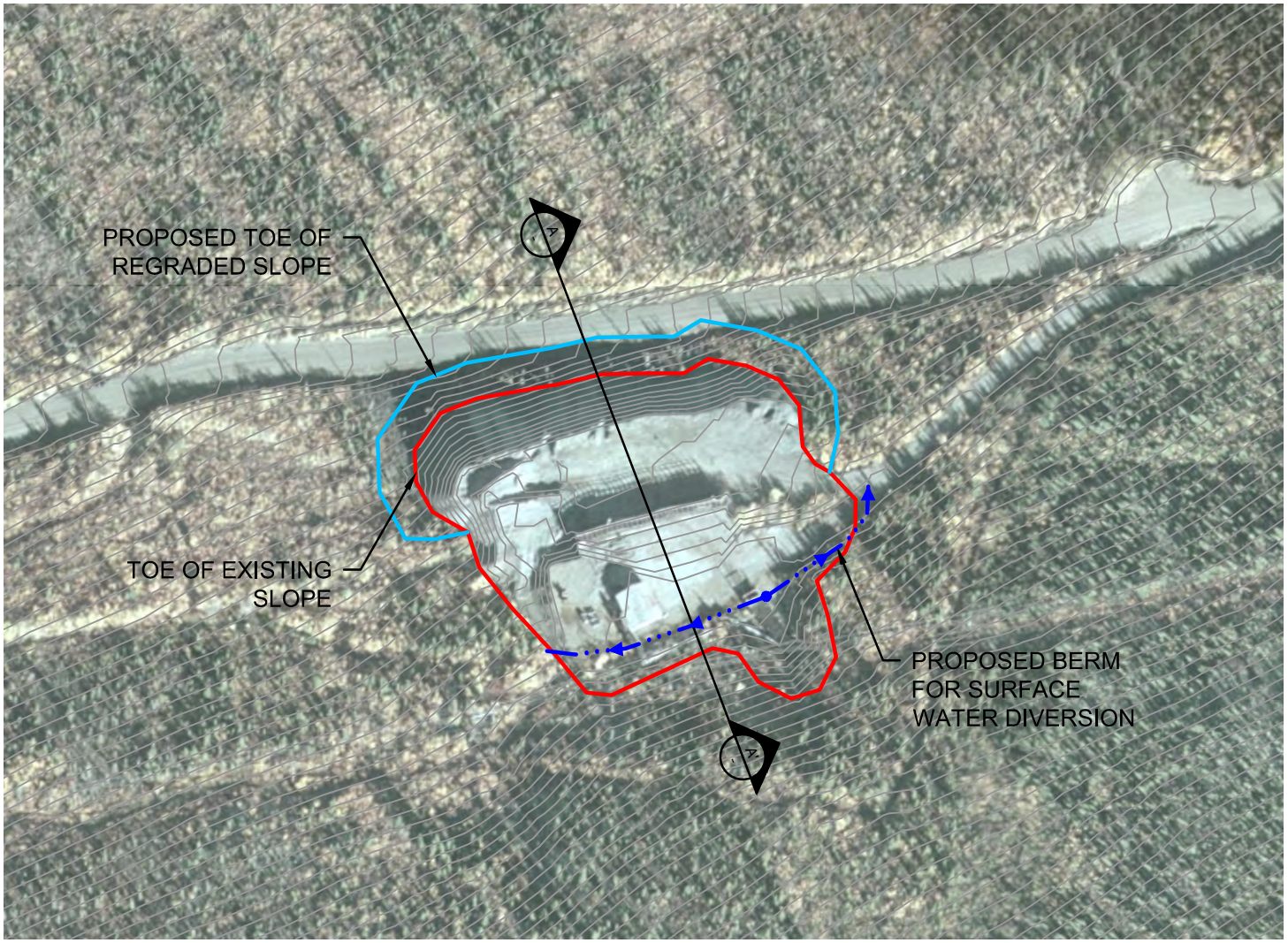
TITLE
ONEK 400 ADIT PLAN

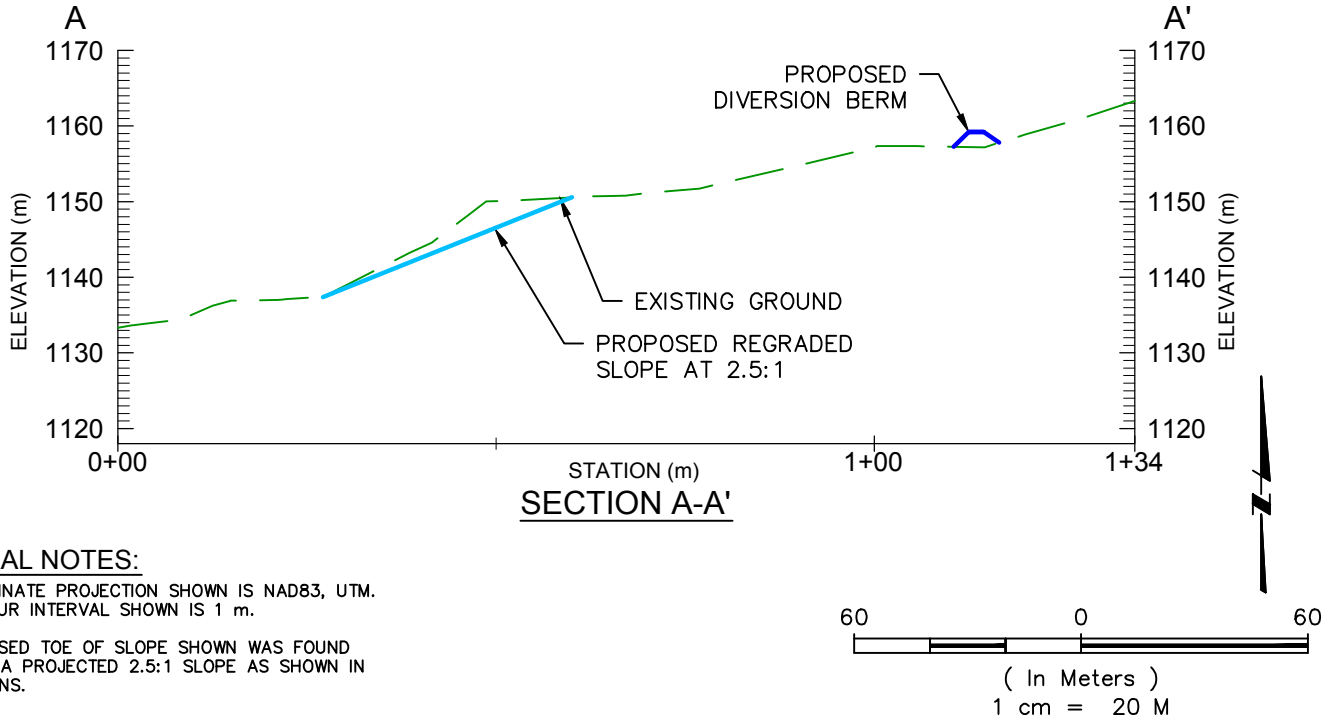
INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-41 REVISION

FILE NAME 102000_Onek 400

DRAWING FILENAME: C:\Users\cwelken\appdata\local\temp\VolPaSet_1252\102000_Onek 400.dwg LAYOUT NAME: Onek 400 Plan DATE: Mar 30, 2011 - 3:33pm CAD OPERATOR: cwelken
LIST OF XREFS: [102000_xTOPO_SECTION 9] [102000_xTOPO_SECTION 9] [InTerraLogic-standard-11x17] [102000_EXHIBIT LEGEND] [InTerraLogic-standard-8x11]





SECTION A-A'

GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

60 0 60

(In Meters)
1 cm = 20 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 20 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
RUBY ADIT
PLAN & SECTION A

INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-42 REVISION

FILE NAME 102000_Ruby

DRAWING FILENAME: i:\Projects\102000 - Keno-Nexus\Keno Coal\Grad\102000_Ruby.dwg LAYOUT NAME: Ruby Plan and Section DATE: Mar 29, 2011 - 3:13pm CAD OPERATOR: ACAD
LIST OF XREFS: [n:\terralogic-border-8x11] [102000_xTOPO_SECTION 4] [102000_EXHIBIT LEGEND]



GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.

60 0 60

(In Meters)
1 cm = 20 M

DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____.
RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 20 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
SADIE LADUE 600 ADIT PLAN

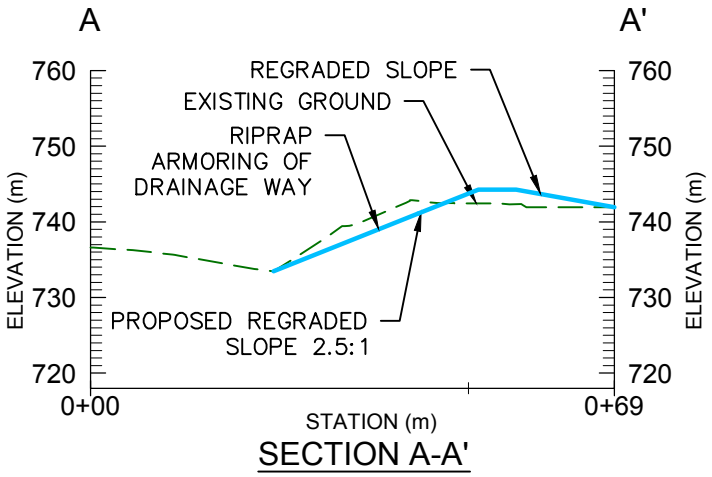
INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 6-43 REVISION

FILE NAME 102000_Sadie Ladue 600

DRAWING FILENAME: i:\Projects\102000 - Keno-Nexco\Keno Coal\Grad\102000_Sadie Ladue 600.dwg LAYOUT NAME: Sadie Ladue 600_plan DATE: Mar 30, 2011 - 3:06pm CAD OPERATOR: cwelken
LIST OF XREFS: [xTerraLogo-border-8x11] [102000_GIS DATA] [102000_TOPO_SECTION 5] [102000_EXHIBIT LEGEND]

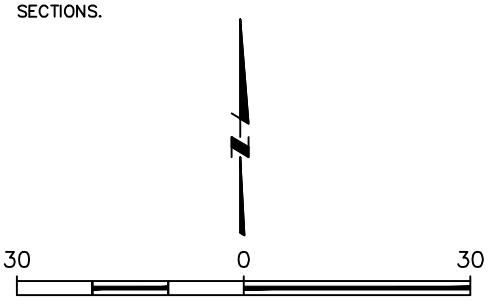




SECTION A-A'

GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.



DESIGNED BY	F. MARINELLI	3-14-2011
DRAWN BY	C. WELKEN	3-14-2011
CHECKED BY	B. CARLSON	3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

DRAWING REFERENCE(S):
EXISTING TOPOGRAPHY PROVIDED BY _____. RECEIVED _____, 20__.

DATUM: NAD83 SCALE: 1 cm = 10 m

PROJECT LOCATION: KENO,YUKON, CANADA

PROJECT: KENO

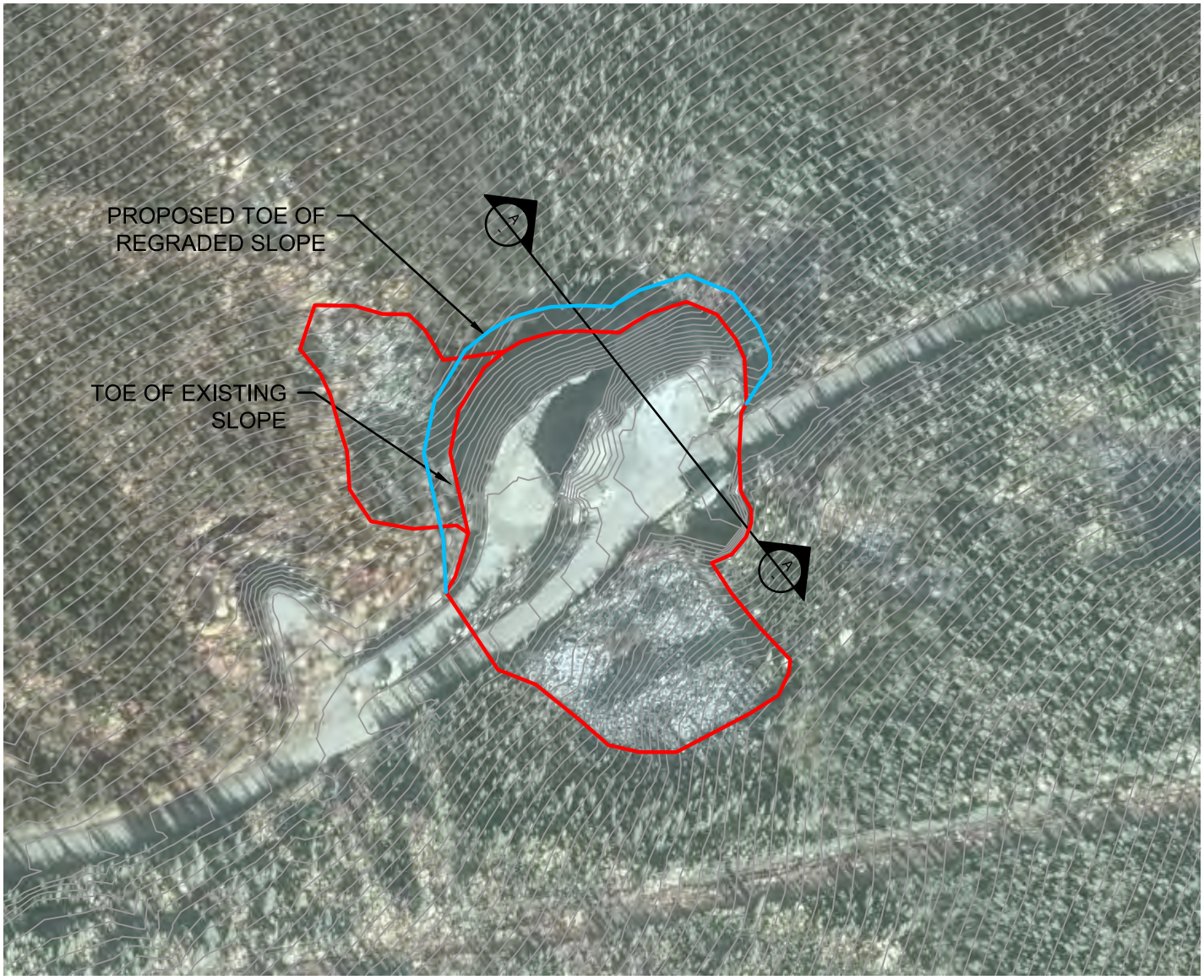
TITLE: SILVER KING 100 ADIT PLAN & SECTION A

INTERRA
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DRAWING: FIGURE 6-44 REVISION

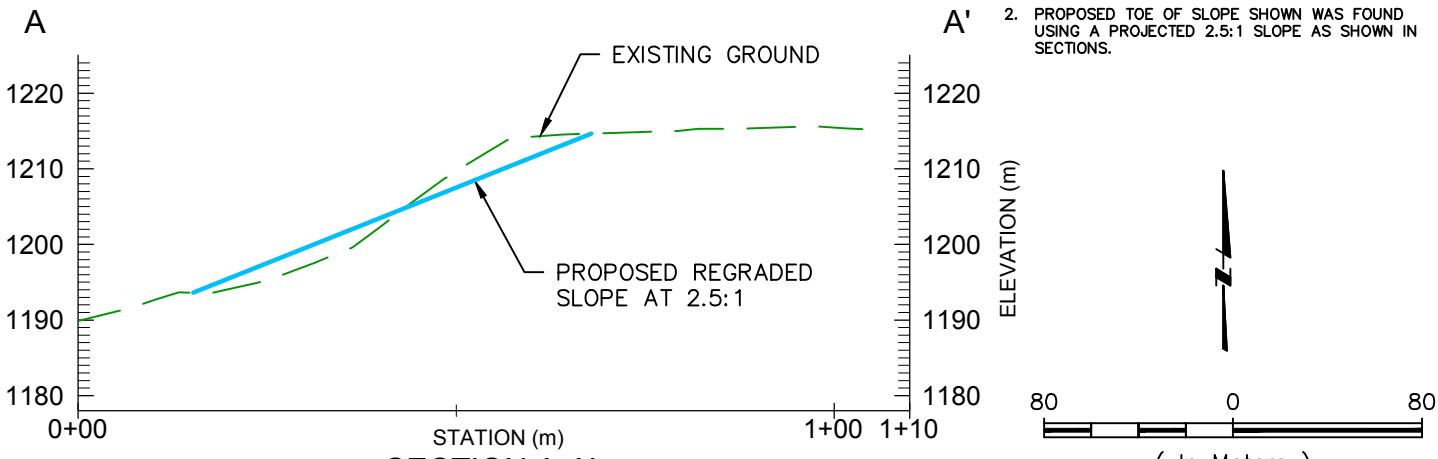
FILE NAME: 102000_Silver King 100

DRAWING FILENAME: L:\Projects\102000 - Keno-Nexus\Keno Coal\Graf\102000_Silver King 100.dwg LAYOUT NAME: Silver King 100 Plan DATE: Mar 30, 2011 - 12:21pm CAD OPERATOR: cwelken
LIST OF XREFS: [102000_xTOPO_SECTION B] [xTerraLogic-Border-8x11] [102000_EXHIBIT LEGEND] [102000_xGIS DATA]



GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
2. PROPOSED TOE OF SLOPE SHOWN WAS FOUND USING A PROJECTED 2.5:1 SLOPE AS SHOWN IN SECTIONS.



SECTION A-A'

DESIGNED BY		3-14-2011
DRAWN BY		3-14-2011
CHECKED BY		3-14-2011
APPROVED BY	B. Carlson	3-14-2011
PROJECT MANAGER	B. Carlson	3-14-2011
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

~~DRAWING REFERENCE(S):~~
EXISTING TOPOGRAPHY PROVIDED BY _____, RECEIVED ____, 20__.

~~DATUM:~~ NAD83 ~~SCALE:~~

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
TOWNSITE ADIT PLAN & SECTION A

INTERRA
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Fort Collins, Co 80525
970.225.8222

DRAWING
FIGURE 6-45

REVISION

FILE NAME
102000_Townsite

DRAWING FILENAME: L:\Projects\102000 - Keno-Nexco\Keno Coal\Grad\102000_Townsite.dwg LAYOUT NAME: Townsite Plan and Section DATE: Mar 29, 2011 - 3:36pm CAD OPERATOR: ACAD
LIST OF XREFS: [n:\terralogic-border-8x11] [102000_xTOPO_SECTION A] [102000_EXHIBIT LEGEND]

6.5 **Mine Shaft Closure**

The primary objectives of permanent shaft closure at Keno Hill are to prevent public access to the workings and to minimize the flow of air and water into/out of the shafts. A number of sites have also been flagged as "complex sites" where shaft closure is one of several measures to be undertaken as part of site closure and environmental remediation.

6.5.1 **Shaft Inventory**

A total of 32 shafts have been identified at Keno Hill which require permanent closure; however, existing information for some of the mine sites is limited and it is possible that additional shafts will also require sealing. A summary of these shafts is provided in Table 6-8.

6.5.2 **Shaft Closure Options**

The following subsections discuss the recommended options for shaft closure at Keno Hill. Hand sketches of each of the options are attached for reference.

6.5.2.1 Concept A – Dry Seal

A dry seal would comprise of backfilling the shaft with suitable granular fill material capped with an impermeable seal of bentonite pellets or lean concrete placed just below the bedrock collar of the shaft. The impermeable seal would be covered with additional backfill and the surface re-vegetated. To provide positive drainage of surface run-off and to account for future settlement of the backfill, the completed seal should be mounded above surrounding grades. Figure 6-46 illustrates a conceptual design of a dry seal shaft closure.

In general, dry seals would be suitable for the smaller and less accessible shaft locations, shafts which are partially collapsed / backfilled, and those with no observable water flow or potential for hydraulic heads developing. Of the 32 shaft locations identified, 23 appear to be suitable candidates for a dry seal.

6.5.2.2 Concept B – Concrete Cap

This concept would involve sealing the shaft with a cap of reinforced concrete poured across the bedrock collar of the shaft. In general, concrete caps are suitable for the

larger and more accessible shaft locations, shafts which are in good condition, and those with observable water inflow/outflow or hydraulic connection to underground workings. Of the 32 shaft locations identified, 9 appear to be suitable candidates for a concrete cap. Figure 6-47 illustrates a conceptual design of a concrete cap shaft closure.

The cap would be seated on a narrow ledge of bedrock around the shaft collar and would likely need to be secured with fully grouted dowels. For an assumed maximum soil cover of 1 m and for no hydraulic head, the thickness of the concrete cap would be approximately 0.3 m. Depending on the size and depth of the shaft, it may be more cost-effective to backfill the shaft with suitable granular fill up to slab grade (refer to Concept A, above) to provide a working surface rather than construct formwork to span across the open void. As with Concept A, the cap would be covered with backfill mounded above surrounding grades, and re-vegetated.

6.5.2.3 Inverted Pyramid Cap

As an alternative to a rectangular-shaped concrete cap as described above, consideration could also be given to sealing the shaft with an inverted pyramid concrete cap. For this option, the concrete would be poured onto a pre-fabricated steel form placed into the shaft (collared in bedrock). This alternative may be more cost effective for sites where constructing formwork and rebar is not practical, or for sites where significant thicknesses of overburden and weathered rock are present. However, this alternative would not be as suitable for sites with water inflows/outflows and hydraulic connection to underground workings. Figure 6-48 illustrates a conceptual design of a dry seal shaft closure.

6.5.3 **Construction Cost Estimate**

Table 6-9 presents a summary of estimated construction costs for shaft closure at the various sites across Keno Hill. These costs are preliminary and are considered accurate to “Level 5” criteria (+100% to -50%).

For a dry seal (Concept A), estimated construction costs range from $7,500 to $15,000; for a concrete cap (Concept B), estimated construction costs range from $25,000 to $100,000. The range in estimated costs reflects variations in shaft dimensions, site conditions, access, and other such constraints.

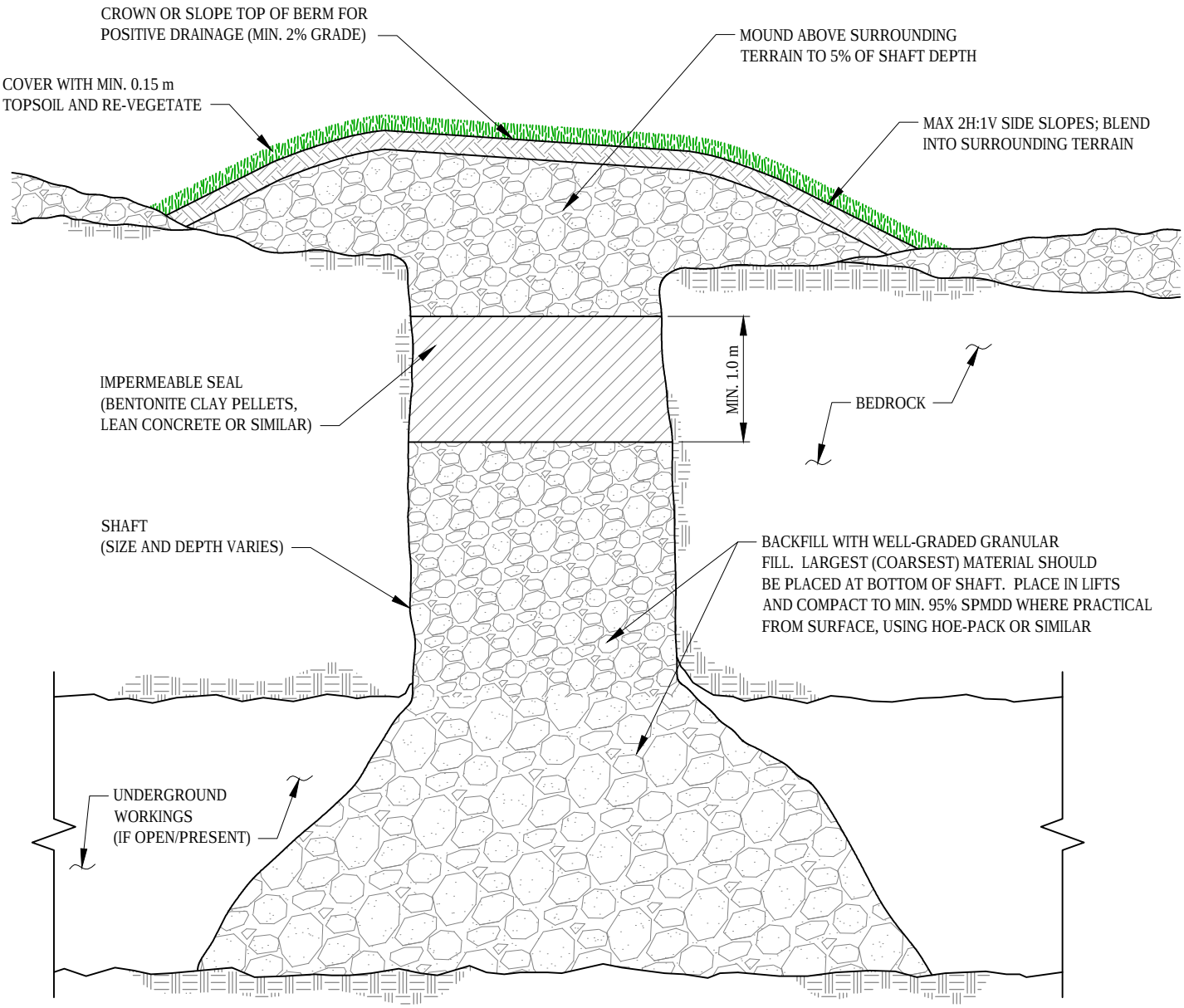
These cost estimates have been based on the following assumptions:

- With the exception of Husky SW, none of the shafts requiring concrete caps (Concept B) have observable water discharge;
- Concrete (standard 25 MPa or 30 MPa mix) can be sourced from a batch plant at Bellekeno Mine. If concrete is not available from the minesite, consideration could be given to employing on-site batching from 1 yd^3 bulk bags of dry ready-mix, although this would be more expensive;
- The majority of the construction equipment required for shaft closure (excavator, rock truck, dump truck, etc.) will already be on site or can be procured locally;
- Locally available overburden, clean waste rock, and/or concrete rubble can be used for backfill material where required;
- For the dry seal (Concept A) locations, the sites can be accessed with a tracked excavator. It is assumed that some clearing and grading may be required to improve access but without the need for significant blasting, benching, road building or slope stabilization works;
- For concrete cap (Concept B) locations, the thickness of the concrete cap and rebar detail are based on an assumed maximum soil cover of 1 m. It is also assumed that the shaft locations would be accessible by truck such that concrete pumping over long distances would not be required.

6.5.4 **Future Shaft Design and Investigation Work**

Refinement of the design and cost information will include verifying the preferred shaft closure options, finalizing shaft closure designs, and refining the construction cost estimates. This work will include a site reconnaissance to assess shaft conditions, water inflows/outflows, soil and bedrock exposures, required depth of stripping, shaft dimensions, potential borrow sources, and site access constraints.

Shaft Name	PWGSC Ref Site	Description	Dimensions, m (L x W x H)	Support/Condition	Site Physiography	Site Access	Closure Issue Categories			Proposed Option for Closure	Closure Rationale
							Human & Wildlife Health and Safety	Water Management	Physical Stability		
Silver King Vent Raise	Silver King	*A ventilation raise is covered by a wooden shed. Shed is 100 m SE of the open pit; door is kept locked; steel mesh covers raise entrance.*	*2 x 2 x ??*	*Unknown; Appears to be stable*	*NW facing slope; well forested; glacial till overburden; host rock is quartzite and schist*	*Road access; Straddles Hwy 11 at Galena Creek, 4 km SW of Elsa*	intrigue risk; close proximity to tourist area			*remove building; cap raise*	*covering the raise will eliminate intrigue risk and access to workings*
Silver King Shaft #1 (Open Pit Shaft)	Silver King	*Timbers and pipes exposed in the bottom of the open pit identify former shaft, filled with waste rock. This is likely the number 3 shaft, which was the main production shaft for this part of the mine*	*1.5 x 1.5 x ??*	*Milled timber supports/Appears to be stable*	*Northwest corner of the open pit. NW facing slope; well forested; glacial till overburden; host rock is quartzite and schist*	*Shaft can be accessed by vehicle; straddles Hwy 11 at Galena Creek; 4 km SW of Elsa.*			cement cap is dilapidated and poorly placed	*redo cap*	*eliminates access to workings*
Silver King Shaft #2	Silver King	*An old raise lined with log timbers that had been sunk in overburden has been left standing at the edge of the open pit*	*1.5 x 1.5 x ??*	*Round log timbers (about 10 to 20 cm diameter) line the shaft horizontally; the shaft has had overburden removed from around it so that it stands as a tower, leaning; the wood timbers are leaning but moderately stable; the raise is filled with overburden*	*South-central side of the open pit*	*Road access; Straddles Hwy 11 at Galena Creek, 4 km SW of Elsa*	intrigue risk; close proximity to tourist area		`	*cover with pit closure*	*covering the raise will eliminate intrigue risk and access to workings.*
Silver King Raise #1	Silver King	*A small raise was located above Galena Creek canyon on the west side; the site is overgrown with dense vegetation; a pipe extends to surface; the raise is collapsed*	*1m x 1m; collapsed at ~1 m depth*	*Some rotten wood supports are present; raise is collapsed*	*In dense bush about 30 m west of Galena Creek (at the top of the canyon), about 30 m south of the old bridge site.*	*Road access to the site; likely foot access to the shaft due to dense bush*					
Husky Raise	Husky #2	*not investigated; shaft house locked at last visit, and during SRK 2006 and PWGSC 2000 visits*									
Husky Shaft	Husky #2	*not investigated; shaft house locked at last visit, and during SRK 2006 and PWGSC 2000 visits*									
Husky SW Shaft	Husky SW	*Main workings, located at the north of the hoist house; workings are flooded to surface and hydraulically connected with the Husky workings*	*Shaft house is 15m x 8m x 25m*	*Head frame structure is supported; the structure appears to be stable*	*Mining structures on a waste rock plateau; coarse grained soils; significant depth of overburden and till; quartzite host rock with interbedded graphitic/micaceous schists*	*Road access (likely 2WD based on photos)*	- Potential ecological risk to flora/fauna in all areas down gradient of adits discharging to the environment through plant uptake of metals - Potential for public access to workings	produces water; <0.5L/sec; discharge is piped through the dump to a discharge point beyond the dump		*See "Complex Sites" sheet*	
Ruby Shaft	Bermingham & Ruby						accessible to public	does not produce water	shaft is open; ground subsidence occurring near shaft	*fill and cap*	*eliminates public safety and access issues*
McLeod shaft	Galkeno Mine						accessible to public	no water	subsidence around shaft, open holes (2007 SRK Baseline Study)	*fill holes and cap*	*prevents access and further subsidence*
Lone Star Shaft	Onek	*The shaft is mostly filled with open pit rock; some timbers and pipes are visible from the pit; the mine is scheduled for future underground production*	*Unknown dimensions; originally ~100m deep*	*Timers are present, however they have been extensively filled in and do not appear to be supporting the structure; shaft appears stable however material inside shaft may be settling*	*Site is on the south slope of Keno Hill; main open pit is on a relatively flat plateau; certain areas of the site have been overgrown; quartzite with carbonaceous phyllite and greenstone lenses host rock*	*2WD access; immediately north of Keno City*	filled and covered		shaft has been filled; no subsidence	*shaft has been filled; do nothing*	*Shaft is not a public safety hazard and therefore no activity is necessary.*
Fisher Shaft	Onek						filled and covered		shaft has been filled; no subsidence	*shaft has been filled; do nothing*	*Shaft is not a public safety hazard and therefore no activity is necessary.*
Shafts SW of Gravel Level Adit	Elsa Mine						shaft house collapsed over an open shaft, presents an intrigue risk; only one shaft located		ground subsidence immediately adjacent to the shaft house on all sides	*fill shaft and subsidence with local borrow. Cap shaft if required*	*eliminates safety and stability issues*
Dixie Shaft	Dixie	*Site is considered a hazardous area; shaft appears to be filled with water and soil ~3 m below ground level*	*1.2m x 2m x ?*	*Collapsed wood framed shafthouse, lagging has partially collapsed, site is considered hazardous. The eastern and western raises have been backfilled and surface installations removed.*	*NW facing slope dipping ~20°; quartzite host rock*	*4WD access to the shaft*	needs inspection		needs inspection	*cap shaft*	*eliminates access and safety issues*
Brefalt Shaft	No Cash Mine						accessible to public			*cap shaft*	*shaft is open inside the building*
Shaft N of tramway and S of Brefalt shaft dump	No Cash Mine								collapsed; minor depression remains; not a risk	*do nothing*	*no action required*
Jock Shaft	Hector-Caulmet	*Located in the 4-11 pit area; limited accessibility*	*1.5m x 1.5m x ?*	*Wooden support; shaft appears to be completely collapsed*	*The area has a moderately steep slope covered by thick moss, bushes and evergreen trees; quartzite host rock with some graphitic schist and greenstone*	*Accessible by gravel roads (requires 4WD vehicle)*			shaft completely collapsed (PWGSC 2000)	*fill and cap as required*	*eliminates public safety and access issues*
Coral and Wigwam Shaft #1	Coral and Wigwam	*Western shaft; open and accessible*	*1.6m x 1 m x ~8m with what appears to be a drift taking off in the SE direction*	*The shaft is cribbed with round timber that appears sound; the shaft is open and unguarded (safety hazard); the dump from shaft has been bulldozed away during the stripping operation.*	*NW facing slope; soils have been stripped and pushed down slope; stripped material consists of glacial till and quartzite and schist colluvium; backhoe trenches visible in the exposed bedrock; moss floor covering indicative of **permafrost**; host rock of interbedded schists and massive quartzite with veins*	*4WD or more required for a rough cat trail; area appears heavily vegetated in photos and hiking may be required*	open to surface; drift visible from surface	no water	subsidence near shaft	*fill*	*eliminates access and safety issues*
Coral and Wigwam Shaft #2	Coral and Wigwam	*Eastern shaft; collapsed and unguarded (safety hazard)*	*Subsidence zone is ~5m diameter x 3m deep; waste rock dump dimensions are 15m x 3m x 6m*	*The shaft is collapsed with timber and an old ladder in the hole; it is unguarded*	*NW facing slope; soils have been stripped and pushed down slope; stripped material consists of glacial till and quartzite and schist colluvium; backhoe trenches visible in the exposed bedrock; moss floor covering indicative of **permafrost**; host rock of interbedded schists and massive quartzite with veins*	*4WD or more required for a rough cat trail; area appears heavily vegetated in photos and hiking may be required*	collapsed; contains wooden ladder and wood and debris - may present a minor intrigue risk	no water	minor subsidence near shaft; actively ravelling walls of waste rock @ angle of repose	*fill and cap as required*	*eliminates access and safety issues*
Betty shafts	Betty							standing water at bottom of both shafts	potential regressive thawing of permafrost	*fill*	*eliminates access and safety issues*
Tin Can Shaft #1	Tin Can	*Shaft is in a boggy area with water level just below ground surface; shaft is almost entirely filled with water; remains of an old ladder project from the hole*	*2m x 2m x ?*	*No evident support; organic material has slumped into hole; quite unstable due to water filling hole*	*Relatively level area of open muskeg forest; schist and phyllite with greenstone lenses bedrock; (thick vegetation covers the surface therefore geology is from literature); no surface drainage noted*	*Shaft can be accessed on foot; no access road into the site; nearest access road is Hwy 2 located approximately 250 m downhill to the east of Shaft #1*	open to surface; ground sluicing covered by dense alders	no water noted	minor subsidence; ground sluicing to east and southeast	*fill and cap as required*	*eliminates access and safety issues*
Tin Can Shaft #2	Tin Can	*Collapsing timbered shaft; dense vegetation; waste pile rock consists of rusty greenstone with ~1% pyrite*	*2m x 1.5m x ~2.5m*	*Rotted timber support; partially collapsed and filled with debris*	*Relatively level area of open muskeg forest; schist and phyllite with greenstone lenses bedrock; (thick vegetation covers the surface therefore geology is from literature); no surface drainage noted*	*Shaft can be accessed on foot; no access road into the site; nearest access road is Hwy 2 located approximately 250 m downhill to the east of Shaft #1*	open to surface; timber supports intact	no water noted	`	*fill and cap as required*	*eliminates access and safety issues*



NOTES:

1. Quantities will vary with shaft depth, connection to underground workings, and other conditions.
2. Remove and dispose of timber, trash, brush, topsoil and other debris in and around shaft area, prior to backfilling. Strip down to bedrock surface at collar where practical.
3. Dewater shaft and workings (if practical) prior to backfilling.
4. Existing steel pipe, concrete rubble (if present) should be removed or incorporated into backfill as directed by engineer.

CONCEPT DRAWING
NOT FOR CONSTRUCTION

STATUS
ISSUED FOR REVIEW

SCALE 1:50

500 0 500 1000 2000mm

CLIENT

ACCESS CONSULTING GROUP

eba A TETRA TECH COMPANY

KENO HILL SHAFT CLOSURES
KENO HILL, YT

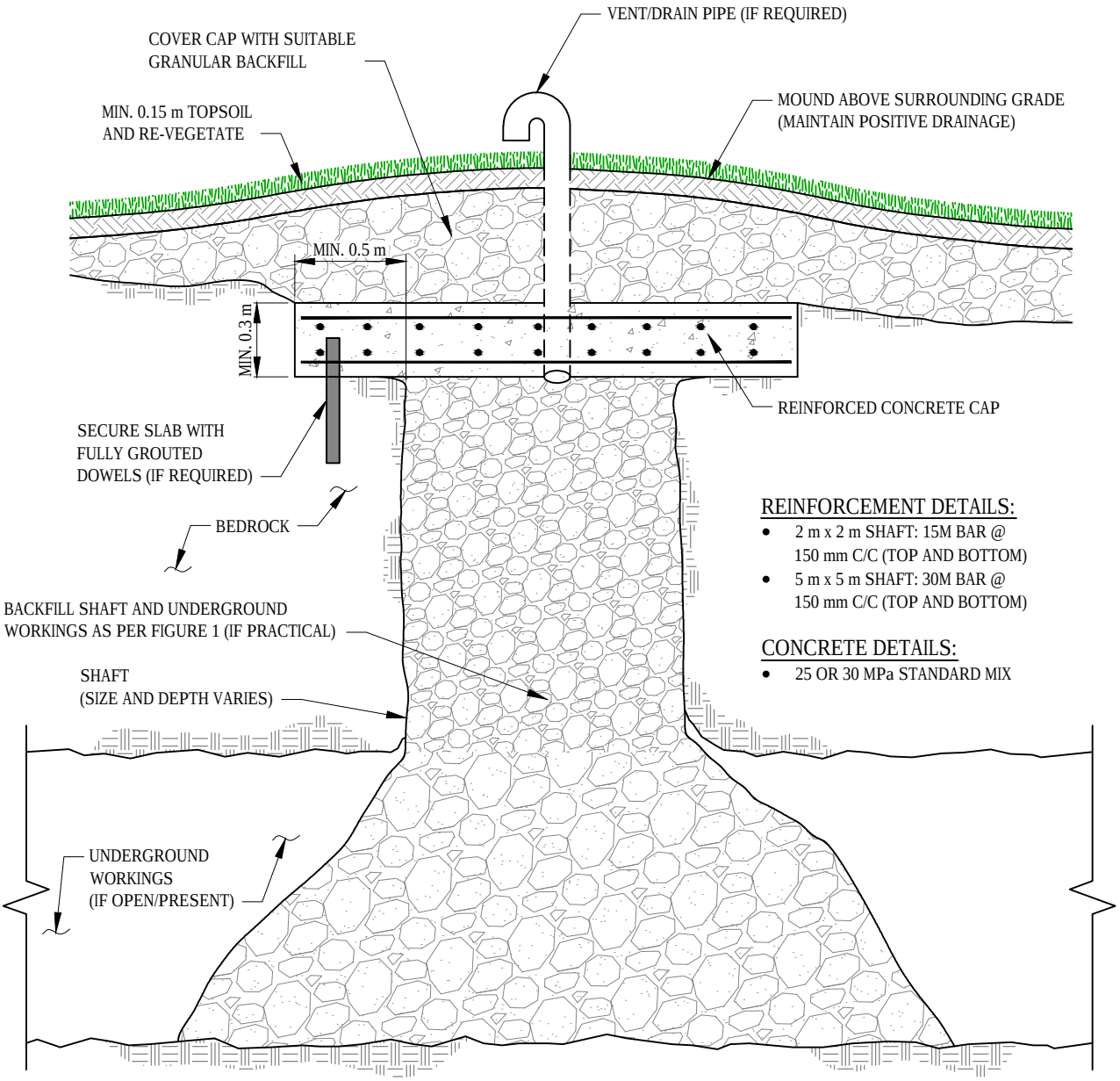
CONCEPT A
DRY SEAL

PROJECT NO.	DWN	CKD	REV
V15101043	SF	JP	0

OFFICE	DATE
VANC	April 4, 2011

Figure 6-46

Q:\Vancouver\Drafting\Engineering\V151\V15101043\V15101043_FIG 1-3_R0.dwg [FIGURE 1] April 04, 2011 - 3:32:59 pm (BY: FOURNIER, SAMUEL)



REINFORCEMENT DETAILS:

- 2 m x 2 m SHAFT: 15M BAR @ 150 mm C/C (TOP AND BOTTOM)
- 5 m x 5 m SHAFT: 30M BAR @ 150 mm C/C (TOP AND BOTTOM)

CONCRETE DETAILS:

- 25 OR 30 MPa STANDARD MIX

NOTES:

1. Quantities will vary with shaft size and required depth of stripping.
2. Remove and dispose of timber, trash, existing buildings, brush, topsoil, and other debris in and around shaft area. Excavate to expose competent, sound rock at collar.
3. Cap dimensions and reinforcement detail assume max 1 m burial at surface, and no uplift hydrostatic or ice loads on base of cap. (To be verified during design).

CONCEPT DRAWING
NOT FOR CONSTRUCTION

STATUS
ISSUED FOR REVIEW

SCALE 1:50

500 0 500 1000 2000mm

CLIENT

ACCESS CONSULTING GROUP

KENO HILL SHAFT CLOSURES
KENO HILL, YT

CONCEPT B
CONCRETE CAP

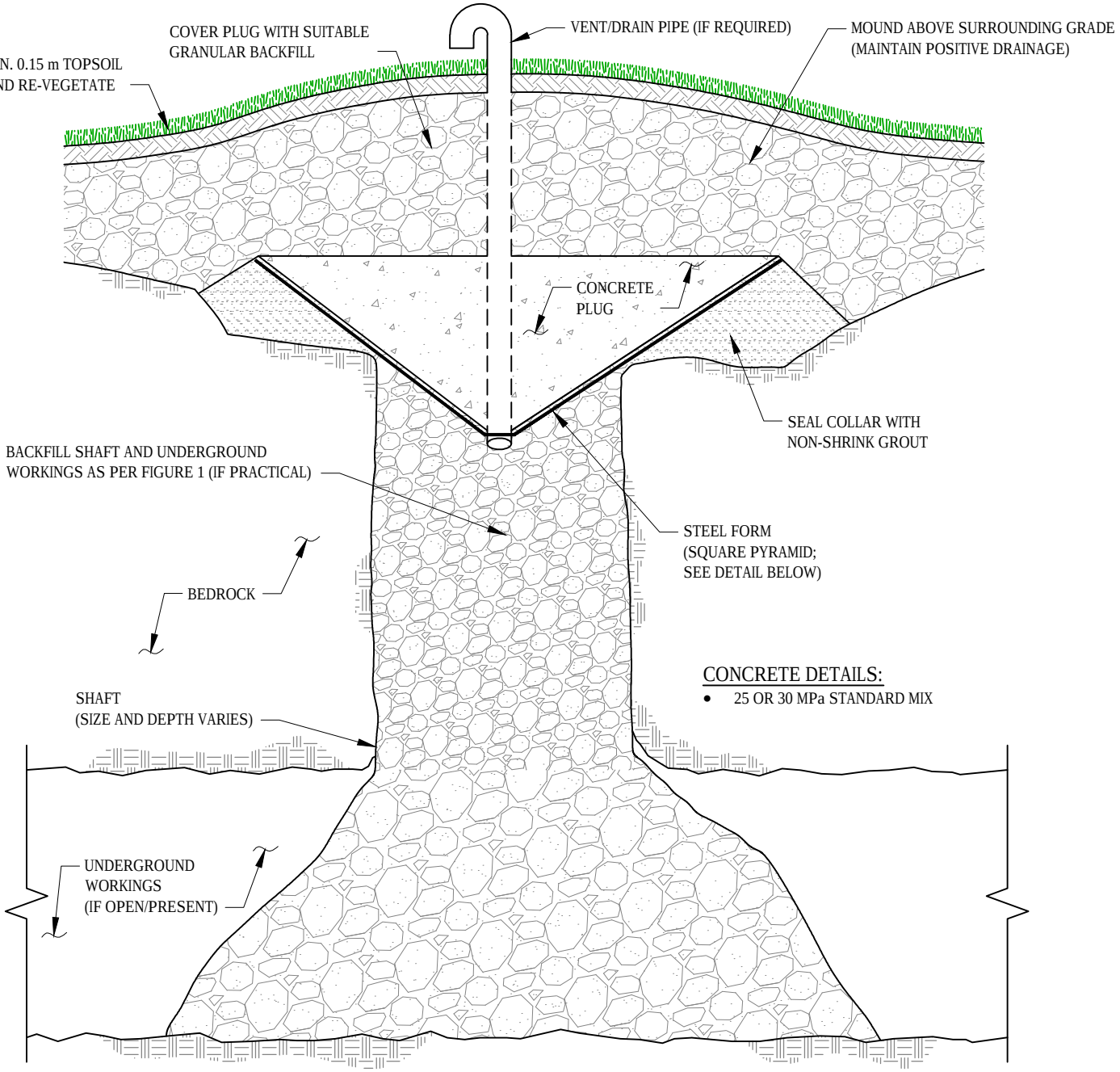
PROJECT NO.	DWN	CKD	REV
V15101043	SF	JP	0

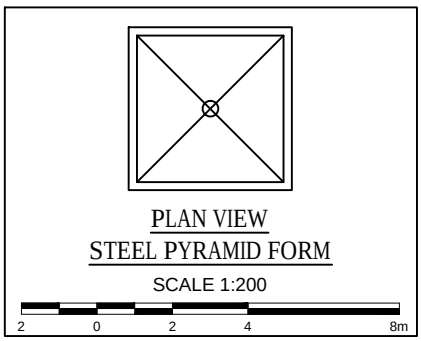
OFFICE	DATE
VANC	April 4, 2011

Figure 6-47

eba A TETRA TECH COMPANY

Q:\Vancouver\Drafting\Engineering\V151\V15101043\V15101043_FIG 1-3_R0.dwg [FIGURE 2] April 04, 2011 - 3:33:11 pm (BY: FOURNIER, SAMUEL)





NOTES:

1. Quantities will vary with shaft size, depth of stripping and other conditions.
2. Remove and dispose of timber, trash, existing buildings, brush, topsoil and other debris in and around shaft area. Excavate to expose competent sound bedrock at collar.

CONCEPT DRAWING
NOT FOR CONSTRUCTION

STATUS
ISSUED FOR REVIEW

SCALE 1:50
500 0 500 1000 2000mm

CLIENT

ACCESS CONSULTING GROUP

KENO HILL SHAFT CLOSURES
KENO HILL, YT

CONCEPT B
INVERTED PYRAMID CONCRETE CAP

eba A TETRA TECH COMPANY

PROJECT NO.	DWN	CKD	REV
V15101043	SF	JP	0

OFFICE	DATE
VANC	April 4, 2011

Figure 6-48

Q:\Vancouver\Drafting\Engineering\V151\V15101043\V15101043_FIG 1-3_R0.dwg [FIGURE 3] April 04, 2011 - 3:33:20 pm (BY: FOURNIER, SAMUEL)

Shaft Name	PWGSC Ref Site	Recommended Shaft Closure Concept	Estimated Construction Cost ($CAD)**		
			Cost	Cost +100%	Cost -50%
Silver King Vent Raise	Silver King	Concept B (Concrete Cap)	$ 35,000.00	$ 70,000.00	$ 17,500.00
Silver King Shaft #1 (Open Pit Shaft)	Silver King	Concept B (Concrete Cap)	$ 25,000.00	$ 50,000.00	$ 12,500.00
Silver King Shaft #2	Silver King	Concept A (Dry Seal)	$ 10,000.00	$ 20,000.00	$ 5,000.00
Silver King Raise #1	Silver King	Concept A (Dry Seal)	$ 10,000.00	$ 20,000.00	$ 5,000.00
Husky Raise	Husky #2	Concept B (Concrete Cap)	$ 35,000.00	$ 70,000.00	$ 17,500.00
Husky Shaft	Husky #2	Concept B (Concrete Cap)	$ 80,000.00	$ 160,000.00	$ 40,000.00
Husky SW Shaft	Husky SW	Concept B (Concrete Cap)	$ 100,000.00	$ 200,000.00	$ 50,000.00
Ruby Shaft	Bermingham & Ruby	Concept A (Dry Seal)	$ 10,000.00	$ 20,000.00	$ 5,000.00
McLeod shaft	Galkeno Mine	Concept A (Dry Seal)	$ 10,000.00	$ 20,000.00	$ 5,000.00
Lone Star Shaft	Onek	Do Nothing	$ -	$ -	$ -
Fisher Shaft	Onek	Do Nothing	$ -	$ -	$ -
Shafts SW of Gravel Level Adit	Elsa Mine	Concept A (Dry Seal)	$ 10,000.00	$ 20,000.00	$ 5,000.00
Dixie Shaft	Dixie	Concept B (Concrete Cap)	$ 25,000.00	$ 50,000.00	$ 12,500.00
Brefalt Shaft	No Cash Mine	Concept B (Concrete Cap)	$ 40,000.00	$ 80,000.00	$ 20,000.00
Shaft N of tramway and S of Brefalt shaft dump	No Cash Mine	Do Nothing	$ -	$ -	$ -
Jock Shaft	Hector-Caulmet	Concept A (Dry Seal)	$ 10,000.00	$ 20,000.00	$ 5,000.00
Coral and Wigwam Shaft #1	Coral and Wigwam	Concept A (Dry Seal)	$ 15,000.00	$ 30,000.00	$ 7,500.00
Coral and Wigwam Shaft #2	Coral and Wigwam	Concept A (Dry Seal)	$ 15,000.00	$ 30,000.00	$ 7,500.00
Betty shafts	Betty	Concept A (Dry Seal)	$ 20,000.00	$ 40,000.00	$ 10,000.00
Tin Can Shaft #1	Tin Can	Concept A (Dry Seal)	$ 15,000.00	$ 30,000.00	$ 7,500.00
Tin Can Shaft #2	Tin Can	Concept A (Dry Seal)	$ 15,000.00	$ 30,000.00	$ 7,500.00
Rico Shaft	Rico	Concept A (Dry Seal)	$ 12,500.00	$ 25,000.00	$ 6,250.00
Sadie Ladue Shaft (No. 1 Shaft)	Sadie Ladue - Wernecke	Concept B (Concrete Cap)	$ 25,000.00	$ 50,000.00	$ 12,500.00
Lucky Queen Shaft #1	Lucky Queen	Concept B (Concrete Cap)	$ 60,000.00	$ 120,000.00	$ 30,000.00
Lucky Queen Shaft #2	Lucky Queen	Concept A (Dry Seal)	$ 15,000.00	$ 30,000.00	$ 7,500.00
Shamrock J18 Raise	Keno No. 9	Concept A (Dry Seal)	$ 15,000.00	$ 30,000.00	$ 7,500.00
Shamrock Shaft	Shamrock	Do Nothing	$ -	$ -	$ -
Prospect Shaft	Shamrock (Original)	Concept A (Dry Seal)	$ 15,000.00	$ 30,000.00	$ 7,500.00
Porcupine Shaft	?	Concept A (Dry Seal)	$ 10,000.00	$ 20,000.00	$ 5,000.00
Unknown Shaft near 5-2 Adit	?	Concept A (Dry Seal)	$ 10,000.00	$ 20,000.00	$ 5,000.00
No. 9 Vein Shaft	Keno No. 9	Do Nothing	$ -	$ -	$ -
Coesus No. 1 Shafts	Croesus No. 1	Do Nothing	$ -	$ -	$ -
Lower Lake Shaft	?	Concept A (Dry Seal)	$ 10,000.00	$ 20,000.00	$ 5,000.00
Upper Lake Shaft	?	Concept A (Dry Seal)	$ 10,000.00	$ 20,000.00	$ 5,000.00
Silver Basin Hand Shafts (Shaft #1)	Silver Basin	Concept A (Dry Seal)	$ 7,500.00	$ 15,000.00	$ 3,750.00
Apex Shaft	Apex	Concept A (Dry Seal)	$ 12,500.00	$ 25,000.00	$ 6,250.00
Christal Shaft #1	Christal	Concept A (Dry Seal)	$ 12,500.00	$ 25,000.00	$ 6,250.00
Christal Shaft #2	Christal	Concept A (Dry Seal)	$ 12,500.00	$ 25,000.00	$ 6,250.00
		TOTALS	**$ 707,500.00**	**$ 1,415,000.00**	**$ 353,750.00**

** Level 5 Construction Cost Estimate for shaft closure at noted locations. No allowance has been made for related costs, including (but not limited to) Design, Permitting, Environmental Remediation, Consultation, Compensation, Site Supervision, Contract Administration, or other.

Table 6-9. Detailed Summary of Shaft Closure Costs and Recommended Design Approaches

6.6 **Mine Adit Closure**

SRK (2008) reviewed the upwards of 70 adits within the former UKHM claim boundaries that need to be assessed to determine how each adit will be treated in closure. Many of the adits represent a moderate to high risk for health and safety, due in part to the natural state of degradation and physical instability, as well as the possible accumulation of toxic gases or the development of an oxygen depleted atmosphere due to inadequate ventilation. In addition, consideration of the need for water management and treatment from the adit sites listed in Section 6.3 requires an adit closure design that allows for management of the adit with the potential cleanout of sludge that can build up within the adit. The recommended options for the different sites included the following adit closure options.

6.6.1 **Plugs**

This category refers to any measure that involves a structure that completely fills a drift for some length within the underground portion of the mine with the intent of minimizing or preventing discharge. Plugs are generally intended to be permanent installations, and may require detailed rock characterization and extensive grouting of the surrounding rock to achieve acceptable performance.

Further investigations would be required before proceeding to final design. Adit plugs can be candidate closure options where any of preventing access, controlling adit drainage, or minimizing brow collapse is required. An appropriately designed adit plug could be used to control mine drainage discharge from an adit, but does not necessarily imply buildup of water behind the plug. As discussed elsewhere it is not anticipated to install an adit plug that causes significant buildup of water as a closure option.

6.6.2 **Seals**

The category of adit seals refers to any measure for which the sole purpose is to prevent public access. Seals are typically cheaper than plugs; however, where rehabilitation of

the adit is required to ensure safe working conditions, costs can increase significantly. Adit seals are not intended for controlling adit drainage waters, but can be designed to allow free drainage.

6.6.3 **Barriers**

The category of adit barriers refers to any measure which prevents inadvertent access by the public, but maintains an opening for authorized persons; barriers are also used where the mine workings provide habitat for animals such as bats. Barriers are typically cheaper than seals; however, there remains a requirement for rehabilitation of the immediate portal area to provide safe working conditions for the seal construction period. Adit barriers are not intended for controlling adit drainage waters, but can be designed to allow free drainage.

6.6.4 **Rock Piles**

Adits that have no ongoing discharge of waters but require closure are good candidates for rock piles. Sized rock is piled into the adit entrance and pushed into the adit for several meters and then additional rock is stockpiled to form a rock slope that forms with the surrounding portal.

6.6.5 **Do Nothing; Natural Collapses**

There are numerous cases among the former UKHM adits where adit collapse is sufficiently complete that access is no longer possible and where little risk remains. A 'Do nothing' closure option may be appropriate in certain cases, while a 'Do nothing now and inspect periodically' option may be appropriate for other cases.

6.6.6 **Recommended Adit Closure Approach**

SRK (2008) recommended adit plugs to be installed at Silver King 100, No Cash 500, Galkeno 300, Galkeno 900, Onek 400, Sadie Ladue 600, and Keno 700. Subsequent evaluation of closure options at Ruby 400 and Bermingham 200 indicate an adit plug would be beneficial for management of water from these adits. In addition, a review of

adits connected to these adits indicated that portal stabilization or infiltration prevention at Silver King 75, No Cash 100, Keno 500 and Keno 200 are required.

The remaining adits can be closed using a rock pile or simply leaving the site as is. The placement of the rock pile will be performed concurrent with the waste rock closure and diversion placement at each site. The work associated with placement of waste rock is accounted for in the waste rock closure costs. Costs associated with the implementation of the portal stabilization and adit plug placement were developed by the Alexco District manager after an inspection of all the portals was performed in 2009.

7. Closure Option Cost and Schedule Information

7.1 Closure Cost Estimate Preparation and Use

The cost estimate summary presented here was generated with costing input from Alexco Environmental Group, Access Mining Consultants, EBA, InTerraLogic, and SRK. This Draft Closure Options Report will be reviewed by INAC, Yukon Government, and FNNND as part of a process to develop a preferred closure option for each mine component. Cost is one of the criteria that will be used to evaluate closure options. This draft report will also be submitted to the Yukon Water Board in partial fulfillment of the requirements of Water Licence QZ07-074, Clause 43. These costs presented in this report are considered to be preliminary and accurate to "Level 5" criteria (+100% to -50%).

The costs, in 2011 dollars, presented are for implementation of the closure and reclamation of all site mine components associated with the historic UKHM liability, and are calculated based on 30 years of operations, in 2011 dollars, including maintenance, monitoring, and reporting, as required. Review of the task descriptors for each site illustrates the range of closure options under consideration, in the cases where multiple options will be assessed. For other sites where only one reclamation or closure option is currently under consideration, only a single cost is shown.

7.2 Site Decommissioning and Reclamation Implementation Schedule

The level of information available at this time only allows for a high level schedule to be presented. It includes the remaining closure planning steps, as well as implementation of decommissioning and reclamation activities. The Keno Hill Closure project schedule has been subject to ongoing revisions since QZ06-074 was originally issued to ERDC in 2006. The current high level closure project master schedule (as of April 2011) is shown in the attached figure.

The project schedule is subject to change depending on the actual progress of the indicated project components. To better understand where potential project slippage is occurring, and to ensure that the schedule remains current as a useful planning tool, the

project master schedule is revised on approximately a bi-monthly basis. In addition to the regular updates, ERDC updates the project master schedule following the completion of major milestones associated within each of the listed project components.

The current project master schedule identifies the anticipated timelines for completion of the following key project components:

- Stakeholder review and finalization of Closure Options for the District.
- Evaluation and selection process for preferred closure options.
- Review and finalization of preferred closure options report.
- Community Consultation.
- Socio-economic Assessment.
- YESAA submission of Closure Plan.
- Yukon Water Board licencing process.
- Detailed design.
- Project Implementation.
- Long-term monitoring.

Water Use Licence QZ06-074 expires on November 30, 2012 which is anticipated to closely coincide with the submission of the water licence application for amendment of this licence to reflect the Closure Plan. ERDC intends to meet and discuss the renewal process for QZ06-074 prior to the submission of the Closure Plan for YESAA assessment. The current schedule for implementation of the Closure Plan for the Keno Hill Project is anticipated to occur over a 5-yr period and will be substantially completed under the terms and conditions of the amended water licence for the project.

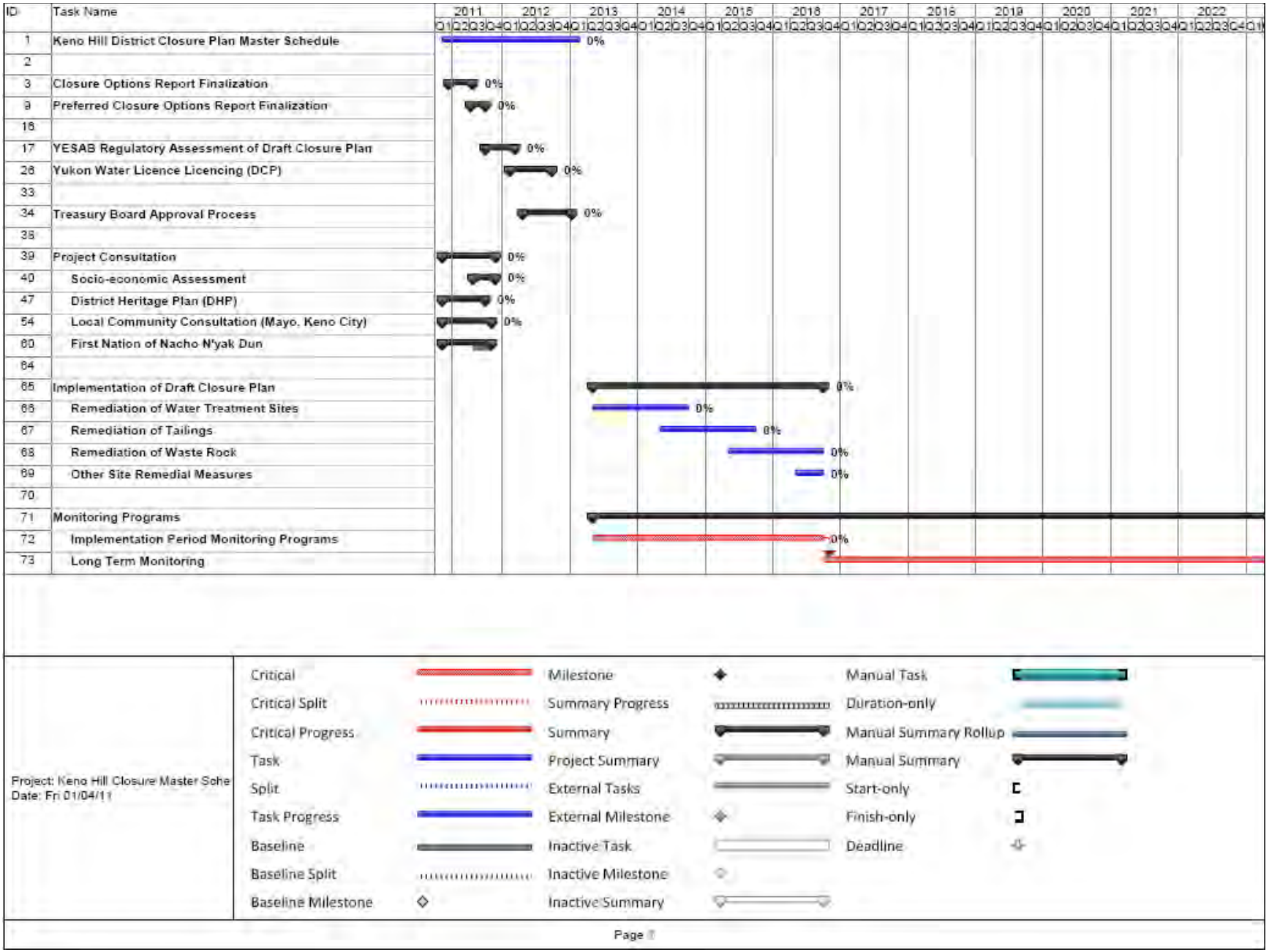


Figure 7-1. Schedule

Keno Closure Costs		
Description	***Additional Details***	***Estimated Costs***
Waste Rock Storage Area/Pits to be filled & Revegetated		
Waste Rock Storage Area Remediation and Revegetation		
Bermingham Pit Waste Rock Storage Area		$ 291,000.00
Black Cap Pit Waste Rock Storage Area		$ 162,000.00
Calument Pit and Waste Rock Storage Area		$ 155,000.00
Galkeno 300/Sime Pit Waste Rock Storage Area		$ 371,000.00
Hector Pit Waste Rock Storage Area		$ 438,000.00
Miller PitWaste Rock Storage Area		$ 66,000.00
No Cash 100 Pit Waste Rock Storage Area		$ 100,000.00
Onek Pit Waste Rock Storage Area		$ 596,000.00
Sadie LaDue (Wernecke) Waste Rock Storage Area		$ 199,000.00
Shamrock Pit Waste Rock Storage Area		$ 98,000.00
Silver King Pit Waste Rock Storage Area		$ 291,000.00
Dixie Adit Waste Rock Storage Area		$ 35,000.00
Elsa +50 Adit Waste Rock Storage Area		$ 122,000.00
Galkeno 300 Adit Waste Rock Storage Area		$ 56,000.00
Galkeno 900 Adit Waste Rock Storage Area		$ 44,000.00
Hector 400 Adit Waste Rock Storage Area	Regrade and Seed Only (Option 1)	$ 135,000.00
Hector 400 Adit Waste Rock Storage Area	Additional Vegetational Cover (Option 2)	$ 713,000.00
Hector 400 Adit Waste Rock Storage Area	Additional Infiltration Cover including clay amendment (Option 3)	$ 2,004,000.00
Husky Shaft Waste Rock Storage Area		$ 308,000.00
Husky SW Shaft Wast Rock Storage Area		$ 391,000.00
Keno 700 Adit Waste Rock Storage Area		$ 264,000.00
Lucky Queen 500 Adit Waste Rock Storage Area		$ 65,000.00
No Cash 500 Adit Waste Rock Storage Area		$ 85,000.00
Onek 400 Adit Waste Rock Storage Area		$ 180,000.00
Ruby Adit Waste Rock Storage Area		$ 58,000.00
Sadie LaDue 600 Waste Rock Storage Area		$ 36,000.00
Silver King 100 Waste Rock Storage Area		$ 160,000.00
Townsite Adit Waste Rock Storage Area		$ 210,000.00
Pits to be Filled & Re-Vegetated		
Onek		$ 275,000.00
Silver King Pit		$ 143,000.00
Misc. Site Improvements		
Site Access and Debris Removal	Site access/debris removal for 43 sites throughout the district	$ 1,297,000.00
District Wide Building Demolition		$ 3,500,000.00

Keno Closure Costs		
Description	***Additional Details***	***Estimated Costs***
	Shafts and Adits	
Silver King		
Silver King Adit Rehab	Adit Rehab and Installation of Low Pressure Water Retaining Hydraulic Plug	$ 571,000.00
Silver King 75 Adit Rehab	Installation of waterproof seal, riprap channel	$ 45,000.00
Silver King Vent Raise	Concept B (Concrete Cap)	$ 35,000.00
Silver King Shaft #1 (Open Pit Shaft)	Concept B (Concrete Cap)	$ 25,000.00
Silver King Shaft #2	Concept A (Dry Seal)	$ 10,000.00
Silver King Raise #1	Concept A (Dry Seal)	$ 10,000.00
No Cash		
No Cash 100		
No Cash 500 Level Adit	Adit Rehab and Installation of Low Pressure Water Retaining Hydraulic Plug	$ 311,000.00
Brefalt Shaft	Concept B (Concrete Cap)	$ 40,000.00
Shaft N of tramway and S of Brefalt shaft dump	Do Nothing	$ -
Bermingham		
Bermingham Adit	Adit Rehab and Installation of Low Pressure Water Retaining Hydraulic Plug	$ 289,000.00
Ruby		
Ruby Adit	Adit Rehab and Installation of Low Pressure Water Retaining Hydraulic Plug	$ 302,000.00
Ruby Shaft	Concept A (Dry Seal)	$ 10,000.00
Galkeno 300		
Galkeno 300 Level Adit	Adit Rehab and Installation of Low Pressure Water Retaining Hydraulic Plug	$ 316,000.00
McLeod Shaft	Concept A (Dry Seal)	$ 10,000.00
Galkeno 900		
Galkeno 900 Level Adit	Adit Rehab and Installation of Low Pressure Water Retaining Hydraulic Plug	$ 284,000.00
Sadie Ladue		
Sadie Ladue Adit	Adit Rehab and Installation of Low Pressure Water Retaining Hydraulic Plug	$ 231,000.00
Onek		
Onek 400 Level Adit	Adit Rehab and Installation of Low Pressure Water Retaining Hydraulic Plug	$ 273,000.00
Lone Star Shaft	Do Nothing	$ -
Fisher Shaft	Do Nothing	$ -
Keno		
Keno 200 Level Adit	Portal Stabilization	$ 51,000.00
Porcupine Shaft	Concept A (Dry Seal)	$ 10,000.00
Keno 500 Level Adit	Portal Stabilization	$ 18,000.00
Keno 700 Level Adit	Adit Rehab and Installation of Low Pressure Water Retaining Hydraulic Plug	$ 393,000.00
Husky		
Husky Raise	Concept B (Concrete Cap)	$ 35,000.00
Husky Shaft	Concept B (Concrete Cap)	$ 80,000.00
Husky SW Shaft	Concept B (Concrete Cap)	$ 100,000.00
Elsa Mine		
Shafts SW of Gravel Level Adit	Concept A (Dry Seal)	$ 10,000.00
Dixie		
Dixie Shaft	Concept B (Concrete Cap)	$ 25,000.00
Hector-Calumet		
Jock Shaft	Concept A (Dry Seal)	$ 10,000.00
Coral and Wigwam		
Coral and Wigwam Shaft #1	Concept A (Dry Seal)	$ 15,000.00
Coral and Wigwam Shaft #2	Concept A (Dry Seal)	$ 15,000.00
Betty		
Betty Shafts	Concept A (Dry Seal)	$ 20,000.00
Tin Can		
Tin Can Shaft #1	Concept A (Dry Seal)	$ 15,000.00
Tin Can Shaft #2	Concept A (Dry Seal)	$ 15,000.00
Rico		
Rico Shaft	Concept A (Dry Seal)	$ 12,500.00
Sadie Ladue (Wernecke)		
Sadie Ladue Shaft (No. 1 Shaft)	Concept B (Concrete Cap)	$ 25,000.00
Lucky Queen		
Lucky Queen Shaft #1	Concept B (Concrete Cap)	$ 60,000.00
Lucky Queen Shaft #2	Concept A (Dry Seal)	$ 15,000.00
Shamrock		
Shamrock Shaft	Do Nothing	$ -
Prospect Shaft	Concept A (Dry Seal)	$ 15,000.00
5-2 Adit		
Unknown Shaft near 5-2 Adit	Concept A (Dry Seal)	$ 10,000.00
Keno No. 9 System		
Shamrock J18 Raise	Concept A (Dry Seal)	$ 15,000.00
No. 9 Vein Shaft	Do Nothing	$ -
Croesus No. 1		
Coesus No. 1 Shaft	Do Nothing	$ -
Silver Basin		
Silver Basin Hand Shafts (Shaft #1)	Concept A (Dry Seal)	$ 7,500.00
Apex		
Apex Shaft	Concept A (Dry Seal)	$ 12,500.00
Christal (Dorothy)		
Christal Shaft #1	Concept A (Dry Seal)	$ 12,500.00
Christal Shaft #2	Concept A (Dry Seal)	$ 12,500.00
Lower Lake Shaft	Concept A (Dry Seal)	$ 10,000.00
Upper Lake Shaft	Concept A (Dry Seal)	$ 10,000.00

Keno Closure Costs		
Description	***Additional Details***	***Estimated Costs***
	Water Treatment	
Silver King		
Silver King - Alternative 1	Managed Natural Attenuation	$ 431,000.00
Silver King - Alternative 2	Mine Pool Treatment	$ 731,000.00
Silver King - Alternative 3	Bioreactor treatment	$ 980,000.00
Silver King - Alternative 4	Mechanical Plant	$ 5,617,000.00
Husky SW Shaft		
Husky SW Shaft - Alternative 1	Managed Natural Attenuation	$ 369,000.00
Husky SW Shaft - Alternative 2	Mine Pool Treatment	$ 426,000.00
Husky SW Shaft - Alternative 3	Bioreactor treatment	$ 437,000.00
Husky SW Shaft - Alternative 4	Mechanical Plant	$ 1,239,000.00
Husky SW Shaft - Alternative 5	Reclamation-only	$ 162,000.00
No Cash 500 Level Adit		
No Cash 500 Level Adit - Alternative 1	Managed Natural Attenuation	$ 472,000.00
No Cash 500 Level Adit - Alternative 2	Mine Pool Treatment	$ 450,000.00
No Cash 500 Level Adit - Alternative 3	Bioreactor treatment	$ 982,000.00
No Cash 500 Level Adit - Alternative 4	Mechanical Plant	$ 5,314,000.00
No Cash 500 Level Adit - Alternative 5	New WTF at Elsa	$ 3,304,000.00
Bermingham Adit		
Bermingham Adit - Alternative 1	Managed Natural Attenuation	$ 414,000.00
Bermingham Adit - Alternative 2	Mine Pool Treatment	$ 560,000.00
Bermingham Adit - Alternative 3	Bioreactor treatment	$ 712,000.00
Bermingham Adit - Alternative 4	Mechanical Plant	$ 3,269,000.00
Ruby Adit		
Ruby Adit - Alternative 1	Managed Natural Attenuation	$ 362,000.00
Ruby Adit - Alternative 2	Mine Pool Treatment	$ 451,000.00
Ruby Adit - Alternative 3	Bioreactor treatment	$ 494,000.00
Ruby Adit - Alternative 4	Mechanical Plant	$ 1,937,000.00
Galkeno 300 Level Adit		
Galkeno 300 Level Adit - Alternative 1	upgrade at Galkeno 300	$ 9,121,000.00
Galkeno 300 Level Adit - Alternative 2	New WTF at Elsa	$ 12,176,000.00
Galkeno 300 Level Adit - Alternative 3	New WTF at ST Hwy near Galkeno 900	$ 11,972,000.00
Galkeno 900 Level Adit		
Galkeno 900 Level Adit (Treatment) - Alternative 1	Bioreactor treatment	$ 954,000.00
Galkeno 900 Level Adit (Treatment) - Alternative 2	Stand-alone small WTF	$ 3,998,000.00
Galkeno 900 Level Adit (Treatment) - Alternative 3	New WTF at ST Hwy near Galkeno 900	$ 1,991,000.00
Sadie Ladue Adit		
Sadie Ladue Adit - Alternative 1	Reclamation-only, No Water Treatment	$ 109,000.00
Sadie Ladue Adit - Alternative 2	Managed Natural Attenuation	$ 463,000.00
Sadie Ladue Adit - Alternative 3	Bioreactor treatment	$ 1,006,000.00
Onek 400 Level Adit		
Onek 400 Level Adit - Alternative 1	Bioreactor treatment with natural attenuation	$ 523,000.00
Onek 400 Level Adit - Alternative 2	Stand-alone small WTF	$ 3,375,000.00
Onek 400 Level Adit - Alternative 3	New WTF at ST Hwy near Galkeno 900	$ 1,525,000.00
Onek 400 Level Adit - Alternative 4	Reclamation with natural attenuation	$ 385,000.00
Keno 700 Level Adit		
Keno 700 Level Adit - Alternative 1	Bioreactor treatment	$ 791,000.00
Keno 700 Level Adit - Alternative 2	Mine Pool Treatment	$ 628,000.00
Keno 700 Level Adit - Alternative 3	Managed natural attenuation	$ 463,000.00
Keno 700 Level Adit - Alternative 4	Water Treatment Plant	$ 3,962,000.00
	Tailings Facilities	
Valley Tailings		
Valley Tailings Facility - Alternative 1	Cover in Place	$ 20,967,000.00
Valley Tailings Facility - Alternative 2A	Relocation-Consolidation of Shallow Tailings and Cover (Dams Remain)	$ 22,733,000.00
Valley Tailings Facility - Alternative 2B	Relocation-Consolidation of Shallow Tailings and Cover (Dams Removed)	$ 26,295,000.00
Valley Tailings Facility - Alternative 3	Relocation-Consolidation of All Tailings to Synthetic Lined Facilities	$ 53,909,000.00
Wernecke Tailings		
Wernecke Tailings - Alternative 1	Cover in Place	$ 77,000.00
Wernecke Tailings - Alternative 2	Combine with Wernecke Millsite tailings and Cover	$ 120,000.00
Mackeno Tailings		
Mackeno Tailings - Alternative 1	Close in Place	$ 261,000.00
Mackeno Tailings - Alternative 2	Consolidate and Cover	$ 247,000.00
Mackeno Tailings - Alternative 3	Combine w/ Valley Tailings and Stabilize remaining site	$ 262,000.00
	District Wide Remediation Costs	
Site Water Quality Monitoring Costs for the District	Receiving Environment Monitoring	$ 4,364,000.00
Water Use Licence Reporting	Annual and other reports as required	$ 750,000.00
Environmental Effects Monitoring		$ 400,000.00
Site Services	Road Maintenance, Snow Removal, Culvert Maintenance, Regulator Interface	$ 3,509,000.00

Table 7-1. Summary of Keno Closure and Reclamation Costs

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KENO HILL SILVER DISTRICT

DRAFT CLOSURE OPTIONS REPORT

Appendix A

Technical Summary Fact Sheets



ALEXCO ENVIRONMENTAL GROUP

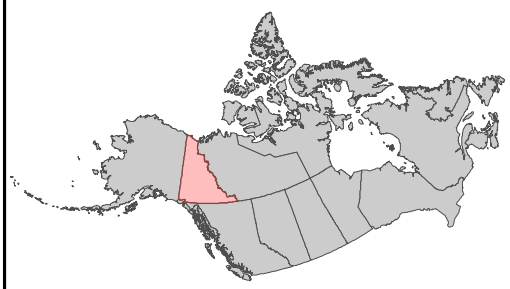
EXISTING STATE OF MINE RECLAMATION PLANNING TECHNICAL STUDIES – KENO HILL, YUKON

TECHNICAL FACT SUMMARY SHEETS

As part of the reclamation and closure of the Keno Hills Silver District (for location see Figure 1), a comprehensive closure plan for the existing state of the mine (ESM Reclamation Plan) will be developed and undergo environmental assessment and licensing processes. In order to support the selection of reclamation options for sites, and allow for environmental assessment and water, significant technical backup and studies are required to support the assumptions and strategies developed for the ultimate reclamation and closure option selected.

This compilation provides a brief summary of the main points of each technical study completed to-date and serves to inform interested parties and the public at large of the main technical points that will assist in selecting appropriate closure options and eventually, final options for the ESM Reclamation Plan.





KENO HILL SILVER DISTRICT

BELLEKENO MINE DEVELOPMENT

ALEXCO

ACCESS CONSULTING GROUP

TYPE A WATER LICENSE APPLICATION

FIGURE 1-1

PROJECT LOCATION

August 2009

Drawn By: HD/MD	Checked By: RM

D:\Project\AllProjects\ALEX05-01\gis\mxd\Overview_MapsProject_Location.mxd

UNITED KENO HILL MINE

TECHNICAL FACT SUMMARY SHEETS

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UNITED KENO HILL MINE

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WATER QUALITY AND RECEIVING ENVIRONMENT CONDITIONS STUDIES

Objectives have been identified by ERDC and INAC in coordination with FNNND and GY that will drive the closure planning process. Among these are a number of objectives for the preservation or remediation of the water quality standard in the South McQuesten River and its tributaries. Water degradation as a result of historical mining and the ongoing impacts produced by historical mine workings have led to significant attention being paid to this area of closure.

This section details studies that have been completed with respect to water quality and conditions in the receiving environment at the Keno Hill Property and the aquatic environment.

Technical Study:

WATER QUALITY DATA REVIEW

Date:

July 2008 – present

Performed By:

ACG

Objectives:

Comprehensively review the water quality database and add any additional information from others; and using this as source data,

Maintain the site-wide database and loading balance

Facts\Description of Study:

- Past sampling programs at Keno Hill have provided a depth of information sufficient for assessing water quality impacts and trends
- The Keno Hill water quality database was updated to include all available known water quality results, and all historic stations were renamed under a common set of KV numbers. A table of concordance exists for all stations
- Water quality data was vetted to ensure the inclusion of only the most reliable, trustworthy results for future analysis, including mass balance updating. This was based on data filters applied by Minnow Environmental
- The database was migrated to a newer, more efficient system for streamlined data input/output
- The database continues to be updated on a regular basis, as new results are obtained
- The data contained in the current, vetted database is the source for inputs to the site-wide loading balance

Information Gaps:

Flow and groundwater monitoring data, although not presently a part of the dataset, is a necessary addition to supplement the overall site loading balance inputs

Results/Conclusions:

- The current Keno Hill Mines water quality database is now an excellent data repository containing reliable data back to 1994 and will serve to provide good input data for models in the future.

Technical Study:

HYDROLOGICAL UPDATE AND ASSESSMENT

Date: 2007

Performed By:

Clearwater Consultants Ltd.

Objective

To refine the understanding of the UKHM hydrology that was originally developed in 1996 and to provide guidance on developing hydrological inputs to the site-wide water balance.

Facts\Description of Study:

- The following three steps were outlined to achieve the aforementioned objective:
    a. Process historical records of water level, direct discharge measurements and survey data collected at the mine's three streamflow gauging stations (KV-7, KV-9 and KV-41)
    b. Use streamflow records developed in (step a) to assess accuracy of flow-estimation techniques documented in the 1996 climate and hydrology study; and,
    c. Outline a proposed method for estimating flows around the Keno Hill property based on the original hydrology study and the streamflow records for the three mine site gauging stations
- Processing of the gauging station data (Step a) was used to produce a mean annual runoff (MAR) for each of the sites which could in turn be used to validate the method developed in the 1996 Hydrological Study (step b)
- The 1996 Hydrology Study developed an empirical relationship between MAR and catchment mean elevation

Information Gaps:

2006 freshet data for Station KV-9 could not be located by the time the memorandum from CCL was issued. The mean annual runoff for KV-9 was thus estimated through a correlation analysis with regional Water Survey of Canada stations.

Water level data collected at mine adits was not processed as the data appears to be of dubious quality

Results/Conclusions:

- Table 1 presents specific catchment areas, MAR, and runoff depth for the three gauging stations

- It was found that the streamflow data collected at the three gauging stations offers an excellent basis for validating the adopted relationship between MAR and catchment median elevation; moreover,
- The hydrological inputs for the new water balance could be estimated using the original techniques presented in the 1996 Hydrology Study; however,
- The availability of the streamflow record at KV-7, KV-9 and KV-41 may offer a more accurate method of assessing chemical loads
- The most complete and accurate data available are for Water Years 2005 and 2006 (i.e. the period from October 1, 2004 to September 31, 2006) and should be used for the next set of water and load balances
- The conditions on the McQuesten River would be expected to best represent seasonal flow conditions at Christal Ck, while those on the North Klondike River provide a reasonable estimation of the seasonal flow distribution for Lightning Ck

Table 1 Results of the Hydrological Survey at Christal, Lightning and Flat Creeks

Site	Site Description	Catchment Area	MAR	Average Runoff Depth
		km^2	m^3/s	mm
KV-7	Christal Creek @ Hansen Road	43.5	0.304	221
KV-9	Flat Creek u/s South McQuesten River	56.5	0.304 - 0.352	170 - 197
KV-41	Lightning Creek u/s bridge @ Keno City	59.1	0.645	344

Technical Study:

SITE WIDE WATER BALANCE/MASS LOADING BALANCE UPDATE

Performed By:

ACG

Objective

To update the site wide loading and water balance based on new information including the update water quality database and the UKHM Hydrological Update and Assessment.

Facts\Description of Study:

- In 1996, as part of the Site Characterization, a mass balance for the site was constructed based on sub-watershed catchment basins. The water balance, which forms the basis for calculating site loading, was developed based on regional hydrological and weather data
- In 2007, Clearwater Consultants Ltd. confirmed the hydrological input parameters that were used to determine the water balance
- Hydrological and water balance data serve as a frame for loading model development. The network of water quality monitoring stations contribute necessary contaminant node inputs
- Together, hydrological data and contaminant information are used to calculate loads at critical points along watershed pathways and at outlet points for each of the three site watersheds (Christal, Flat, and Lightning Creeks)
- In 2008, the contaminant loads were updated to reflect more recent conditions. Data from 2006 – 2008 was used to determine year by year loads from adit discharges and in receiving waters
- Adit discharges have similarly been updated with more recent flow volumes exiting from the adits

Information Gaps:

Clearwater Consultants have recommended that the hydrology for the model be updated based on flow data gathered at the site, coupled with regional hydrology data where appropriate.

Because the model is based on observed loads at output nodes, it is difficult to predict what those loads would look like under different loading scenarios without making assumptions about the site attenuation capacity. The attenuating properties of the site will be under investigation in summer 2009 so that more concrete statements can be made about contaminant dissipation.

Results/Conclusions:

- The highest loads originate from the Galkeno 300 and Onek adits. Galkeno represents the highest treated load (on the order of 40kg Zn/year after treatment), while Onek produces the highest untreated load (at between 575 – 975kg Zn/year). Both discharges report to ground

- The mass balance model has served to produce an estimation of the degree of attenuation at the site. When loading is at its highest (i.e. in years where there is little or no treatment at any of the adits) the attenuation capacity has been shown to be roughly 90% of the load entering the watersheds

Deliverables

An excel spreadsheet has been developed and refined which accepts inputs from a master water quality database and calculated loads at eleven basin output points, including Lightning Creek, Christal Creek immediately before discharge to the South McQuesten, and the final discharge point on the South McQuesten River for all site drainage.

A written report is in progress.

Technical Study:

SURFACE WATER QUALITY ASSESSMENT FOR UNITED KENO HILL MINE COMPLEX

Date: 2007

Performed By:

Minnow Environmental Inc.

Objective

To identify parameters and locations of concern within the downstream waters relative to established guidelines and background. This data, together with toxicity data and receiving watershed use objectives will be combined to develop an approach for considering the development of a Site Specific Water Quality Objectives (SSWQO) or water quality goals for various parameters and locations.

Facts\Description of Study:

- The following steps were outlined to achieve the aforementioned objective:

    a. The data were screened to identify where data should be removed from analysis due to errors.

    b. Background concentration for each parameter were established based on the upper limit of background data distribution for the combined data from KV-1 and KV-37

    c. Background concentrations which exceed the Canadian Water Quality Guidelines (CWQG) were identified

    d. Locations that exceed background and/or CWQG at measurable and sustainable frequencies were identified

    e. Parameters and locations where concentrations are highest were identified

    f. An assessment of trends over time was conducted to anticipate if concentrations are increasing or decreasing relative to CWQG and/or background

    g. Modifying factors and toxicity literature were considered to assess the opportunity for SSWQO development following the guidelines

Results/Conclusions:

- Background concentrations of several parameters exceed the CWQG, suggesting that concentrations of these parameters are naturally elevated. Contaminants of concern were identified as **total Zn** and **Cd**, while potential contaminants of concern were identified as: **total Al, As, Cr, Mn, Nitrite, P, Se, and Ag**

- Many stations were found to have concentrations for numerous parameters that exceeded CWQG in more than 10% of samples

- Significantly fewer stations were found to have concentrations for numerous parameters that exceeded CWQG in more than 50% of samples. The stations that exhibited this were concentrated at Christal Creek, No Cash Creek, and the upper portion of Lightning Creek and Flat Creek watersheds.

- Only a few locations exhibited parameters with median values 5X or more the CWQG; however, it was not uncommon for parameter maximum values to exceed 5X the CWQG

- The key locations of concern are KV-39, KV-29, KV-21 and KV-47

- While background concentrations are elevated for some parameters, even these high background values are exceeded in some cases (notably at Christal Creek, No Cash Creek, and the upper portion of Lightning Creek and Flat Creek watersheds); thus, a two-tiered approach to SSWQO is suggested which could permit higher concentrations in some near-field areas and higher protection in downstream areas

Technical Study:

BENTHIC INVERTEBRATE MONITORING PROGRAMS

Date: Summer 2007 – March 2008

Performed By:

Laberge Environmental Services

Objective:

To determine the population size and diversity of benthic invertebrate communities within the Keno Hill watersheds, and explain these variables through metal concentration levels.

Facts\Description of Study:

- Water quality, stream sediment and substrate samples for benthic invertebrate sampling were collected for laboratory analysis
- Stream sediment samples were collected from areas of deposition along the stream banks
- Substrate samples for benthic invertebrate sampling were collected from riffle areas at each sample location

Information Gaps

Historical benthic and sediment data was recently acquired and will be incorporated into future assessment of Keno Hill benthic data, including a report on Environmental Conditions at the property.

Results/Conclusions:

- CCME guidelines were exceeded for Cd and Zn in waters of all drainages, including the background drainage
- Concentrations of As, Cd, Pb and Zn were high in stream sediments at most sites, including at the background site, KV-1
- Highest sediment metals concentrations were documented at KV-9, Flat Creek
- Over time, metal concentrations have been greater in the sediments at Flat and Christal Creeks than the South McQuesten and Lightning drainages
- Benthic invertebrate populations were robust and healthy in the South McQuesten river and Lightning Creek drainages; good representation of chemically-sensitive insects indicates a healthy aquatic environment
- KV-6, Christal Creek at Keno Highway, was the least diverse of the site studied
- Populations at the other two sites on Christal Creek and KV-9 at Flat Creek, were depressed

- High concentrations of metals at Flat and Christal Creeks appear to be negatively impacting benthos community health

Technical Study

FISHERIES ASSESSMENT AND UPDATE

Date

September 17 – 19, 2008

Performed By

Access Consulting Group

Introduction

Fish living in polluted waters tend to accumulate heavy metals in their tissues. These metals can accumulate in significant quantities without causing mortality in species. The KHSD is an environment where high levels of metals have been observed in the aquatic environment (see previous Water Quality and Receiving Environment Conditions studies), and where fish that are used for human consumption exist. As a result, understanding the level of metals that are present in fish species in waters of the KHSD is necessary from a closure perspective.

This study investigates fish and fish habitat at a total of seven sites on Christal Lake, Christal Creek, Lightning Creek and Flat Creek. Results of fish tissue analysis were compared to the results of previous studies, and barriers to fish movement were investigated.

Objective

To investigate fish and fish habitat in several aquatic environments in the KHSD to determine levels of metals uptake in fish, and the potential risk to humans by consumption of these fish, and to identify any barriers to fish movement in streams and assess the feasibility of their removal.

Facts\Description of Study

Fish Tissue Analysis:

- Sites were fished using Gee's minnow traps and electrofishing where conditions allowed.
- Species at each site were identified and enumerated, and fork length measured before release.
- Water quality parameters temperature, conductivity, pH and dissolved oxygen were collected at each site

Habitat Barrier Investigation:

- The fisheries investigations carried out in 1995 and 2006 were reviewed as they identified former bridge crossings that posed barriers to fish movement in Christal Creek.
- The locations of the barriers was revisited, and re-evaluated for their potential to present partial or complete obstruction to upstream fish movement.
- Considerations were given to the need for and method of removal of these barriers.

Results/Conclusions

Fish Tissue Analysis:

- Lightning Creek yielded slimy sculpin and arctic grayling, Flat Creek yielded northern pike, Christal Creek yielded slimy sculpin, and no fish were retrieved from Christal Creek.
- Variation from 2006 analysis:
    - Christal Lake (slimy sculpin): values within range of variation for Christal Lake, with the exception of manganese, which had decreased by roughly half
    - Lightning Creek (slimy sculpin): values within range of variation for Lightning Creek, with the exception of nickel, which had increased by an order of magnitude
    - Lightning Creek (arctic grayling): values within range of variation for Lightning Creek, with the exception of nickel, which had a value of 0.93 in 2008 vs. non-detect in 2006
    - Flat Creek (slimy sculpin vs. arctic grayling): most values were within the reasonable range of variation compared with other values in Flat Creek, with the following exceptions: 2008 values for arsenic, lead and manganese were notably low compared with previous evaluations.
- Grayling have been singled out as the primary fish-based source of heavy metals consumption by humans in this geographic area. Based on the results of chemical analysis, the metals levels found in Lightning Creek grayling tissue were well below acceptable human consumption levels. The only exception to this is that the level of arsenic in grayling tissue was found to exceed the threshold for consumption by toddlers.

Habitat Barrier Investigation:

- Three of four barriers identified in 1995 and 2006 were still in place in 2008
- The barrier were confirmed as an impediment to fish movement
- It was recommended that the barriers be removed according to best practices and in adherence with regulations. Recommendations are made in the report to achieve this.

Deliverables

Final Report: Fisheries Assessment Project

Technical Study:

AQUATIC RESOURCE ASSESSMENT FOR UNITED KENO HILL MINES

Date: April 2008 – March 2009

Performed By:

Minnow Environmental Inc.

Objective

To provide an integrated assessment of the available biotic (fish and benthic invertebrate community) and abiotic (water and sediment) data such that current conditions within the headwaters tributaries down gradient of the mine and further downstream in the South McQuesten River are characterized.

This report, along with the Water Quality Assessment Report for United Keno Hill Mines will serve as key supporting documents for other ERDC initiatives, such as preparation of the Closure Plan, determination of water quality goals and objectives, and the development of a long-term monitoring program

Facts\Description of Study:

- The following steps were outlined to achieve the aforementioned objectives:

    a. The watershed characteristics for each watershed were assessed and an overview of mine influences and habitat characteristics were determined

    b. The water quality assessment for UKHM was considered in view of the aquatic characteristics of the site

    c. Current and historical sediment quality at the Keno Hill mine was evaluated

    d. Benthic invertebrate community health was evaluated

    e. Current and historical fisheries data including community composition, fish condition and metal concentrations in tissues was considered and evaluated

    f. Data was integrated to provide an exhaustive assessment of the current aquatic conditions at Keno Hill

Results/Conclusions:

- Analysis of water quality identified cadmium and zinc as key contaminants of concern in waters downstream of the Keno Hill property. Concentrations of these substances are at levels that are potentially toxic to aquatic biota in portions of the tributaries receiving mine drainage (particularly Christal Creek). However, contaminant levels in the South McQuesten River are currently below levels of concern

- Sediment guidelines are based on concentrations measured in whole sediment samples (not just the fine fraction), so potential risks to benthic biota cannot be ascertained from the available sediment data

- Benthic invertebrate communities in lower Christal and Flat Creeks were characterized by relatively low abundance and number of taxa compared to reference and other, mine exposed areas. Correlation analysis suggested that reduced number of taxa may be related to elevated water concentrations of mine-related variables such as major ions (e.g., sulphate, hardness, conductivity), cadmium, and zinc

- The presence of both adult and juvenile Arctic grayling in most watercourses indicates availability of suitable spawning and rearing habitats. Portions of Christal Creek showed limited fish diversity and densities, particularly at KV-7 where no fish were found in 2006. No large and consistent patterns were evident in mine-exposed areas that would suggest that conditions had either improved or degraded over time

- Whole body analysis of slimy sculpin showed levels of arsenic in excess of reference sediment concentrations and wildlife consumption benchmarks at most areas downstream of UKHM, particularly in Christal and Flat Creeks. Metal concentrations in Arctic grayling muscle were less than human or wildlife consumption benchmarks in almost all samples from all areas. No consistent increases or decreases were evident over time based on comparison of data from 2006 to data from 1994-95

- Modifications and guidance for developing a long-term monitoring program for Keno Hill were recommended based on the findings of the water quality and aquatic resources assessment, in particular ensuring that monitoring programs retrieve all necessary data and that redundancies are eliminated.

Technical Study:

APPROACH FOR DEVELOPING WATER QUALITY GOALS FOR UNTIED KENO HILL MINES

Performed By:

Minnow Environmental

Introduction

Minnow Environmental was retained by ERDC to provide an assessment of water quality and biological characteristics at the Keno Hill Mines Property. Extending from those assessments, Minnow was requested to assist in developing a framework for determining water quality goals for each watershed affected by the Keno Hill Mines. Based on that framework, Minnow has also included a discussion which proposes achievable goals for the Keno Hill Mines receiving environment.

Objective

To develop an approach to assessing water quality downstream of Keno Hill Mines that will serve to protect resident biota and prevent further degradation of water quality within the immediate receiving environment and allow for no further degradation in the South McQuesten Rive relative to upstream conditions.

Facts\Description of Study:

- Aqueous cadmium and zinc concentrations were assessed for routine monitoring stations in Christal Creek, Flat Creek and the South McQuesten River both upstream and downstream of Keno Hill Mines relative to Canadian Water Quality Guidelines (CWQG)
- For stations where trends were observed over time, slopes were plotted and statistically compared using analysis of covariance
- Toxicity information was gathered from Environment Canada and scientific literature for cadmium and zinc
- Because of the significant impact of hardness levels on toxicity, reported effects concentrations for cadmium and zinc were converted based on common water hardness (a hardness of 100mg/L was used as an appropriate, conservative value for Keno Hill)
- The lowest toxic effect concentration corresponding to an exposure hardness of 100mg/L was identified for each study and species where possible, and other measures were used to derive a toxic effect concentration when hardness data was not available
- Recent water concentrations of cadmium and zinc measured at key locations downstream of Keno Hill were compared to toxic threshold concentrations reported in the literature for different aquatic species (at a water hardness of 100mg/L).
- Water quality in each of the watersheds was evaluated relative to toxicity data and an approach to developing appropriate water quality goals was derived.

Results/Conclusions:

South McQuesten River

- In mid-2007 it was noted that concentrations of various metals including cadmium and zinc had increased upstream in the South McQuesten River at KV-1. Over the same period, concentrations of cadmium and zinc were found to be increasing at the same rate downstream at KV-4 and KV-5 as upstream at KV-1.
- The conclusion is that a source upstream of KV-1 was responsible for the increase in water concentrations at KV-1 and that Keno Hill Mines are not causing a measurable increase in concentrations downstream of the mines at KV-4 and KV-5
- Because the concentrations continue to increase, and it is not known whether or for how long this will continue, it is not possible to establish a single numerical value that represents the upper limit of upstream background conditions.
- Rather than a single numerical value, it is proposed that water quality objectives in the South McQuesten downstream of Keno Hill Mines be linked to upstream concentrations and allow for no further degradation of water quality. Minnow makes detailed recommendations as to the analysis and statistical methods to be carried out to achieve this in their report.

Lightning Creek

- Concentrations of metals in Lightning Creek have generally been below CWQG, and as such the existing or proposed CWQG should be adequate as water quality goals for this watershed

Flat and Christal Creeks

- Historical concentrations of cadmium and zinc have been elevated well above (10x or more) CWQG.
- It is not realistic to propose CWQG as goals for these watersheds as the number of sources and uncertainty of future loads from surface contamination are great.
- Thus, the approach taken for Flat and Christal Creeks must be a species-specific approach based on toxicity levels.
- The toxicity data for species in Flat and Christal Creeks show that if cadmium and zinc concentrations remain stable or decline over time, biological impacts will be minimal and existing biological communities will be protected.
- The report goes on to describe specific measures to be carried out in order to assess whether or not the diversity and abundance of resident biota are being protected.

Deliverables

Draft Report: Approach to Developing Water Quality Goals for United Keno Hill Mines (Minnow 2010)

Technical Study:

LONG-TERM AQUATIC MONITORING PROGRAM FOR UNTIED KENO HILL MINES

Performed By:

Minnow Environmental

Introduction

ERDC has requested that Minnow Environmental Inc. assist in identifying the requirements of a comprehensive, site-wide Long-Term Aquatic Monitoring Program (LTAMP). Such a program will need to support the environmental assessment, closure planning, and regulatory processes in the short-term and provide adequate information to evaluate environmental conditions relative to closure initiatives and redevelopment/operations in the long-term.

Objective

To develop a Long Term Monitoring Program for Keno Hill Mines

Facts\Description of Study:

Approach for Monitoring Water Quality

- The current known conditions for water quality indicate that cadmium and zinc are contaminants of concern, and there are a number of other potential substances that cannot be ruled out as possible contaminants of concern due to limitation of the data set, which should be addressed in an LTAMP.
- Factors that need to be considered and incorporated into the LTAMP study design include: planned remediation measures, the scope of future mining, placer mining activities and adequate characterization of reference areas (which does not currently exist at the Keno Hill Mines Property).
- Minnow proposes a framework for water quality monitoring in a number of areas including the location of sites, parameters for analysis, total vs. filtered metals, flow, method and frequency of collection, data analysis and the incorporation of these items into a future water licence for closure.
- Given the framework defined by Minnow for comprehensive monitoring of water quality, they propose a starting point for the LTAMP, which would evolve over time as data are collected. The LTAMP begins with the collection of a significantly greater amount of data over the course of two to three years in the receiving environment to quantitatively determine the minimum number of data points that will need to be collected in the future to fully characterize the impact of the mines and the closure plan.

Approach for Monitoring Sediments

- Metal analyses over the past 20 years have shown that arsenic, cadmium, lead, manganese and zinc occur at levels well above Canadian Sediment Quality Guidelines (CSQG) in the fine fraction of sediments. Bulk analysis in 2009 showed that the levels of arsenic, cadmium, lead and zinc are elevated in bulk samples, as well as in fines.

- As with water quality monitoring, consideration must be given to a number of factors that influence contamination levels in sediments, including: locations where deposition may occur most rapidly and the amount of particulate metal in the water. In the case of Keno Hill Mines, it can be noted that these two factors converge to produce an environment where benthic communities are most likely exposed to mine-related substances via water pathways rather than sediment pathways

- Similar to the LTAMP associated with water quality, Minnow presents a framework and establishes parameters for determining the most appropriate locations, analyses and collection methods for sediment monitoring. Minnow proposes a sediment monitoring program for the LTAMP based on these parameters, and incorporates monitoring for reference areas (which do not exist in the current monitoring program).

Approach to Monitoring Benthic Invertebrate Communities

- Benthic communities within Christal Creek and Flat Creek have shown impairment through reduced abundances and number of taxa relative to the other watercourses sampled in the area. The benthic communities within the South McQuesten River and Lightning Creek had higher numbers of taxa and abundance suggesting limited impairment at these locations. This corresponds to the observation that water quality is significantly lower in the areas of Flat and Christal Creeks than the South McQuesten River and Lightning Creek.

- Minnow expounds the merits of benthic monitoring as a way of assessing the potential effects of the chemical condition of water and sediment on the health of aquatic systems.

- A report is underway for completion in 2010 which aims to determine the most effective study design and sampling method for benthic community monitoring within the context of the LTAMP.

Approach to Monitoring Fish Communities

-

Data Quality Objectives and Quality Control

- Minnow details a standard approach to developing data quality objectives and implementing quality control as a component of the LTAMP as a way of qualitatively defining sensitivity, precision, accuracy, comparability, compatibility, representativeness and completeness of the dataset.

Reporting

- Reporting is suggested as a method of review to regularly assess and report the condition of water quality, sediment quality, benthic community health and fish community health. Two types of reports are detailed: Annual Water Quality Reports and Comprehensive Aquatic Ecosystem Study Reports.

Results/Conclusions:

The LTAMP will integrate biological and chemical information for a weight-of-evidence approach, including the following components:

- Water Chemistry and Hydrology (flow): Water quality monitoring is important as water is the main vector for off-site transport of contaminants and can be monitored frequently to serve as an early warning indicator of changing conditions
- Sediment Chemistry: The receiving environment downstream of UKHM is generally erosional and deposits of fine sediments are typically sparse and patchy. Therefore, exposure to sediments by biota is likely quite limited
- Benthic Invertebrate Community Monitoring: Benthic invertebrates are good, community-level integrators of localized conditions over time, they are important components of aquatic food webs and there are standardized methods for their collection and evaluation
- Fish Community and Population Assessment: Fish tend to occupy the upper trophic levels of aquatic ecosystems and are often their most visible and valued components. Both population and community-level assessment can be used as indicators of longer-term exposure conditions (e.g., over years)

The LTAMP will incorporate a standard quality control program and be subject to regular reporting for purposes of review.

Deliverables

Draft Report: Long-Term Aquatic Monitoring Program for Untied Keno Hill Mines

ADIT WATER QUALITY STUDIES

Adit water quality studies.

Technical Study:

ADIT DISCHARGE SURVEY

Date: Summer 2007

Performed By:

ACG

Objective

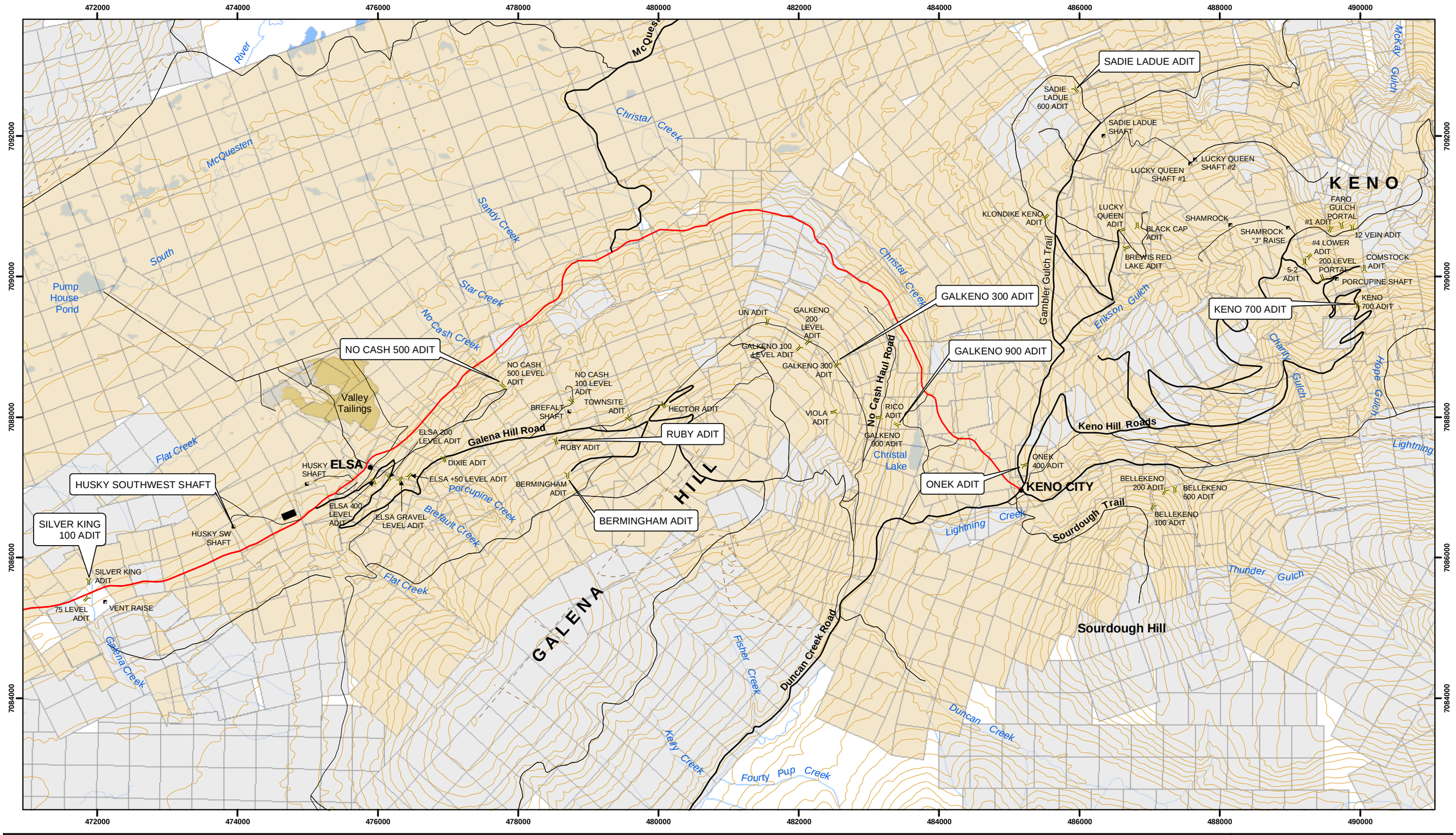
To reaffirm the understanding of adit flow paths and down gradient water quality.

Facts\Description of Study:

- The following survey components were outlined to achieve the aforementioned objective:
    a. Determine the discharge path from adit to a surface water source if possible;
    b. GPS the discharge path;
    c. Establish sample locations;
    d. Obtain water samples at locations along the path;
    e. Collect in-situ water quality;
    f. Receive lab results of water's analysis;
    g. Collect a photo library; and
    h. Report on the results of the survey.
- The adits included in the study were: Silver King 100, Husky South West, Bermingham, Ruby, No Cash 500, Galkeno 300, Galkeno 900, Keno 700, Onek, and Sadie Ladue (Figure 2)
- Results were compared with CCME Fresh Water Aquatic Life Guidelines and Effluent Standards as Part E of the Water Use Licence (QZ06-074)

Results/Conclusions:

- The survey was able to successfully identify and confirm the receiving waters drainage for the adit network
- Site locations for AMP monitoring were successfully identified
- Hydraulic catchment areas for the mass loading model were verified (Table 2)



N

1:50,000
(when plotted on 11x17 inch sheet)

0 1 2 4 km

Legend

Topography
- Town
- Silver Trail
- Secondary Road
- Limited-use road
- Trail
- Watercourse
- Waterbody

Mine Workings
- Valley Tailings
- Adit
- Shaft (to surface - connection to underground not determined)

Quartz Claims
- Elsa Reclamation and Development Corp. and Related Companies Quartz Claims
- Other Quartz Claim

First Nation Settlement Land
- First Nation Settlement Land

Notes:
This map is for illustrative purposes only.
This is not a legal document.
National Topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:50,000. Cadastral data compiled by Natural Resources Canada. Reproduced under license from © Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.
Quartz claim boundaries are current as of December 7, 2007.
Data source: http://geomaticsyukon.ca.
Ownership is current as of Dec. 11, 2007. Digital claim status report obtained from the Mining Recorder website at http://www.yukonminingrecorder.ca/
Projection: UTM Zone 8 NAD83
NTS Sheet 105M/13 and 105M/14

ERDC
ACCESS

Keno Hill Silver District
Adit Discharge Survey

Adit Discharge Survey Locations

Drawn By: HD	Date: March 2008	**FIGURE 2**
Checked by: DC	Our File: D:\Projects\AProjects\ALEX-05-01\gis\mxd\UKHM\AditDischargeSurvey_Summer07\Rpt_OV.mxd	

Table 2 Adit Discharge Survey Matrix

Adit	Receiving Water Drainage	AMP Monitoring Station	1996 Mass Balance Catchment	2008 Mass Balance Catchment
Silver King 100	Flat Creek via ground	SK100-7, SK100-8, SK100-9	Galena Creek above the mouth	Galena Creek above the mouth
Husky South West	Flat Creek via ground	HSW-6	Flat Creek above station KV-9 and below Porcupine Creek diversion channel	Flat Creek above station KV-9 and below Porcupine Creek diversion channel
Bermingham	No Cash Creek via ground	Berm-4	No Cash Creek above Highway 2 which drains to South McQuesten River between station KV-2 and KV-1	No Cash Creek above Highway 2, which drains to South McQuesten River between station KV-2 and KV-1
Ruby	Star Creek via ground	Ruby-5	No Cash Creek above Highway 2, which drains to South McQuesten River between station KV-2 and KV-1	No Cash Creek above Highway 2, which drains to South McQuesten River between station KV-2 and KV-1
No Cash 500	No Cash Creek	No Cash-500-4	No Cash Creek above Highway 2	No Cash Creek above Highway 2
Galkeno 300	Christal Creek	GK300-4	Christal Creek between station KV-7 and KV-6	Christal Creek between station KV-7 and KV-6
Galkeno 900	Christal Lake	GK900-3	Christal Creek above station KV-6	Christal Creek above station KV-6
Keno 700	Lightning Creek	Keno 700-4	Hope Gulch above KV-39	Hope Gulch above KV-39
Onek	Christal Creek via ground	MDP7	Christal Creek above station KV-6	Christal Creek above station KV-6
Sadie Ladue	Ladue Creek via unnamed Watercourse	Sadie-3	Ladue Creek via unnamed watercourse northeast of KV-35 and southwest of KV-73	Ladue Creek via unnamed watercourse northeast of KV-35 and southwest of KV-73

Technical Study

ONEK AND NO CASH PATHWAY INVESTIGATION

Date

2007

Performed By

ACG

Introduction

Based on measured loads of zinc and other contaminants from the No Cash 500 and Onek adits, considerably higher metals loads are expected down gradient in both Christal and Flat Creek than are observed. Modelling loading contamination with the Mass Loading Model developed for the site has shown a net negative balance of contaminants along the downstream path from these two adits.

Objective

This study aims to identify the mode of contaminant reduction in the No Cash 500 and Onek drainages, and to account for the negative variance in estimated versus actual contaminant load in Christal Creek and Flat Creek, thereby confirming that geochemical attenuation and reduction are occurring.

Facts\Description of Study

The following steps were carried out to achieve the study objective:

A review of the mass balance for the Christal Creek and Flat Creek areas was undertaken to establish the magnitude of load reduction within the watersheds

An investigation of the location of No Cash and Onek adit flow paths was carried out to delineate contaminant pathways

At Onek and No Cash adits, test pits were hand dug to groundwater, and manually-driven piezometers were installed within shallow groundwater. The pits and piezometers were sampled for zinc, other metals (including cadmium, iron, manganese, silicon) and for major ions of interest. Ions of interest particularly included sulfate and bicarbonate

At No Cash, sulfide precipitates or sulfide odors were observed which indicated an ion transfer process is occurring, which suggests attenuation mechanisms. The iron and manganese precipitates (ferricrete) below No Cash adit were several feet thick.

A chemical analysis of the results was carried out to establish the likely mechanisms responsible for load reduction. The two principle mechanisms investigated were dilution from groundwater sources and attenuation.

Results/Conclusions

Field observations and laboratory analyses indicated to the study team that at both No Cash 500 and Onek, naturally occurring organic materials are breaking down under anaerobic sulphate-reducing conditions, precipitating zinc as a sulphide mineral from concentrations as high as 90 PPM at Onek and under steep hydraulic gradients such as exist at No Cash 500, and in both cases result in groundwater and surface water seepage high in bicarbonate concentrations and substantially devoid of zinc loading.

Deliverables

Final Report: Contaminant Loading and Transport Pathways Investigation – Onek and No Cash 500

Technical Study

BIOREACTOR PILOT TEST

Date

April 2010

Performed By

Alexco Resource US Corp.

Introduction

The Galkeno 900 Adit discharges high metals content water continuously at steady rate of 3-4l/s. The adit discharges from the side of Galena Hill within a distance of 1km of Christal Lake. There is limited room for natural attenuation or wetlands treatment of adit discharge prior to surface water contact in Christal Lake and Christal Creek. Consequently, this location will likely require some active water treatment and management, and this consideration led to the determination that a pilot test bioreactor would be located at the Galkeno 900 site.

Objective

The objective of this study is to demonstrate the viability of sulphate reduction technology for the removal of metals, especially zinc and other metals that react with aqueous sulphide. The goal is ultimately to promote bioreactor cell treatment as a viable long-term treatment alternative for mines in the district with suitable water characteristics as well as the Galkeno 900 adit

Facts\Description of Study

The bioreactor solid phase substrate is comprised of coarse rock collected from a nearby placer mining operation. Baffles have been constructed within the cell to direct flow in a sinuous manner through the bioreactor. The first few months of operation involved a growth phase for naturally-occurring sulphate-reducing bacteria (SRB) to colonize the surface of the gravels, in time forming a microbial coating. An organic growth substrate comprised of dissolved organic carbon forms (sugars, alcohols, complex carbohydrates and proteins from milk) is used to promote this colonization. The organic substrate supports microbial growth until sulfate reduction is the predominant microbial activity in the reactor, and then to support microbial sulfate reduction, which is a microbial reaction that transfers electrons from organic carbon, causing sulfate to be reduced to sulfide. Sulfide reacts with many dissolved metals, forming highly insoluble precipitates, which are filtered by the gravels within the cell. The reactor also has the potential for other reactions to occur as a result of alkalinity being formed from the oxidation of organic carbon, and it is common to observe carbonate mineral formation within the reactor

Results/Conclusions

The minimum goal of 0.5 mg/L zinc was consistently achieved with one exception, during the period of the pump failure. Other metals were also consistently improved with the exception of a short period when reduction onset occurred when some metals were released with the reductive dissolution of iron and manganese.

Hydraulic residence times associated with the 0.5l/s flow rate (9 to 21 days hydraulic residence time) were sufficient to consistently achieve treatment goals. Hydraulic residence times associated with the 1.0l/s flow rate (4.5 to 10.5 days hydraulic residence time) may have been sufficient to achieve treatment goals, with the pump failure being the source of uncertainty in this assessment.

The sulphate reduction rate was assessed and will be updated in the next year (2010-11) after consistent treatment approach is maintained to determine if there is an annual range that may be affected by temperature.

The organic carbon loading rate requirement has been assessed and will be further refined in the next year (2010-11)

Monitoring requirements for the bioreactor system have been assessed and will be adjusted in the following year (2010-11) to reflect an updated operational approach. Several biological toxicity tests will be performed to demonstrate that the system is stably achieving the water quality improvements sufficient to allow direct stream discharge

Deliverables

Final Report: Galkeno 900 Sulphate-Reducing Bioreactor Interim Report

VALLEY TAILINGS STUDIES

The Valley Tailings Area (VTA) has long been a significant source of contamination to the receiving environment of the Flat Creek drainage.

Technical Study:

VALLEY TAILINGS GEOTECHNICAL CLOSURE STUDY

Date: October 2007

Performed By:

SRK Consulting

Introduction

The summary outlines the section of the geotechnical closure studies conducted by SRK that pertains to the Valley Tailings Area.

Objectives

To develop an understanding of the foundation conditions under VTF Dams #1, #2 and #3 for use in determining the long-term dam stability. Monitor physical hydrogeology, geochemistry and temperature at a number of common locations along the dams.

To develop an understanding of the current conditions at selected waste rock piles so that closure measures can be developed on a pile-by-pile basis. Assess the geotechnical suitability and realistic reclamation outcomes for the re-sloped footprint of select piles.

Facts\Description of Study:

- A field study was conducted at the VTA to help assess the first objective:
    a. Six boreholes were drilled at the crests of Dams #1, #2 and #3 to log soil stratigraphy, depth to bedrock, geotechnical conditions and permafrost extent and monitor groundwater flow and thermal regime
    b. Boreholes were drilled within the tailings impoundments behind Dams #1 and #3 to determine the extent of tailings, overburden, permafrost, bedrock depth and lithology, to collect soils for soils characterization, and to monitor water levels and groundwater chemistry
    c. Other boreholes were completed to monitor water chemistry and levels, background characteristics, and groundwater down gradient of the VTF
- Additional information on dam performance was gathered from the following information repositories:
    a. 2007 seismic hazard calculation
    b. 2007 VTA dam classification
    c. Review of historical records

d. 1996 flood frequency analysis

e. Review of the stability analysis completed by EBA in 1982

- Waste rock sites were inspected and assessed via the following:

a. A review of the historical stability of the waste rock piles

b. Water management considerations, including assessment of running surface waters that could pose a risk of future undercutting and instability

c. An assessment of the state of deterioration of wooden support structures

d. Resloping considerations

Information Gaps:

A desktop study to evaluate the stability of selected crown pillars was to be conducted based on a review of operational records of the shallow stopes at the major mines. However, the records consist of a digital library of tens of thousands of unsorted data files which through considerable effort was not able to produce more information on crown pillar stability.

Results/Conclusions:

Valley Tailings Foundation Conditions

- The VTF dams are currently under static loading conditions, but it is unclear whether their respective safety factors meet appropriate values for closure
- The parameters used in the stability analysis completed for static loading conditions in 1982 are believed to be reasonable and can be used in future analysis to assess their current and post-closure stability
- These same parameters, coupled with the recent seismic hazard information, can be used for pseudo-static analyses to evaluate the stability of the dams under seismic loading assuming that the foundation layers will not liquefy
- At some point prior to final closure design, the assumption that the foundation stratum immediately below the peat at each of the permanently installed dams will not liquefy in response to the design earthquake should be checked with a geotechnical drilling program that will obtain suitable relative density data using Standard Percussion Tests or other suitable methods

Waste Rock Pile Closure Options

- A decision matrix has been developed for Keno Hill waste rock piles to provide a framework for stakeholders to assess the requirements for closure (Table 3)
- Waste rock closure options are currently in the process of being established; for most waste rock dumps this will mean resloping either with or without vegetative cover

- Also included in the example decision matrix are a number of considerations for implementation of a closure measure for a given waste rock pile. For example, one closure option might be to reslope the waste rock 2.5H:1V. A consideration in this case might be the additional land that would be covered during the resloping exercise. Stakeholders may wish to consider weighing the benefits of resloping against covering the additional footprint area with waste rock

Technical Study:

VALLEY TAILINGS GROUNDWATER SAMPLING PROGRAM

Date: Summer 2006

Performed By:

ACG

Objective

To intersect and sample groundwater flowing through the Valley Tailings

Facts\Description of Study:

- Two piezometers were placed upstream and two downstream of the observed linear vegetation feature west of Valley Tailings Pond #1
- Potential Sampling locations were surveyed by walking the entire length of the vegetation feature. Low-lying areas and indications of water neat the surface were surveyed.
- Potential install locations were selected by driving a piezometer to test for the presence of water.
- Where water was found, it was tested to determine whether it was flowing or stagnant. If found to be flowing, a piezometer was installed

Results/Conclusions:

- Groundwater samples are successfully retrieved from the installed piezometers and are stored in a groundwater quality database. These data contribute to the understanding of groundwater chemistry influenced by the valley tailings area.

Technical Study:

VALLEY TAILINGS GROUNDWATER MASS LOADING AND CONTAMINANT MASS BALANCE REPORT

Performed By:

Alexco Resource Corp.

Objective

To provide baseline conditions about the quantity, source and transport of contaminants within the Valley Tailings Area drainage prior to the implementation of closure measures, with special emphasis on the impact of groundwater contamination.

Facts/Description of the Study

- The report derives water and mass balances for nodes within and around the tailings via an estimation of contamination and flow
- The study involved two phases; first, a field program was carried out to collect groundwater samples from the Valley Tailings area using drive-point piezometers. Second, the surface water quality database for the site was investigated together with the flow regime of the Valley Tailings Area
- During the first phase, drive-point piezometers were installed in the Valley Tailings and nearby areas and water samples collected for contaminant analysis. Tubing was installed to allow future access to the wells and a cap placed atop to prevent contamination
- In the second phase, the water quality database was examined together with estimated flow to derive an estimate of contaminant load produced by surface water travelling through the Valley Tailings Area and Flat Creek watershed.
- The second phase was also used to determine an estimate of the groundwater and contamination flux from the Valley Tailings into the Flat Creek watershed based on observed chemical loads in the area.
- Data from these two phases were analyzed in context with each other to determine the magnitude of potential loading from groundwater contamination in and around the Valley Tailings Area.

Results/Conclusions

Outcomes of this study are:

- Waters passing through the Flat and Porcupine Creek basins accumulate significant loadings of dissolved salts, dissolved zinc, and other soluble contaminants
- Sulphate, arsenic and zinc are all mobile in the saturated tailings and transmit between the tailings interface beneath and down gradient from the Valley Tailings.

- Significant flows of water transmit at the interface between the tailings and the surface of the original terrain.
- Thus, it can be concluded that the Valley Tailings are a source of contaminant loading to the South McQuesten River Valley.
- There is a new understanding that groundwater seepage from the tailings represent a significant load, which is potentially far greater than the surface loading posed by decant discharges.

A number of recommendations were made following the results of this study. Because of the potential for zones of high variability around and beneath the tailings, it was suggested that a systematic study be carried out along given transects to better understand the spatial distribution of organic levels, metals/sulphate contamination and groundwater flow velocities. This would provide a baseline for measuring the effectiveness of various cover systems, and may help determine how closure strategies could be used to enhance natural processes to reduce groundwater loading.

Deliverables:

Final Report: Valley Tailings Groundwater Mass Loading and Contaminant Mass Balance Report.

Technical Study:

ASSESSMENT OF GROUNDWATER REGIME AT THE VALLEY TAILINGS FACILITY

Date: Summer 2007 – February 2008

Performed By:

SRK Consulting

Objective

To develop an understanding of the physical hydrogeology of the Valley Tailings Facility to enable an estimation of groundwater flux through the facility to be derived. This flux will be used to estimate current contaminant loadings from the VTA into the receiving environment.

Facts\Description of Study:

- To achieve the above objectives, the following broad measures were taken:
    a. Review all available data
    b. Conduct a geotechnical percussion drilling program to provide information on the unconsolidated materials at the site (Figure 3)
    c. Develop a conceptual hydrogeological model for the site
    d. Calculate groundwater flux
- Available data reviewed for the study included previous reports, memos and drill logs, grain size analysis data from boreholes, aerial photography and EBA reports
- Results of the drill program and conceptual model were used to estimate the hydraulic characteristics of the unconsolidated materials beneath the tailings and the dams

Information Gaps:

Percussion drilling creates a grain size bias towards coarse soil fractions as a result of fines being flushed with water or circulating air. This can impact on the interpretation of grain size analysis results which are used to estimate hydraulic conductivity. Thus, hydraulic conductivity was derived using low estimations of grain size.

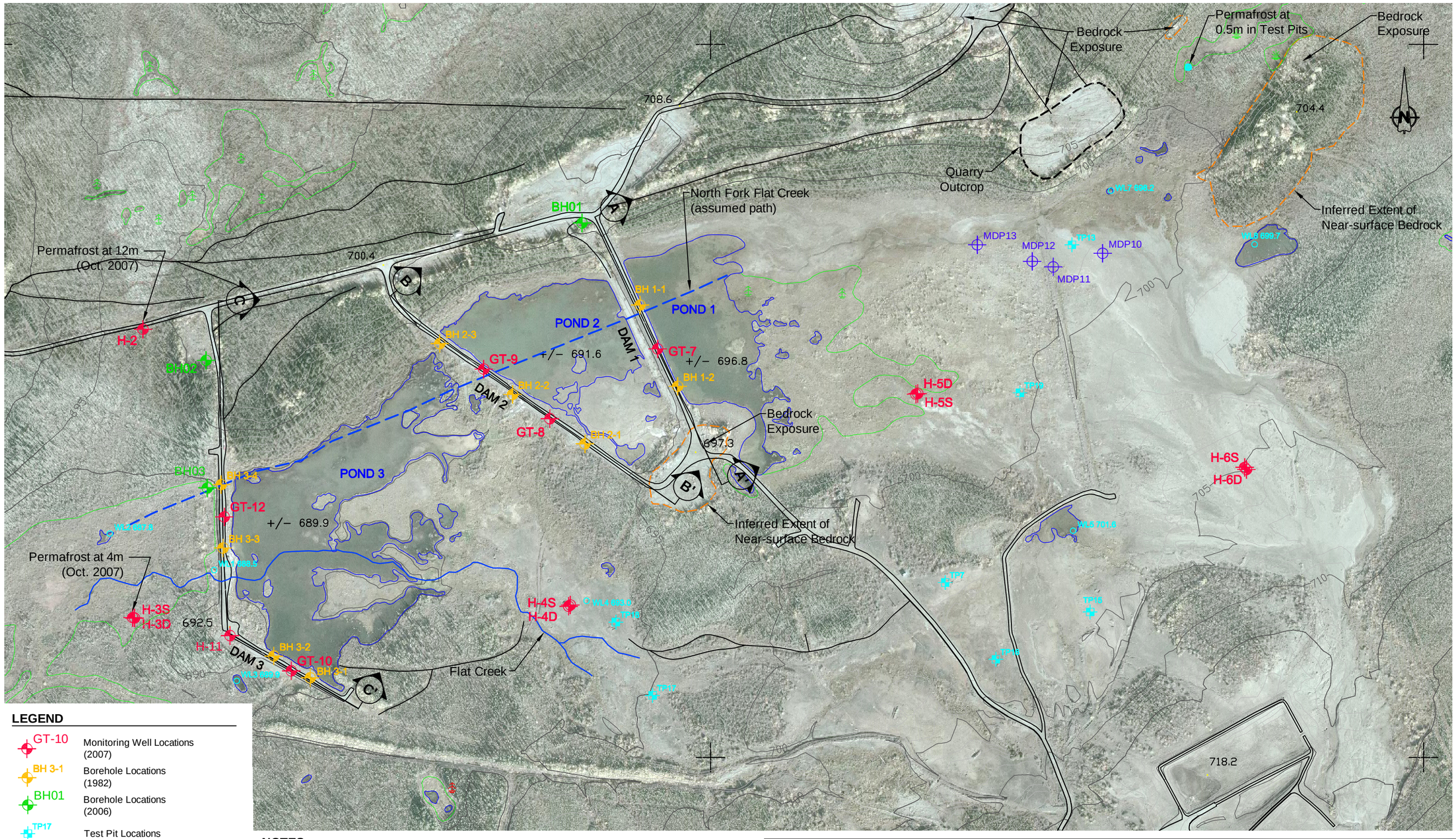
Results/Conclusions:

- A net flux of 18m^3/day was estimated to leave the VTF via groundwater flow beneath Dam 3
- The flux was estimated using data not collected under ideal conditions. Because the flux is sensitive to changes in hydraulic conductivity, further information should be gathered to increase the hydrogeological understanding, including:

a. Refinement of the site water balance to allow better estimates of the seepage loss from the Porcupine Diversion

b. Slug testing in the existing well to attempt to derive a better estimate of hydraulic conductivity in the overburden beneath the VTF

- There is little evidence to support the idea that Zn is being carried into deep seated water beneath the tailings (see 2007/08 Geochemical Studies: Tailings Geochemical Assessment)



LEGEND

GT-10	Monitoring Well Locations (2007)
BH 3-1	Borehole Locations (1982)
BH01	Borehole Locations (2006)
TP17	Test Pit Locations
MDP10	Manual Drive Points

Note:
GT-* locations also contain Thermistor Strings
H-* locations are Monitoring Wells only

NOTES

1. Base drawing and orthophoto provided by ERDC. Orthophoto prepared by AeroGeometric, from photos flown September 2006 by Geodesy Remote Sensing Inc, Calgary, Ab.
2. Coordinate projection is NAD83, UTM projection.
3. Contour interval is 1 metre.

0 50 100 150 200 250
Scale in Metres

SRK Consulting
Engineers and Scientists
Vancouver B.C.

SRK JOB NO.: 1CE12.000.GT2
FILE NAME: 1CE012_000-GT2-7.dwg

ERDC

Keno Hill Project

Assessment of Groundwater Regime at the Valley Tailings Facility

Drillhole Locations

DATE:	APPROVED:	FIGURE:
Feb. 2008	BG	2.1

J:\01_SITES\UKHM\ACAD\Acad 2007\1CE012_000-GT2-7.dwg

Technical Study:

TAILINGS GEOCHEMICAL ASSESSMENT

Date: Summer 2007 – February 2009

Performed By:

SRK

Objective

To better understand in-situ tailings weathering conditions at the Valley Tailings Facility (VTF).

Facts\Description of Study:

- To support the evaluation of closure options, a work plan was developed to answer the following questions:
    - What is the current metal loading from the VTF?
    - What is the widespread potential for order-of-magnitude increases in metal loading rates due to widespread and significant decreases in tailings pH?
- To tackle the questions listed above, test pits were excavated in May 2007, from which tailings horizons were logged and water chemistry was obtained. Water chemistry in the pits was considered an approximation of tailings pore water chemistry immediately adjacent.
- Shallow drive points were installed to measure water quality in July and August of 2007
- Paired sets of test wells were installed in October 2007. Samples continue to be collected and tested for water quality.

Results/Conclusions:

- Current contaminant loading exiting the VTF occurs through both surface water and groundwater pathways. These pathways report to the west of Dam #3 and to the Porcupine Diversion
- Portions of Porcupine Creek, Brefault Creek, and the Porcupine Diversion traverse exposed tailings, and contribute most of the chemical load to the Porcupine Diversion and Flat Creek

  Current Contaminant Loading

    - The average contained zinc mass of 21kg/m2 is in the range of attenuation capacity of 2 to 3 metres of peat by sorption processes alone (this is equal to the amount of peat observed in borehole profiles)
    - Complete leaching of all contained zinc from the tailings is highly unlikely, in part due to the fact that much of the tailings is saturated and thus not available for oxidation

- There appears to be sufficient capacity within the underlying peat to attenuate all the zinc contained within the tailings (should it be released) by sorption alone. It is however, unlikely, that 100% of the zinc will be leached out of all the tailings

Potential for Increased Metal Loading due to Acid Generation

- The implications of the mineralogical findings for future contaminant loadings from the VTF as a whole are that widespread, highly acidic (pH<4) conditions are not expected to develop, and no significant remobilization of sorbed zinc is anticipated

- Current contaminant loadings can be considered to provide a good indication of the magnitude of future loadings

Technical Study

VALLEY TAILINGS REPROCESSING ASSESSMENT

Date

June 2009

Performed By

Elsa Reclamation Development Company

Introduction

Between 1920 and 1989, approximately 4.6 million tons of tailings were deposited in the Elsa Tailings Facility in the upper Flat Creek valley, encompassing an area of roughly 130ha. Under final closure of the tailings, consolidation and movement are likely to be carried out to some degree. As such, investigating a reprocessing scenario associated with final closure is logical and prudent in that it offers the potential to offset closure costs and create a reduced footprint for final covering.

Objective

To offer a scoping level assessment of the potential economics of reprocessing silver from the Elsa Valley Tailings using conventional techniques.

Facts\Description of Study

- Previous assessments were studied in detail to extract historical information about the original placement of the tailings and their estimated volume and grade. This information was used for comparison to the recent work that has been carried out at the Valley Tailings with respect to the economic potential of the tailings.
- As a part of the Valley Tailings Closure Study (see following study), 19 test pits were excavated throughout the Valley Tailings in 2007 to collect geochemical information.
- The results of investigating historical work were compared with and combined with the results of the recent work done by SRK in 2007 and equivocated to produce a reasonable assessment of the economics of reprocessing the Valley Tailings.

Results/Conclusions

- Results of the recent work carried out in 2007 confirm the findings of previous studies.
- Reprocessing the Valley Tailings is an economically feasible option.
- There is a significant quantity of silver in the tailings, with the addition of an appreciable amount of manganese and gold.

Deliverables

Technical Study

VALLEY TAILINGS CLOSURE OPTIONS

Date

June 2009

Performed By

SRK Consulting

Introduction

Elsa Reclamation and Development Company Ltd. (ERDC) is in the process of preparing a closure plan for the various components of the former United Keno Hill Mine (UKHM) property in the Yukon. In 2007/08 SRK reviewed the geochemical stability, local hydrogeological and geotechnical conditions of the Valley Tailings Facility (VTF) as part of the closure studies (SRK 2008a, 2008b, 2009a). The results of these investigations showed the main issues that require consideration in selection of a closure option for the VTF are:

- Prevention of wind dispersion of tailings and erosion of tailings by surface runoff; and
- Management of surface water through and/or around the VTF

Objective

The objective of this study is to conduct and use a closure options analysis to support the selection of the preferred closure option for the VTF

Facts\Description of Study

The following areas were investigated here through previous studies to determine closure options that would be best suited to the VTF:

- The quantities and volumes were estimated used for costing of closure options were estimated based on the results of prior field investigations by Alexco, BGC, and SRK.
- The results from the SRK's previous field investigations were combined with Alexco's Soils Characterization and Drilling Report to develop a computer generated model in GEMS© that was used to estimate the volume of cover material within the Potential Borrow Area.
- Addition of lime during tailings relocation is an appropriate way to minimize short term metal release from existing pore water and stored salts. Testing was conducted to develop site specific lime demands for the VTF tailings as a part of the 2008 VTF site investigation.

Results/Conclusions

Two broad options that meet the requirements for closure of the VTF have been identified. The first option (Option 1) consists of leaving the tailings in place and constructing a soil cover over the tailings. There are two variants, to Option 1 that define how surface water in and around the VTF will be

managed. The second option (Option 2) consists of relocating the older thin tailings located behind Dams #2 and #3 as well as along the south east quadrant of the VTF to behind Dam #1.

Option 1A: Cover in Place

Option 1B: Cover in Place with Spillway

Option 2: Partial Relocation

Deliverables

Final Report: 2009 Valley Tailings Facility Closure Options

WASTE ROCK STUDIES

Technical Study:

WASTE ROCK GEOTECHNICAL CLOSURE STUDY

Date: October 2007

Performed By:

SRK Consulting

Introduction

The summary outlines the section of the geotechnical closure studies conducted by SRK that pertains to the waste rock dumps at the property.

Objectives

To develop an understanding of the foundation conditions under VTF Dams #1, #2 and #3 for use in determining the long-term dam stability. Monitor physical hydrogeology, geochemistry and temperature at a number of common locations along the dams.

To develop an understanding of the current conditions at selected waste rock piles so that closure measures can be developed on a pile-by-pile basis. Assess the geotechnical suitability and realistic reclamation outcomes for the re-sloped footprint of select piles.

Facts\Description of Study:

- A field study was conducted at the VTA to help assess the first objective:
    a. Six boreholes were drilled at the crests of Dams #1, #2 and #3 to log soil stratigraphy, depth to bedrock, geotechnical conditions and permafrost extent and monitor groundwater flow and thermal regime
    b. Boreholes were drilled within the tailings impoundments behind Dams #1 and #3 to determine the extent of tailings, overburden, permafrost, bedrock depth and lithology, to collect soils for soils characterization, and to monitor water levels and groundwater chemistry
    c. Other boreholes were completed to monitor water chemistry and levels, background characteristics, and groundwater down gradient of the VTF
- Additional information on dam performance was gathered from the following information repositories:
    a. 2007 seismic hazard calculation
    b. 2007 VTA dam classification
    c. Review of historical records

d. 1996 flood frequency analysis

e. Review of the stability analysis completed by EBA in 1982

- Waste rock sites were inspected and assessed via the following:

a. A review of the historical stability of the waste rock piles

b. Water management considerations, including assessment of running surface waters that could pose a risk of future undercutting and instability

c. An assessment of the state of deterioration of wooden support structures

d. Resloping considerations

Information Gaps:

A desktop study to evaluate the stability of selected crown pillars was to be conducted based on a review of operational records of the shallow stopes at the major mines. However, the records consist of a digital library of tens of thousands of unsorted data files which through considerable effort was not able to produce more information on crown pillar stability.

Results/Conclusions:

Valley Tailings Foundation Conditions

- The VTF dams are currently under static loading conditions, but it is unclear whether their respective safety factors meet appropriate values for closure
- The parameters used in the stability analysis completed for static loading conditions in 1982 are believed to be reasonable and can be used in future analysis to assess their current and post-closure stability
- These same parameters, coupled with the recent seismic hazard information, can be used for pseudo-static analyses to evaluate the stability of the dams under seismic loading assuming that the foundation layers will not liquefy
- At some point prior to final closure design, the assumption that the foundation stratum immediately below the peat at each of the permanently installed dams will not liquefy in response to the design earthquake should be checked with a geotechnical drilling program that will obtain suitable relative density data using Standard Percussion Tests or other suitable methods

Waste Rock Pile Closure Options

- A decision matrix has been developed for Keno Hill waste rock piles to provide a framework for stakeholders to assess the requirements for closure (Table 3)
- Waste rock closure options are currently in the process of being established; for most waste rock dumps this will mean resloping either with or without vegetative cover

- Also included in the example decision matrix are a number of considerations for implementation of a closure measure for a given waste rock pile. For example, one closure option might be to reslope the waste rock 2.5H:1V. A consideration in this case might be the additional land that would be covered during the resloping exercise. Stakeholders may wish to consider weighing the benefits of resloping against covering the additional footprint area with waste rock

Table 4 Example decision matrix to be used for review of conceptual closure options for waste rock piles
Keno Hill Closure Planning
Rev. 00, March 2008

			Waste Rock Dump Closure Requirements				Considerations for implementation									Waste Rock Dump Closure Options					
																1. Reslope 2.5:1, revegetate	2. Reslope 2.5:1, growth media, revegetate	3. Reslope 2.5:1, soil cover, revegetate	4. Relocate	5. Reprocess high grade waste dumps	6. Do nothing
Waste Rock Dump	Size Category[1]	Tonnage[2]	Ensure geotechnical stability	Reduce chemical loading	Revegetate	Esthetic improvement	Water course near toe	Adit discharging	Steep dump face angle	Can dump be used for borrow source?	Steep slopes below dump (<3H:1V)	Status of adjacent vegetation	Adjacent surface materials similar to coarse waste rock	Value of area to be covered by resloping	Increase in load due to disturbance, or to increased surface area	Suitable for dumps without ARD concerns and sufficient fines to promote revegetation without additional growth media	Suitable for dumps with no compelling ARD concerns	Suitable for dumps that have ARD concern that require reduction or mitigation of metals load		Potential option that can be incorporated into remaining scenario, very specific to only 1 or 2 dumps, may not carry forward into options analysis	
Bermingham pit dumps	A	1,500,000																			
Calumet 1-15 pit (2 dumps)	A	1,000,000							X		X		X								
Onek	A	600,000							X		X (SE only)										
Sime dumps	A	450,000									X		X								
Black Cap	A	390,000	X						X		X		X								
Hector 400 adit dump	A	198,000	X						X		X		X		X						
Galkeno 100/200/300	A	150,000	X					X													
No Cash 500	A	138,100	X				X	X	X					Creek							
Silver King pit dump	A	120,000																			
Hector #1 Vein Pit	A	100,000	X						X		X		X								
Stone (3 piles)	B	84,540																			
Coral & Wigwam	B	75,000											X								
Miller	B	63,000											X								
Lucky Queen 500 adit dump	B	61,900																			
Bellekeno 625	B	48,000	X (erosion)				X	X						Creek							
Elsa 400	B	44,100																			
Silver King 100 adit	B	43,000	X (erosion)				X	X						Creek							
Ruby	B	28,900						X													
Keno 700	B	27,500	X (erosion)				X	X	X					Creek							
Calumet C-Structure	B	25,000																			
Sadie Ladue (Wernecke)	B	24,500																			
Galkeno 900	B	20,800						X													
Dixie	B	19,800																			
Husky SW	B	17,000																			
Shamrock King	B	16,200											X								
Highlander	B	15,000					X	X													
Keno 200	B	14,600											X								
Townsite	B	14,300											X								
Bellekeno 200	B	13,000																			
Gerlitski	B	10,281																			
Hector 4-11 pits	B	10,000											X								
Sadie Ladue 600	C	9,500	X (erosion)					X													
Shamrock	C	9,000	X (erosion)						X				X								
Onek 400 adit dump	C	7,500	X (erosion)					X													
Bermingham adit dump	C	7,000						X	X												
No Cash 100	C	6,500																			
Elsa 200	C	6,000																			
Lucky Queen shaft area	C	5,000											X								
Husky	C	4,600																			
Porcupine Pit Dump	C	3,400											X								
UN adit dump	C	3,200																			
Comstock 150	C	3,100											X								
Comstock 275	C	3,100											X								
Lake	C	2,550																			
Bellekeno 100 (48 Vein)	C	2,450																			
Klondike Keno	C	2,000						X													
Elsa +50	C	1,550																			
Cub & Bunny (pit dump)	C	1,350																			
Flame & Moth	C	small- est. >1000 t																			
Bellekeno 100 (50 Vein)	D	500																			
Monument & Ladue Fraction adit	D	500											X								
Nabob No. 2	D	480											X								
Gold Hill No. 2	D	100 t + trenching											X								
Keno No. 9 System	D	Many small piles											X								
Apex	D	trenching																			
Divide	D	trenching																			
Fox	D	trenching																			
Lake View	D	trenching											X								
Nabob	D	trenching											X								
Silver Basin	D	trenching											X								
Betty	D	none											X								
Christal (Dorothy)	D	minimal																			
Duncan Creek	D	none																			
Blue Bird	D	minimal																			
Croesus No. 1	D	minimal																			
Kijo	D	minimal																			
Rico	D	minimal																			
Shepherd	D	minimal																			
Tin Can	D	minimal																			

Notes
1. Size Category: A= >100,000 tonnes; B= 10,000 to 100,000 tonnes; C= 1,000 to 10,000 tonnes; D= <1000 tonnes
2. Tonnage- short tons (Source: Primary 1996 SCR, secondary PWGSC 2000 and estimates from SRK inspections)

Technical Study:

WASTE ROCK GEOCHEMICAL ASSESSMENT

Date: October 2007 – February 2009

Performed By:

ERDC/SRK

Objective:

To characterize and assess long term geochemical stability of various waste rock piles.

Facts\Description of Study:

- Samples were collected as part of the baseline environmental assessment conducted in 1996; however, the samples were not analyzed at that time due to financial difficulties. The samples were revisited in 2007 and those deemed intact and uncompromised were sent to the lab for analytical testing
- To identify and site considerations that required consideration for each dump, a matrix was developed that consisted of the categorized dumps (by size), a suite of closure considerations, and various candidate closure options
- Acid Base Accounting (ABA) testing (total sulphur, sulphate sulphur, by both NaCL and NaCO3 leach, inorganic carbon, and Sobek NP) and elemental analysis (four acid digestion with ICP-AES finish) were carried out on the samples
- A toe seep survey was carried out
- Results from the extraction tests were used to develop reasonable worst-case estimates of current chemical loading from individual waste rock piles. Worst-case loading estimates were then compared to known load sources to evaluate whether loading from waste rock piles is likely to be significant at district scale

Results/Conclusions:

- All leach extraction tests demonstrated that the various dumps contained a store of soluble oxidation products. Any dump disturbance (e.g. for resloping or relocation purposes) will lead to a short-term increase in loading from the disturbed material. Column test results from 1996 showed and initial zinc release exceeding steady-state release by 14 to 300 times – these results provide an indication of the increases in short term loads that might be expected immediately following disturbance of waste rock
- Results from the shake flask extraction work indicated that the largest waste rock load is likely to be generated by the Hector Adit dump. Scoping calculations carried out to provide an indication of porewater chemistry indicated that zinc concentrations could be on the order of a few hundred

mg/L. For comparison, the porewater zinc concentrations suggested by the scoping calculations are of the same magnitude as concentrations observed in the Galkeno 300 adit discharge.

- The Hector Adit dump is several kilometers from the nearest downgradient receiving water (as is the case for most other dumps in the district). Based on the modest chemical loadings from the waste rock dumps relative to other sources in the district, and based on the length and attenuating nature of the downgradient flowpath to the receiving environment, it is unlikely that contaminants from the waste rock dumps pose a significant risk to water quality in the receiving streams that are the focus of reclamation across the former UKHM site.

Technical Study:

ALTRUA WASTE ROCK GEOCHEMICAL ANALYSIS

Date:

January 2008

Performed By:

Altrua Environmental Consulting

Introduction

Review static test data of 1996 Keno Hill site-wide waste rock characterization sampling that were analyzed in 2006 for standard ICP multi-elements, acid base accounting, and leachate extraction.

Objective:

Objective is to identify any geochemical parameters that are controlling or are strongly correlated with generation of net acidity and/or Zn or Pb leaching. This purpose of this review is to provide a tool to assist in prediction of ARD/ML in any future development in the Keno Hill area, and to provide a basis for field classification of potentially reactive material during excavation.

Facts\Description of Study:

This review consisted of four phases:

- Conduct general review of data and generate of statistical summaries;
- Identify reactive samples in dataset;
- Analyze data for trends and database criteria that appear to control or correlate strongly with
- Sample reactivity, and that can be used to isolate reactive samples; and
- Check of criteria against the database to determine over or under-filtering

Results/Conclusions:

- In the 47-sample leachate extraction database examined, net acidic samples are defined as those yielding a leachate pH $\leq$5.5. Metal leaching samples are defined as those with Zn loading $\geq$10 mg/kg, and/or Pb loading $\geq$3 mg/kg. Any sample meeting at least one of these three conditions is defined as “reactive”.
- As observed in section 7 of the 1996 Characterization Study, it is important to note that most samples were taken from adit dump waste rock pile samples, and thus tend to be comprised of material in close proximity to mineralization. Samples from open pit waste piles, comprised of a greater amount of rock further from the vein systems, are less sulphidic and show less evidence of acidity and metal solubilization.

- Of the 47 samples, 17 (36%) meet one or more of the "reactive" criteria, with 6 of the 17 being net acidic, 13 zinc-leaching, and 8 lead-leaching. The quartzite units sampled showed the highest proportion of reactive samples (46%), followed by mixed quartzite and schist (40%), and vein (25%). Pit wall samples appear to store less soluble products, (none of the pit wall samples were reactive), likely a function of the more exposed environment relative to a waste rock dump with limited infiltration and transport of solutes.

- An average of 40% of sulphur is in the soluble form of sulphate, as indicated by an average SO4: Total S ratio of 0.4 for the 47 samples. Other elements with elevated soluble fraction are Ca, Co, Cd, Mn, and Zn (averaging 11%, 11%, 9%, 6% and 5% respectively).

- Various geochemical parameters were evaluated to identify a simple filter to best isolate the reactive samples from the non-reactive samples, using information normally available in an exploration database (eg. lithology, ICP analyses, simple field tests). While priority was given to ensuring complete isolation of the net acidic samples, it was considered that minor under-filtering of metalleaching would not be detrimental to overall drainage quality of a waste rock storage area. After several trials, the following filter criteria were identified to discriminate reactive samples in the 47- sample database:

    1. S_{via} ICP $\geq$ 0.25% and Ca $\leq$ 0.51%; or
    2. Pb $\geq$ 5000ppm; or
    3. Zn $\geq$ 5000ppm.

- When these criteria are applied to the 47-sample database, 16 of the 17 reactive samples are isolated, along with 4 non-reactive samples. 100% of the net acidic samples, 92% of the zinc-leaching samples, and 100% of the lead-leaching samples are isolated. On the other hand, 13% of the samples isolated using these criteria were actually non-reactive in the leachate extraction test, indicating that some potential 'dilution' by non- ARD/ML waste rock is possible if using this filter for waste rock classification.

- Similar results are obtained when substituting a Fizz Rating of <3 in place of ICP Calcium $\leq$ 0.51% – the reactive samples are filtered identically, however 'dilution' by non-reactive samples increases to 20%. Nonetheless, these results indicate Fizz Rating to be a potential screening parameter, which is of interest as a field screening tool for segregating rock during active mining.

UNDERGROUND MINE AND ADIT STUDIES

Technical Study:

ADIT CLOSURE STUDIES

Date: Summer 2007

Performed By:

SRK Consulting

Objective:

Build on existing risk rankings for adits and move towards a specific closure measure for each adit, in consideration of the broad range of adit conditions that exists at the site.

Facts\Description of Study:

- Each of the 70 adits at Keno Hill will require a site-specific closure measure
- Restricting public access is a requirement for all adits. Certain adits will require long-term drainage control with restricted public access, yet allow operational access. Other adits are fully collapsed and require no additional work.
- For adits which produce water, water control issues must be addressed. Where water is acceptable for direct discharge, the closure measure must allow free drainage while preventing public access. Where water requires treatment, an additional consideration of how to collect and treat the water is necessary.
- Adit closure designs fall into four categories: plugs, seals, barriers and natural collapses
- Adit plugs fill a portion of the mine shaft and are designed as permanent structures. They can be used where preventing access, controlling adit discharge, or minimizing brow collapse is necessary.
- Adit seals are any closure measure where the sole purpose is to prevent access. If rehabilitation of the adit is required later, costs can become expensive. They are not intended to control drainage, but allow free drainage.
- Adit barriers are a closure method which prevents inadvertent access by the public (such as grates or gates). They are not intended to control drainage, but allow free drainage.
- Natural collapses are where sufficient adit collapse has already produced a situation where little safety risk remains. These can be grouped into ‘do nothing’ closures, and ‘do nothing now and inspect later’ closures.

Information Gaps:

Once adit closure measures have been considered and selected, further modifications will need to be made on a site-by-site basis for the design to be implemented under different conditions.

Water treatment sites are in the process of being assessed to determine water management closure options, at which point an appropriate closure option will be selected.

Results/Conclusions:

- SRK has developed an adit closure matrix for the 70 adits at Keno Hill. Closure requirements for each adit in this study are outlined in this matrix, presented in Table 4, alongside the recommended closure option for that site.

Table 1 Decision Matrix For Selection Of Adit Closure Measures
Keno Hill Closure Planning
Rev. 00, March 31 2008

				Adit Closure Requirements						**Considerations for implementation**					**Adit Closure Options**									
				Adit closure requirements capture the specific closure objectives for each adit. 'Control public access' is the default minimum requirement identified for all sites, including those where public access is prevented at present by the fully collapsed condition of the adit.						*Considerations for implementation are intended to record specific site features or elements that need to be incorporated into the selection of a closure option for each adit.*					**1. Plugs (control water)**			**2. Seals (drain freely, prevent access)**				**3. Barriers (secure adit, allow authorized access)**			**4. Do nothing**	
Mine	**Adit**	**EASTING (UTM NAD 83)**	**NORTHING (UTM NAD 83)**	Prevent public access	Allow free drainage	Control contaminated water	Control ice plugging	Control air flow	Historical considerations	Removal of Structures	Upgrade/ development of access required for equipment	2008 Inspection Required	Water management decision required	Requirement for long term supply of electricity	1a. Bulkhead	1b. Poured massive concrete plug	1c. Composite Soil Plug (aka Millenium Plug)	2a. Masonry Wall	2b. Polyurethane membrane	2c. Rock fill	2d. Rock pile	3a. Steel grate	3b. Steel grate with masonry frame	3c. Insulated steel doors with masonry frame	4a. No further inspection required	4b. Inspect periodically
Silver King	50 East	471913	7085390	X						?	X	X														Recommended
	50 West	471930	7085397	X						?	X	X														Recommended
	75	471902	7085448	X					X		X								Alternate				Alternate			Recommended
	100	471894	7085683	X		X				X			X	X	Subject to water management decision											
Elsa	+50	476462	7087122	X																					Recommended	
	50	476295	7087026	X																					Recommended	
	Gravel	476361	7087088	X																					Recommended	
	100	476302	7087070	X																					Recommended	
	200	476207	7087107	X						X	X									Alternate	Recommended					
	400	475940	7087109	X	?	?	X			X				?						Alternate	Recommended					
No Cash	100	478735	7088249	X						X	X									Alternate	Recommended					
	500	477766	7088469	X		X				X	X		X	?	Subject to water management decision											
Dixie	200	476921	7087409	X	?		X			X										Alternate	Recommended					
Ruby	400	478522	7087681	X	X	?	X			X										Alternate	Recommended					
Bermingham	200	478682	7087211	X	X	?	?			?										Alternate	Recommended					
Townsite	500	479535	7087969	X																	Recommended					
Hector	400	480069	7088176	X					X													Barrier recommended subject to historical considerations				
UN		481538	7089358	X	?		?														Recommended					
Galkeno	Unnamed	482019	7088898	X																	Alternate				Recommended	
	100	482022	7088988	X																	Recommended					Alternate
	200	482164	7089062	X																	Recommended					Alternate
	300	482593	7088740	X		X				X			X	X	Subject to water management decision											
	900	483420	7087919	X		X				X			X	X	Subject to water management decision											
Viola		482506	7088134	X						?	?	X													Recommended	
Rico		483171	7088044	X																					Recommended	
Bellekeno	100- 48 Vein	486969	7086702	X						?	X	X									Recommended					
	100- 50 Vein	487064	7086679	X						?	X	X									Recommended					
	200	487017	7086770	X						X											Recommended					
	625	487350	7086990	X		X				X			X	X	Subject to water management decision											
	Mayo Mines	487125	7086914	X																	Alternate				Recommended	
	Eureka	487191	7086212	X																	Alternate					Recommended
Onek	400	485207	7087326	X		?	X			X	X		X	?	Subject to water management decision											
Sadie Ladue	600	485996	7092671	X		?					X		X		Subject to water management decision											
Lake		487302	7092905	X							X														Recommended	
Stone	Upper adit	488718	7092560	X							X														Recommended	
	Middle adit	488825	7092633	X						X	X														Recommended	Alternate
	Lower adit	488929	7092724	X							X														Recommended	
Highlander	Main Adit	487937	7092203	X	X				X	X	X														Recommended	Alternate
	Upper Adit 1	487844	7092105	X							X														Recommended	
	Upper Adit 2	487844	7092105	X							X														Recommended	
	Upper Adit 3	487830	7092119	X							X														Recommended	
Klondike Keno	Lower adit	485597	7090841	X	X					X	X										Alternate				Recommended	
	Upper adit	485599	7090854	X							X														Recommended	
Lucky Queen	500	486646	7090562	X	X					X											Recommended					
Black Cap		486884	7090560	X	X																Recommended				Alternate	
Brewis Red Lake (aka Shepherd Adit)		486731	7090393	X																					Recommended	
Croesus	Adit #1	486614	7089660	X							X														Recommended	
	Adit #2	486611	7089617	X							X														Recommended	
	Adit #3	486602	7089570	X							X														Recommended	
	Adit #4	486602	7089539	X							X														Recommended	
Kijo	Upper adit	486103	7089785	X							X														Recommended	
	Middle adit	486100	7086775	X							X														Recommended	
	Lower adit	486093	7089758	X							X														Recommended	
Shamrock	60	488110	7090690	X						?	X														Recommended	
	200	488132	7090646	X						X	X										Recommended					Alternate
	Lower (Adit B)	487920	7090577	X						?	X														Recommended	
Monument and Ladue Fraction		491064	7091110	X							X														Recommended	Alternate
Keno #9	Faro Gulch 100 (aka N	489572	7090659	X						?	X	X													Recommended	
	Faro Gulch Portal (200 level)	489728	7090744	X						?	X	X														Recommended
	Keno 200	489491	7089993	X						X											Recommended					
	Keno 700	489977	7089610	X	X	?	X		X	X			X		Subject to water management decision											
	12 Vein Adit	489877	7090733	X						?	X														Recommended	Alternate
	Lower No. 4 Vein Adit	489253	7090254	X							X														Recommended	
	Upper No. 4 Vein Adit	489266	7090290	X							X														Recommended	
	5-2 Vein Adit	489167	7090202	X							X														Recommended	
	No. 1 Vein Adit	489508	7090665	X						?	X	X													Recommended	Alternate
	No. 3 Vein Adit	489538	7090710	X						?	X	X													Recommended	Alternate
Comstock Keno	150	490014	7090123	X						X											Recommended					
	275	489939	7090056	X						X											Recommended					
	Porcupine 50	489705	7089944	X						X											Recommended				Alternate	

Technical Study:

MINE HYDROGEOLOGICAL MODEL

Date: 2007 –

Performed By:

ERDC

Objective:

To prepare a hydrogeological model for the mine site in an effort to better understand the potential future changes in mine water discharge points, quantities and quality, such as occurred at the Galkeno 300 adit in 1997. It will aim to understand the interconnectedness of the mine workings including underground workings, veins, faults, surface topography and likely flow pathways.

To prepare a geometric model of the mine workings to cover areas of environmental interest.

Facts\Description of Study:

- Models of the Silver King, Husky, Galkeno and Bellekeno mine workings with partial surfaces were produced.
- The 3-dimensional surfaces of the models were created using the 2-metre digital elevation model generated from aerial photography flown in 2006.
- These models are initial and intended for demonstrative purposes only.
- Updating of the models is ongoing. Engineering plans and sections are being digitized along with survey data to increase the accuracy of the models.

Results/Conclusions:

- Although the models are preliminary in nature, they are illustrative in terms of the relationship between various underground mine components

REVEGETATION AND TERRESTRIAL STUDIES

Technical Study:

TERRESTRIAL EFFECTS ASSESSMENT (PHASES I, II AND III)

Date: September 2007 – March 2008

Performed By:

EDI Environmental Dynamics Inc.

Objective

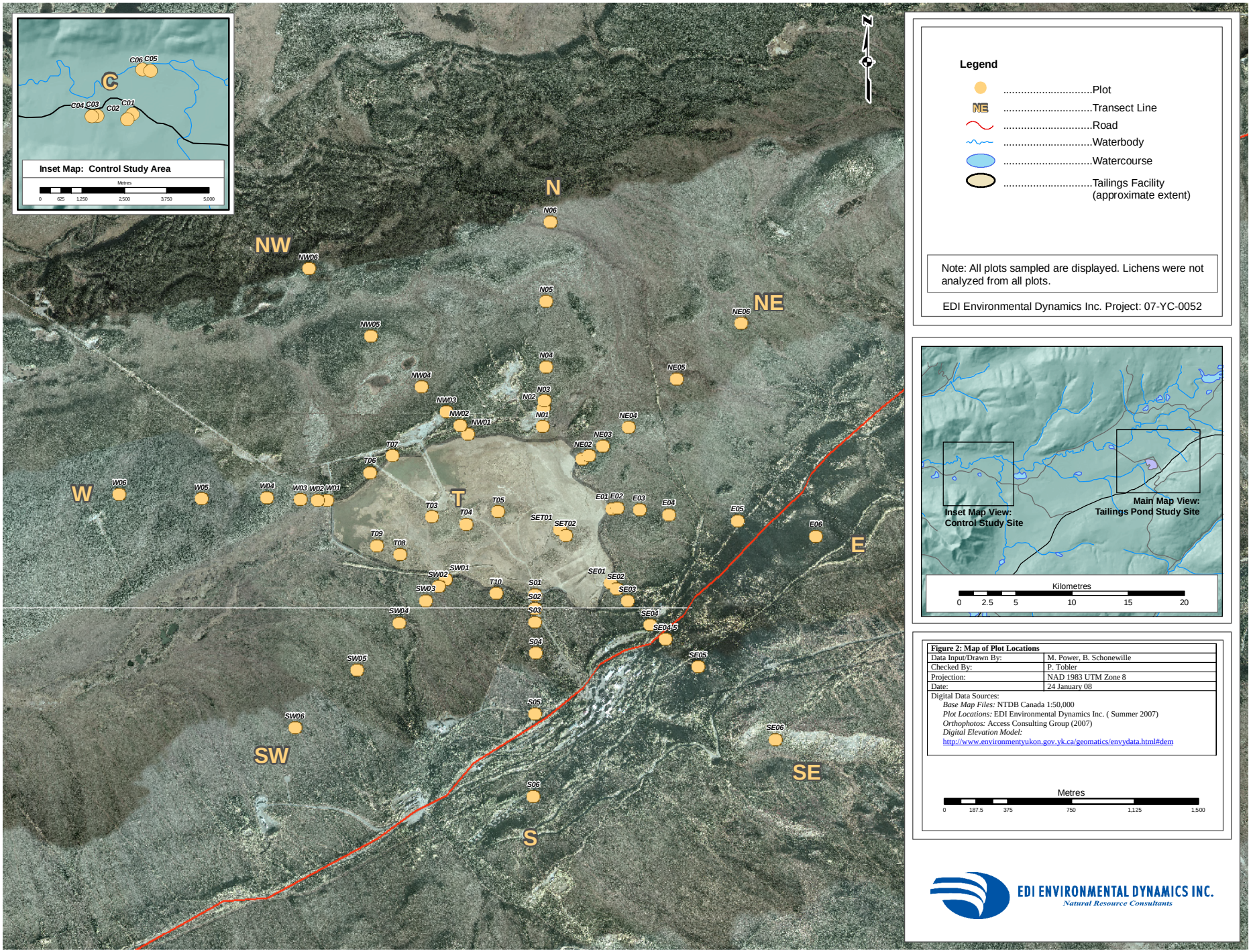
To determine if aerial dispersion of metals has occurred and, if so, determine the extent of such dispersion into the natural terrestrial ecosystem surrounding the Valley Tailings Facilities.

Facts\Description of Study:

- The study focused on lichen as they receive most of their nutrients from air and rainfall, and thus are excellent indicators of airborne contamination
- Samples were collected along 8 transects radiating outwards in cardinal directions from the centre of the Valley Tailings. Plots were established along the transects for sampling at increasing distances from the first plot (Figure 4)
- Results were analyzed to determine if metals levels were elevated compared to Yukon background data and to control site data, and if so, the magnitude and spatial extent of the contamination
- Analysis also included a review of the comparability of the two lichen species collected

Results/Conclusions:

- There is indication of contamination of metals (As, Cd, Ag, Zn) immediately around the eastern 'dry' portion of the tailings facility (e.g. Figure 5), although to limited spatial extent, especially when compared to other Yukon sites
- The Valley Tailings may have the potential to continue to contribute metals to the surrounding terrestrial environment. To assess if this is the case, deployment of moss bags is recommended
- There may be a need to assess other components of the terrestrial ecosystem in the future



Legend

- Plot
- NE — Transect Line
- Road
- Waterbody
- Watercourse
- Tailings Facility (approximate extent)

Note: All plots sampled are displayed. Lichens were not analyzed from all plots.

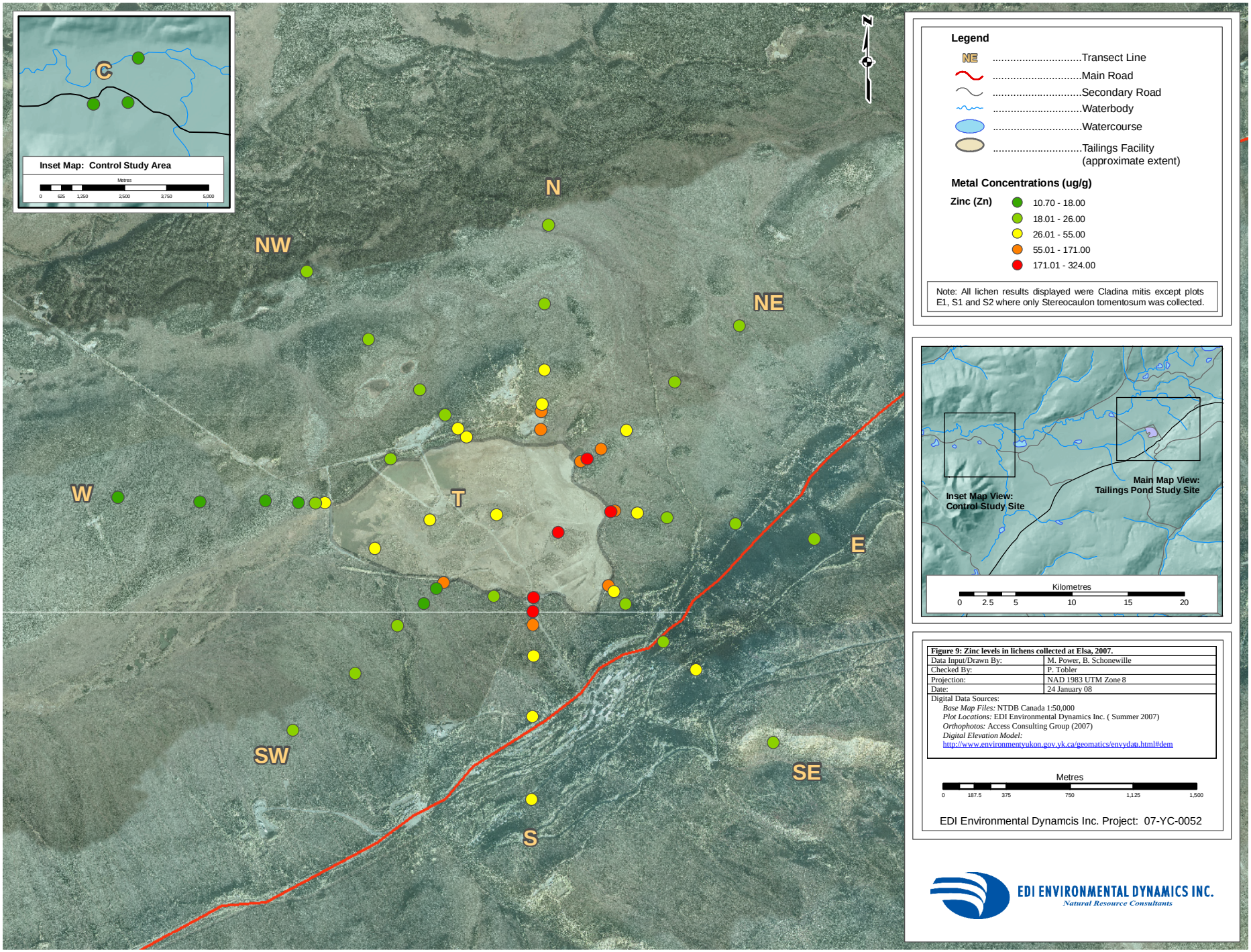
EDI Environmental Dynamics Inc. Project: 07-YC-0052

Figure 2: Map of Plot Locations	
Data Input/Drawn By:	M. Power, B. Schonewille
Checked By:	P. Tobler
Projection:	NAD 1983 UTM Zone 8
Date:	24 January 08

Digital Data Sources:
Base Map Files: NTDB Canada 1:50,000
Plot Locations: EDI Environmental Dynamics Inc. (Summer 2007)
Orthophotos: Access Consulting Group (2007)
Digital Elevation Model:
http://www.environmentyukon.gov.yk.ca/geomatics/envydata.html#dem

Metres
0 187.5 375 750 1,125 1,500

EDI ENVIRONMENTAL DYNAMICS INC.
Natural Resource Consultants



Legend

- NE ..... Transect Line
- ..... Main Road
- ..... Secondary Road
- ..... Waterbody
- ..... Watercourse
- ..... Tailings Facility (approximate extent)

Metal Concentrations (ug/g)

Zinc (Zn)

- 10.70 - 18.00
- 18.01 - 26.00
- 26.01 - 55.00
- 55.01 - 171.00
- 171.01 - 324.00

Note: All lichen results displayed were Cladina mitis except plots E1, S1 and S2 where only Stereocaulon tomentosum was collected.

Figure 9: Zinc levels in lichens collected at Elsa, 2007.	
Data Input/Drawn By:	M. Power, B. Schonewille
Checked By:	P. Tobler
Projection:	NAD 1983 UTM Zone 8
Date:	24 January 08

Digital Data Sources:

Base Map Files: NTDB Canada 1:50,000
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Metres
0 187.5 375 750 1,125 1,500

EDI Environmental Dynamcis Inc. Project: 07-YC-0052

EDI ENVIRONMENTAL DYNAMICS INC.
Natural Resource Consultants

Technical Study:

VALLEY TAILINGS REVEGETATION ASSESSMENT

Date:

August 2007 – January 2008

Performed By:

S.P. Withers

Introduction

Objective

To facilitate future revegetation efforts at the Valley Tailings Area of the former Keno Hill mine site

Facts\Description of Study:

- Archived reports on earlier tailings revegetation trials were reviewed
- An inventory of the state of natural revegetation occurring on the mill tailings was carried out and the vegetation types were delineated on a current aerial photograph

Results/Conclusions:

- Some notable conclusions were reached during revegetation tests carried out between 1976 and 1984

    a. The principal contributor to the inhibition of long-term plant growth on much of the tailings is the impenetrable surface that occurs when salts, primarily zinc sulphate, migrate upward through the tailings slimes

    b. The slightly acidic nature of the tailings (pH 6 – 7) produces a top layer of soil with pH between 6.7 – 6.8, which is near enough to neutral to not significantly impede plant growth

    c. Phytotoxic concentrations of Cd, Pb, Zn, Cu and Mn are found in the rooting zones of most soils on the unvegetated portion of the tailings impoundment; the high levels of extractable ions appear to be a significant impediment to the establishment of vegetation on these areas

    d. Plant development on the metalliferous tailings is restricted by very low levels of macronutrients (nitrogen, phosphorous and potassium) and high concentrations of phytotoxic metals; as such, repetitive application of nitrogen fertilizers and phosphorous is required for plant growth

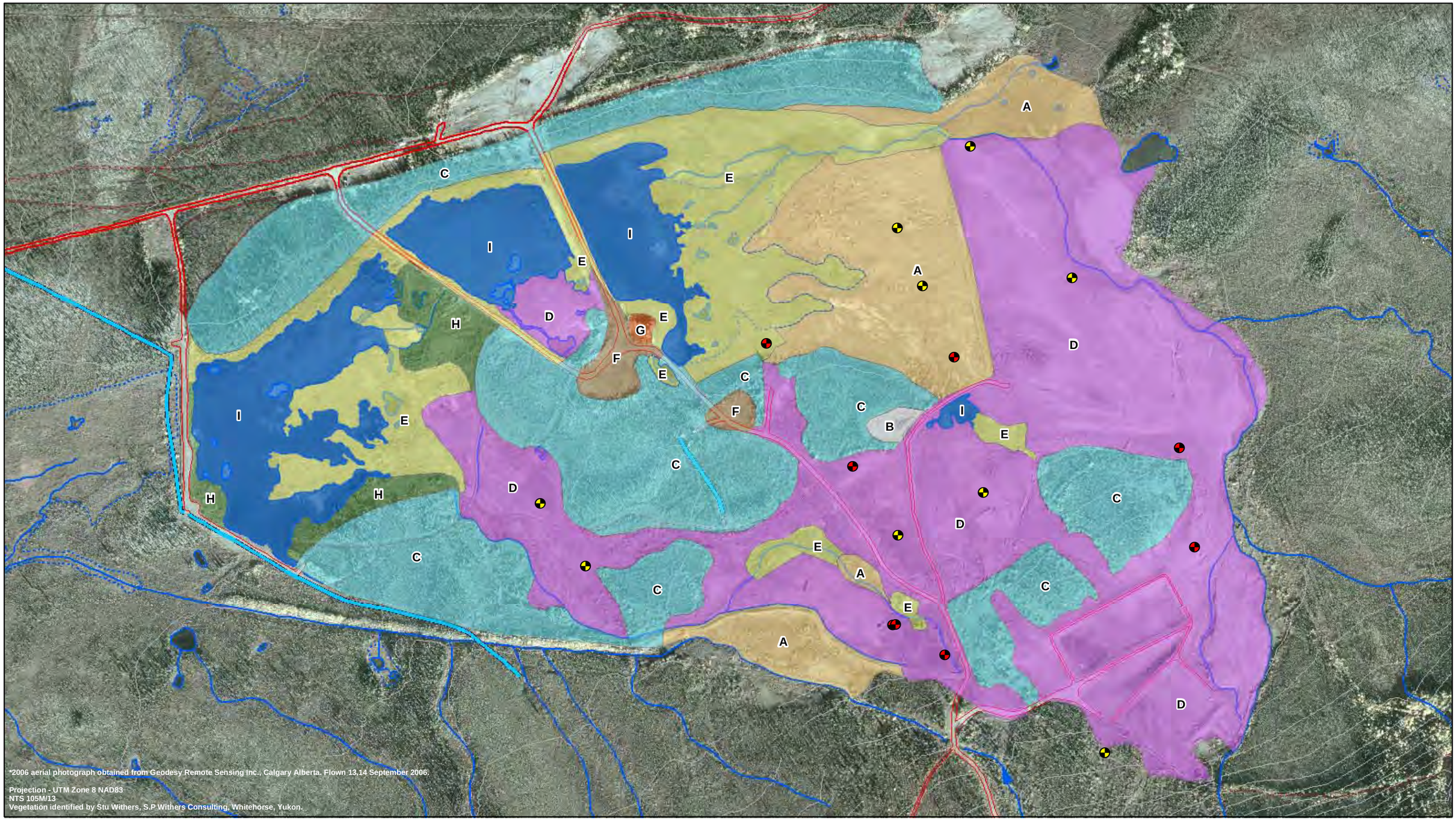
- The vegetation types observed in the valley tailings during the 2007 assessment are primarily locally occurring indigenous species that have naturally colonized the tailings. Their type and extent is illustrated in Figure 6

- There are large sections of barren ground in the tailings area; to resume efforts to vegetate these areas, the following are recommended:

    a. Soil samples were collected from nine test pits on the valley tailings impoundment in 2007, and in order to help characterize the current state of the impounded tailings, should be analyzed for texture, total metals, extractable ions, organic content, available nutrients, cation exchange capacity, carbon-nitrogen ratio and pH

    b. A field survey of the unvegetated area of the tailings should include a series of transects with in-situ measurements of soil pH and moisture content and an examination of soil permeability

    c. Experimentation with soil caps should be conducted



N

DRAFT

0 50 100 200 300 m

Legend

- Test Pit Est 1995
- Test Pit Est 2007
- Public Road
- Exploration Roads
- Trails
- Cutlines
- Contours
- Water Course (actual and potential)
- Swampy area
- Pipe

Valley Tailings Vegetation Type

- A - Willow Regeneration
- B - Bluejoint Meadow
- C - Undisturbed Closed Black Spruce
- D - Barren
- E - Water Sedge
- F - Balsam Poplar Regeneration
- G - Undisturbed Open Black Spruce
- H - Water Horsetail
- I - Water

ALEXCO RESOURCE CORP.

VALLEY TAILINGS VEGETATION STUDY

VALLEY TAILINGS VEGETATION TYPES

Drawn By: HD	Date: December 2007	**FIGURE**
Checked by: DC/SW	File: D:\Projects\AllProjects\ALEX-05-01\gis\mxd\UKHM\VegetationStudies\ValleyTailings\Veg2007\ValleyTailingsVeg.mxd	

Technical Study:

REVEGETATION TRIALS – GALENA HILL WASTE ROCK DUMPS

Date:

July 2007 – January 2008

Performed By:

S.P. Withers

Objective

To establish effective measures for revegetating the discontinued waste rock dumps in the Elsa area

Facts\Description of Study:

- Three revegetation test sites were established on Galena Hill including two waste rock dumps and one control site
- The sites' physical characteristics were assessed prior to the test plots
- The sites were recontoured and seed and fertilizer were added

Results/Conclusions:

- The level of available nitrogen and potassium was low at the waste rock dump sites
- Available phosphorous was moderate at the Simes dump and low at the Hector dump
- A visual examination of the test plots should take place in mid-summer 2008, including an assessment of soil erosion
- Soil and vegetation samples should be taken from the test plots and analyzed for metal concentrations; soil should be texture classified and analyzed for available nutrients, pH, cation exchange capacity, carbon-nitrogen ratio and the percent of organic matter
- More fertilizer should be added in the fall 2008

GENERAL STUDIES

Technical Study:

AERIAL PHOTOGRAPHY AND ORTHOPHOTO DEVELOPMENT

Date: 2006

Performed By:

Aero Geometrics Ltd.

Objective

To create new colour airphotos of the UKHM properties and prepare orthorectified images for closure planning and baseline environmental assessment purposes

Facts\Description of Study:

- Fly new 1:10 000 colour aerial photographs of the UKHM district
- Produce orthophotos from aerial stereopairs

Results/Conclusions:

- Site wide orthophotos were produced at 1: 10 000 scale. These form the base for site mapping of baseline environmental data.

Technical Study:

METEOROLOGICAL STATION PLANNING AND INSTALLATION

Date: Spring 2007 –

Performed By:

ACG

Objective

To install an automated meteorological station (measuring temperature, precipitation, solar radiation, wind speed and direction) and accompanying data logger on Galena Hill and tie station with existing YG snow course

Facts\Description of Study:

- ERDC purchased and installed an Onset HOBO Datalogging Weather Station on Galena Hill above the Hector Adit
- The station is equipped with the following sensors:
    a. Air temperature
    b. Relative humidity
    c. Barometric pressure
    d. Rainfall
    e. Wind speed and direction
    f. Solar radiation and,
    g. Soil temperature
- Sensors relay 15-minute average values to the logger, which records and stores readings every 15 minutes continuously
- Data is downloaded from the station monthly and is integrated into the Site Environmental Database for closure planning purposes

Results/Conclusions:

- Data is being collected on an ongoing basis for future assessment

SITE REMEDIATION

Technical Study:

PHYSICAL HAZARDS REDUCTION PROGRAM

Date:

September 2005 – Present

Performed By:

Access Consulting Group

Introduction

As a result of 75 years of mining in the Keno Hill District, the Keno Hill Property contains numerous health and safety hazards. Many of the hazardous sites are accessible to the public, and in some cases local literature even encourages tourists to visit these sites. As a result there is a high risk of human exposure to health and safety hazards such as open shafts and stopes, unstable pit walls, and open or partially accessible adits and buildings.

Since 2006, ERDC has been systematically working to remove these hazards in order to reduce the risk to public health and safety. Through a combination of review of documentation and local knowledge of the Property and consultation with stakeholders including INAC, GY Department of Heritage and the First Nation of Nä Cho N'yak Dun (FNNND), ERDC has been responsibly eliminating these hazards to protect the public.

The Physical Hazard Reduction Program is ongoing.

Objective

To identify, rank and mitigate the risks associated with each site observed and documented as hazardous.

Facts\Description of Study:

- The process by which sites are remediated is detailed in Figure 1.
- The first overall step in eliminating property hazards occurred in 2005-06, when SRK was contracted by ERDC to document baseline conditions and identify high risk sites to be remediated.
- Documented physical hazard information on the Keno Hill Property was reviewed to determine which sites required attention. The body of information included: PWGSC Environmental Baseline Assessment, the SRK Preliminary Baseline Assessment Report, the 2006 ERDC Physical Hazards Report and discussions with site caretakers and historic operators possessing historical knowledge of site operations.
- A register of physical hazards was developed and hazards were ranked according to their severity. This register is updated on an annual basis as sites are remediated.
- Work was begun in 2007 on sites which required the most immediate attention.

- Every season since 2007, additional hazards at Keno Hill have been reduced or mitigated through the Hazards reduction program. To date remediated sites and items include:
    - ✓ Coral and Wigwam
    - ✓ Dixie
    - ✓ Bermingham Adit and Ruby Shaft House
    - ✓ No Cash 100 Adit and Brefalt Shaft House
    - ✓ Hector-Calumet Pit
    - ✓ Onek, Lonestar and Fisher Shaft
    - ✓ Black Cap, Shepard and Lucky Queen Adits
    - ✓ Lucky Queen Shaft House
    - ✓ Lakeview Head Frame
    - ✓ Highlander Adit
    - ✓ Keno Mine Area on Keno Hill
    - ✓ Keno No. 9 System
    - ✓ Townsite Adit
    - ✓ Sadie Ladue
    - ✓ Wernecke Shaft
    - ✓ Wire Hazards
    - ✓ Keno 700 Area
- Prepare a final project report.

Results/Conclusions:

- The risk registry is included as Table 4. Mitigated and partially mitigated risks are noted in the table

Deliverables:

Risk Register and annual summary reports

Keno Hill Physical Hazard Risk Registery

Assigned Site No.	Site Name	Location Description	UTM Coordinates	Description of Existing Physical Hazards	Hazard Identified By	Consequence	Likelihood	Likelihood	Risk Rating		Mitigation Measures	Actions Complete
						Severity	Exposure	Probability	Numerical	Descriptive		
1	Silver King	Straddles the Silver Trail Highway at Galena Creek, approximately 4km southwest of Elsa town site	473050E, 7085275N	Open Pit has no barriers to prevent access; temporary barriers have fallen down.	SRK 2005 Site Inspection	Moderate	Remote	Unlikely	0.3	Moderate	The site is gated and locked, and is actively treated by Alexco employees.	✓
				Compressor building accessible to the public.	SRK 2005 Site Inspection	Low	Remote	Unlikely	0.03	Low		✓
2	Husky & Husky SW	12km west of Keno City on Silver Trail Highway, past the first turnoff for the Elsa townsite, downhill via an access road for 0.5km.	474740E, 708677N	Power pole and power line west of headframe.	SRK 2005 Site Inspection	Low	Remote	Unlikely	0.03	Low	Site is actively treated and thereby, continually monitored be Alexco employees.	✓
				Boiler House accessible.	PWGSC Baseline Assessment	Low	Remote	Unlikely	0.03	Low		✓
				Storage Shed accessible.	PWGSC Baseline Assessment	Low	Remote	Unlikely	0.03	Low		✓
				Workshop accessible.	PWGSC Baseline Assessment	Low	Remote	Unlikely	0.03	Low		✓
				Shaft House and Headframe were accessible at Husky SW.	PWGSC Baseline Assessment	Low	Remote	Unlikely	0.03	Low		✓
				Hoist House accessible.	PWGSC Baseline Assessment	Low	Remote	Unlikely	0.03	Low		✓
				ATCO Trailer accessible.	PWGSC Baseline Assessment	Low	Remote	Unlikely	0.03	Low		✓
3	Elsa	Located within the Elsa townsite on the north-facing slope of Galena Hill.	476000E, 7087000N	Powderhouse corner vent raise appears to be subsiding with a linear depression crossing Calumet Drive.	PWGSC Baseline Assessment	Moderate	Occasional	Possible	10	Moderate	The site is gated, and is continually monitored and used by Alexco employees.	✓
				Adit has an ice plug	ACG Site Characterization	Low	Remote	Unlikely	0.03	Low		✓
				Several buildings in various stages of repair may need to be either dismantled or entry adequately blocked to prevent entry.	PWGSC Baseline Assessment	Low	Remote	Unlikely	0.03	Low		✓
4	Dixie	3.6km along Calumet Drive from the junction with Wernecke Road.	477000E, 7087200N	Ditch running along side of Garage/Office building could be subject to erosion during peak flows, which could result in the structure collapsing; accessible.	PWGSC Baseline Assessment	Low	Occasional	Possible	1	Low		
				Shaft is partially collapsed and filled with water to a depth of approximately 3m below ground level.	PWGSC Baseline Assessment	Critical	Occasional	Possible	100	Extreme	Upon investigation, the remedial work necessary was too extensive for the 2007 season. Site will be planned in propective action.	✓
				Two collapsed raises show evidence of subsidence.	PWGSC Baseline Assessment	Critical	Occasional	Possible	100	Extreme	Investigated and deemed stable. However, a revisit in the summer of 2008 is suggested.	✓
				200 Level Adit is blocked with timber cribbing.	PWGSC Baseline Assessment	Low	Remote	Rare	0.01	Low	The entrance to this adit was sealed off with 25 cm wire mesh.	✓
5	Coral & Wigwam	Follow the Bermingham Road for 2.8km from the Hector Portal to a cat trail that leads northwest for 100m to site.	477900E, 7086250N	Two shafts present that are open and accessible.	PWGSC Baseline Assessment	Critical	Unusual	Possible	30	Extreme	Excavated all timber and debris from shafts and backfilled both sites.	✓

note:

cell pattern indicates site has been mitigated or partially mitigated.

Keno Hill Physical Hazard Risk Registery

Assigned Site No.	Site Name	Location Description	UTM Coordinates	Description of Existing Physical Hazards	Hazard Identified By	Consequence	Likelihood	Likelihood	Risk Rating		Mitigation Measures	Actions Complete
						Severity	Exposure	Probability	Numerical	Descriptive		
6	Bermingham & Ruby (Arctic & Mastiff)	Near the summit of Galena Hill, approximately 1.5km southwest of Calumet town site via the gravel road from Calumet.	474740E, 708677N	Ruby shaft area has collapsed on skip; area in front of shaft has failed also; shaft house accessible.	PWGSC Baseline Assessment	Critical	Occasional	Possible	100	Extreme	Excavated both shafts clean of timber, debris and backfilled with material from adjoining waste dump. Part of the shaft house was torn down and burned to access larger shaft. Note: larger shaft may need additional work as sinking may occur	✓
				One of the dumps is open without any berming.	SRK 2005 Site Inspection	Moderate	Occasional	Possible	10	Moderate		
				Ruby 400 Level adit accessible	ACG Site Characterization	Moderate	Occasional	Possible	10	Moderate		
				Bermingham 200 level Adit has collapsed somewhat but is still accessible.	PWGSC Baseline Assessment	Critical	Occasional	Possible	100	Extreme	Excavated duff, topsoil, timbers, and debris. Backfilled with large rock and topsoil and duff laid atop as cover.	✓
				Explosives magazine and Detonator House accessible.	PWGSC Baseline Assessment	Low	Occasional	Possible	1	Low		
				Water Shack accessible.	PWGSC Baseline Assessment	Low	Occasional	Possible	1	Low		
				Two residential buildings were considered unsafe, yet accessible.	PWGSC Baseline Assessment	Low	Occasional	Possible	1	Low		
7	No Cash	Located on the mid-northwest slope of Galena Hill via a road leading from the Elsa-Calumet road.	477230E, 7088058N	No Cash 100 Level Adit partially collapsed.	PWGSC Baseline Assessment	Critical	Occasional	Possible	100	Extreme	Excavated duff and topsoil and adit cleaned of timer and debris. It was backfilled with large rock then topsoil and duff was put on the disturbed area. Wire was cut and removed	✓
				No Cash 500 adit inaccessible	ACG Site Characterization	Low	Occasional	Possible	1	Low	Doors are locked.	✓
				Brefalt shafthouse is accessible	PWGSC Baseline Assessment	Critical	Occasional	Possible	100	Extreme	Secured doors and windows with 10 cm wire mesh.	✓
				Garage accessible.	PWGSC Baseline Assessment	Low	Occasional	Possible	1	Low		
				Lunch Room accessible.	PWGSC Baseline Assessment	Low	Occasional	Possible	1	Low		
8	Betty	Old trailheads extend northeast from the No Cash mine towards the Betty mine site.	479251E, 7088632N	One shaft collapsed due to permafrost; retaining approximately 1ft of water.	ACG 2006 Site Inspection	Low	Remote	Rare	0.01	Low		
9	Hector Calumet	Located on the northwest slope of Galena Hill, on the Calumet Road.	480900E, 7088300N	Underground opening present in west corner.	SRK 2005 Site Inspection	Critical	Occasional	Possible	100	Extreme	excavated and backfilled	✓
				Other concern would be berming the open pits and wall failure in some areas.	SRK 2005 Site Inspection	Critical	Occasional	Possible	100	Extreme	Investigated and deemed stable. However, a revisit in the summer of 2008 is suggested.	✓
				Sinkholes present in pit floor.	SRK 2005 Site Inspection	Critical	Occasional	Possible	100	Extreme	a 1m berm was put at the pit entrance to prevent access.	✓
				Shacks, bunk house, and water storage building all accessible.	PWGSC Baseline Assessment	Low	Occasional	Possible	1	Low		
10	Dragon & Miller (UN Adit; Miller separate workings)	Located on the north slope of Galena Hill along the Calumet Back Road.	481500E, 7088800E	UN Adit open but blocked by ice year round.	PWGSC Baseline Assessment	Moderate	Occasional	Possible	10	Moderate		

note:

cell pattern indicates site has been mitigated or partially mitigated.

Keno Hill Physical Hazard Risk Registery

Assigned Site No.	Site Name	Location Description	UTM Coordinates	Description of Existing Physical Hazards	Hazard Identified By	Consequence	Likelihood	Likelihood	Risk Rating		Mitigation Measures	Actions Complete
						Severity	Exposure	Probability	Numerical	Descriptive		
11	Galkeno 200	Located on the northeast slope of Galena Hill via the Calumet Back road, approximately 3.9km from the Duncan Creek road.	482600E, 7088600N	100 Level Adit timbers have collapsed making access difficult, but still possible.	SRK 2005 Site Inspection	Moderate	Occasional	Possible	10	Moderate		
				200 Level Adit is open and unsafe.	PWGSC Baseline Assessment	Critical	Occasional	Possible	100	Extreme	Upon investigation, site was isolated enough for remdial work to be continued into the 2008 season.	✓
				Unnamed Adit has collapsed.	ACG Site Characterization	Moderate	Occasional	Possible	10	Moderate		
				Unnamed shaft is in accessible.	PWGSC Baseline Assessment	Moderate	Occasional	Possible	10	Moderate		
				Macleod shaft is partially collapsed and inaccessible.	PWGSC Baseline Assessment	Moderate	Occasional	Possible	10	Moderate		
				Subsidence/sinkhole uphill of the 300 adit.	SRK 2005 Site Inspection	Moderate	Remote	Rare	0.1	Low		
14	Bluebird	Northeast slope of Galena Hill, approximately 4km northwest from Keno City; 70m upslope from Silver Trail	482750E, 7089825N	Three shafts were located east of cabin, two with ladders. Shafts filled in but still relatively deep (approx. 1-2m) One small shaft located north of other shafts only 0.5m deep.	ACG 2006 Site Inspection	Moderate	Remote	Unlikely	0.3	Moderate		
				Log cabin accessible; in poor condition.	ACG 2006 Site Inspection	Low	Remote	Unlikely	0.03	Low		
15	Tin Can	250m uphill of Silver Trail Highway.	483743E, 7088748N	One partially caved shaft found further down slope; still somewhat accessible however, not too deep (approx 2.5m)	ACG 2006 Site Inspection	Moderate	Remote	Unlikely	0.3	Moderate		
16	Rico	Northwest slope of Galena Hill, 450m upslope of Galkeno 900 site via old dirt road that branches off Calumet Back road roughly 2.2km north of junction with Duncan Creek Road.	483300E, 7087700N	One open shaft above adit, collapsed inward approximately 4m in depth; water retained in bottom.	ACG 2006 Site Inspection	Moderate	Remote	Unlikely	0.3	Moderate		
19	Onek	Located on the south slope of Keno Hill immediately northeast of Keno City.	487406E, 7087196N	Open pits in the south end have no berms on them (location is vehicle accessible).	SRK 2005 Site Inspection	Moderate	Continuous	Likely	300	Moderate		
				Collapsed rock above 400 Level Adit; timbers of 400 Level in poor shape.	SRK 2005 Site Inspection	Major	Continuous	Likely	900	Extreme	Investigated and deemed stable. However, a revisit in the summer of 2008 is suggested.	✓
				Lone Star shaft inaccessible except for 5m deep hole within open pit.	PWGSC Baseline Assessment	Major	Continuous	Likely	900	Extreme	Excavated of timbers and backfilled	✓
20	Klondike-Keno	Northwest slope of Keno Hill, approximately 1.5km southwest of Wernecke town site.	484700E, 7090700N	Subsidence has occurred behind collapsed adit.	ACG 2006 Site Inspection	Low	Occasional	Unlikely	0.3	Low		
				Drillers shack located north of adit roof structure on it's way to collapsing	ACG 2006 Site Inspection	Low	Occasional	Unlikely	0.3	Low		
21	Sadie Ladue	Located on the northwest slope of Keno Hill at the Wernecke Camp.	486400E, 7092000N	Collapsed stope located between Shaft #2 and Pit #1; loose slabs in roof a hazard.	PWGSC Baseline Assessment	Major	Frequent	Likely	270	Extreme	Stope was mound filled with material; now inaccessible.	✓
				A number of buildings in various states of repair are present on the site.	PWGSC Baseline Assessment	Low	Frequent	Possible	3	Low		
22	Bellekeno	South side of Sourdough Hill Road at the 100 level adit site	487126E, 7086385N	Open shaft along right side of road partially covered by collapsing frame	SRK 2005 Site Inspection	Major	Continuous	Almost certain	3000	Extreme	Shaft was filled and recontoured with backhoe.	✓
				Further up road along right side, another open log-lined vent about 3m deep	SRK 2005 Site Inspection	Major	Continuous	Almost certain	3000	Extreme	Shaft was filled and recontoured with backhoe.	✓
				Minor tension cracks along edge of pond and along crest of waste rock slope.	SRK 2005 Site Inspection	Low	Frequent	Unlikely	0.9	Low		
		80m along a trail leading off of Sourdough Hill Road.		Eureka: 2 open shafts located west of cabin; one overgrown and one is fairly deep 1 large stope failure in the middle of road 1 large open vent raise	SRK 2005 Site Inspection	Critical	Occasional	Possible	100	Extreme	Workings were filled and recontoured with backhoe.	✓
				Powder mag is in poor condition and accessible.	PWGSC Baseline Assessment	Low	Occasional	Possible	1	Low		
				Wash house is in poor condition and accessible.	PWGSC Baseline Assessment	Low	Occasional	Possible	1	Low		

note:

cell pattern indicates site has been mitigated or partially mitigated.

Keno Hill Physical Hazard Risk Registery

Assigned Site No.	Site Name	Location Description	UTM Coordinates	Description of Existing Physical Hazards	Hazard Identified By	Consequence	Likelihood	Likelihood	Risk Rating		Mitigation Measures	Actions Complete
						Severity	Exposure	Probability	Numerical	Descriptive		
23	Kijo	Located on the mid-southwest slope of Keno Hill, roughly 500m north of Erickson Gulch via Blackcap Road which branches off Wernecke Road, 80m down the slope.	486200E, 7089600N	One collapsed portal south of the collapsed adit; entrance to small for accessibility.	ACG 2006 Site Inspection	Low	Remote	Unlikely	0.03	Low		
24	Croesus No. 1	Midway up the western slope of Keno Hill, extending roughly 350m along an azimuth of 5 degrees up the north side of Erickson Gulch from the creek via the Blackcap Road which branches off of Wernecke Road, 1.3km to the northwest.	486655E, 7089425N	One shallow caved in shaft found up the hill from the adits.	ACG 2006 Site Inspection	Low	Occasional	Unlikely	0.3	Low		
25	Black Cap, Shepherd & LQ Adit	Three sites located on the western slope of Keno Hill, roughly a kilometre north of Erickson Gulch, all within 450m of each other.	486950E, 7091675N	Black Cap Adit accessible.	SRK 2005 Site Inspection	Major	Occasional	Likely	90	Extreme	Excavated of timber and debris and backfilled and sloped.	✓
				Lucky Queen Adit accessible through broken timbers.	ACG 2006 Site Inspection	Major	Frequent	Likely	270	Extreme	Excavated snow shed and adit of timber, pipe, debris and backfilled, resloped and recontoured. All old mining equipment and metal was removed. Burnable material was burned on-site.	✓
				Sheperd (Brewis Red Lake) Adit bulldozed, inaccessible	PWGSC Baseline Assessment	Low	Occasional	Rare	0.1	Low	Excavated timber and debris and backfilled and sloped.	✓
				Two shafts present that are open and accessible.	ACG Site Characterization	Major	Occasional	Likely	90	Extreme	Upon investigation, site was isolated enough for remdial work to be continued into the 2008 season.	✓
				Open pits with no berming present.	SRK 2005 Site Inspection	Moderate	Occasional	Possible	10	Moderate		
				Workshop accessible.	PWGSC Baseline Assessment	Low	Occasional	Possible	1	Low		
26	Lucky Queen	Located on the northwest slope of Keno Hill, roughly 1.25km east and uphill of the Wernecke Camp.	487700E, 7092700N	Doors unlocked on Shaft #1 headframe.	ACG 2006 Site Inspection	Major	Occasional	Almost certain	300	Extreme	Secured open shaft with timber, barricaded the double door and secured all windows and openings with 24 cm wire mesh.	✓
27	Lake	250m west of Gambler Gulch, midway down the north-western slope of Keno Hill, via the Lower Faro Gulch Trail.	490150E, 7090640N	Large headframe present above shaft, access to descent ladder nailed shut, however, access can be gained from side of shaft as ground has collapsed . Shaft may be approximately 5m deep.	ACG 2006 Site Inspection	Critical	Remote	Possible	10	Extreme	Searched extensively for this site. To perform sufficient physical hazard reduction at this site too much damage would nee d to be done to surrounding vegetation and area.	✓
28	Shamrock	Near the summit on the southwest side of Keno Hill; can be seen from Keno City	488018E, 7090536N	Shamrock J headframe is collapsing into the shaft and ground subsidence is occurring on the east side of the shaft.	ACG 2006 Site Inspection	Critical	Continuous	Almost certain	10000	Extreme	Material was removed and burned, and shaft was filled and recontoured with backhoe.	✓
				Main Site Building accessible.	PWGSC Baseline Assessment	Low	Frequent	Possible	3	Low		
				Generator Shed accessible.	PWGSC Baseline Assessment	Low	Frequent	Possible	3	Low		
29	Highlander	2km northwest of Keno Hill Summit on the south side of Gambler Gulch.	487900E, 7092100N	One caved in adit with a small opening that still allows accessibility.	ACG 2006 Site Inspection	Critical	Occasional	Possible	100	Extreme	Site was actively explored and confirmed inaccessible.	✓
				Ore processing building accessible.	ACG 2006 Site Inspection	Low	Occasional	Possible	1	Low		
				Bunkhouse accessible.	ACG 2006 Site Inspection	Low	Occasional	Possible	1	Low		
				Cabin accessible.	ACG 2006 Site Inspection	Low	Occasional	Possible	1	Low		
31	Stone	2.3km north of Keno Summit in Faro Gulch; south of Faro Gulch Trail.	488800E, 7092500N	One adit partially caved and difficult to access.	ACG 2006 Site Inspection	Low	Unusual	Unlikely	0.09	Low		
				Dry Building accessible.	ACG 2006 Site Inspection	Low	Remote	Unlikely	0.03	Low		

note:

cell pattern indicates site has been mitigated or partially mitigated.

Keno Hill Physical Hazard Risk Registery

Assigned Site No.	Site Name	Location Description	UTM Coordinates	Description of Existing Physical Hazards	Hazard Identified By	Consequence	Likelihood	Likelihood	Risk Rating		Mitigation Measures	Actions Complete
						Severity	Exposure	Probability	Numerical	Descriptive		
32	Keno Mine	Sites occur across a broad, relatively gentle slope above Hope Gulch southeast of the Keno Summit on Keno Hill via the Keno 700 Road.	490250E, 7089350N	Keno 200 Adit collapsed some approx. 3m deep; accessible from door at front.	PWGSC Baseline Assessment	Major	Continuous	Almost certain	3000	Extreme	secured the adit with 25 cm wire mesh on all openings. The sinkhole above the adit was excavated of duff, vegetation and timber and backfilled with local material and resloped. Duff and vegetation was replaced as cover.	✓
				Comstock 150 Adit door sealed but has some damage.	PWGSC Baseline Assessment	Major	Continuous	Almost certain	3000	Extreme	secured with 25 cm wire mesh	✓
				Comstock 200 Adit door sealed but accessible from smaller door on west side.	PWGSC Baseline Assessment	Major	Continuous	Almost certain	3000	Extreme	secured with 25 cm wire mesh	✓
				Porcupine Pit Portal is blocked by wood planks and has collapsed along a majority of its length.	PWGSC Baseline Assessment	Minor	Continuous	Unlikely	9	Low		
				Garage building subjected to erosion at base from being positioned on waste rock pile.	PWGSC Baseline Assessment	Low	Continuous	Possible	10	Low		
				Drill equipment shop was unstable, slipping into the erosion channel.	PWGSC Baseline Assessment	Low	Continuous	Possible	10	Low		
				The mining/geologist office was unstable and slipping into the erosion channel.	PWGSC Baseline Assessment	Low	Continuous	Possible	10	Low		
				All building on the site were accessible.	PWGSC Baseline Assessment	Low	Continuous	Possible	10	Low		
33	Main Fault & Nabob	North face of Keno Hill, approximately 0.75km northwest of Monument Hill, adjacent to the Keno No.9 System via the Silver Basin Gulch Trail.	490150E, 7090640N	Old house & old outhouse accessible.	ACG 2006 Site Inspection	Low	Continuous	Possible	10	Low		
36	Keno No. 9 System	Located on the Keno Hill summit via the Keno Signpost road.	48?300E, 7090200N	Faro Gulch Portal not inspected. Unsure of condition.		Critical	Frequent	Possible	300	Extreme	This site was located and confirmed to be beyond property borders.	✓
				Open pits on top of Keno Hill summit.	SRK 2006 Site Inspection	Major	Continuous	Likely	900	Extreme	Excavated and backfilled with local material	✓
				Two open holes are present just east of the Signpost.	SRK 2006 Site Inspection	Critical	Continuous	Almost certain	10000	Extreme	Excavated and backfilled with local material	✓
47	Monument & Ladue Fraction	Northwest facing slope of Monument Hill summit, approximately 1.5km past the signpost via the Silver Basin Gulch Trail.	490900E, 7090900N	One collapsed adit located on east facing slope of Silver Basin Gulch just below summit of Monument Hill; not accessible. Trenching present on top of cirque.	ACG 2006 Site Inspection	Low	Occasional	Possible	1	Low		
48	Apex	Located approximately 250m south of 4th switchback past the intersection of Signpost Road and Keno 700 Road.	488640E, 7088920N	One lined shaft located in Trench #3, a couple of meters deep. Possible subsidence immediately west of the hole.	ACG 2006 Site Inspection	Low	Unusual	Possible	0.3	Low		
				Wood cabin accessible.	ACG 2006 Site Inspection	Low	Occasional	Possible	1	Low		
71	Christal (Dorothy)	Located on the western slope of Keno Hill south of Erickson Gulch via a foot trail departing Keno Road about 2.5km out of Keno City.	486780E, 7088540N	One timber lined shaft approximately 2.5m deep with approximately 6" of water.	ACG 2006 Site Inspection	Moderate	Remote	Possible	1	Moderate		
				One shaft located north of first shaft, approx. 1m deep with approx. 0.5ft of water in it.	ACG 2006 Site Inspection	Moderate	Remote	Possible	1	Moderate		
76	Townsite Mine	6.2km along Calumet Drive from the junction of Wernecke Road .	479500E, 7087800N	Rock overhang has caved in at adit entrance and is considered a safety hazard.	PWGSC Baseline Assessment	Critical	Frequent	Possible	300	Extreme	Excavated of timber and debris and backfilled, sloped and contoured.	✓
77	Sadie Ladue 600 Adit	6km north of Keno City via a 1km trail leading north from Wernecke Camp.	485950E, 7092700N	One adit present; still accessible.	PWGSC Baseline Assessment	Critical	Occasional	Possible	100	Extreme	Investigated and deemed stable. However, a revisit in the summer of 2008 is suggested.	✓

note:

cell pattern indicates site has been mitigated or partially mitigated.

Keno Hill Physical Hazard Risk Registery

Assigned Site No.	Site Name	Location Description	UTM Coordinates	Description of Existing Physical Hazards	Hazard Identified By	Consequence	Likelihood	Likelihood	Risk Rating		Mitigation Measures	Actions Complete
						Severity	Exposure	Probability	Numerical	Descriptive		
78	Elsa Village	Located on the south side of Silver Trail Highway, 11.5km west of Keno City.	476000E, 7087000N	Green shack accessible.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Shack #1 & 2 beside sawmill accessible.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Carpentry shop accessible.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				No. 5 bunkhouse accessible.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Union shop building accessible; in poor condition.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Snack bar accessible through a back door.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Dining hall accessible.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Wooden walkways are in poor condition at Mill site.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Access available to the grizzly bay at Mill site.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Utilildor collapsing at mill site.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Retaining wall failing on south side of Mill site.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Light vehicle shop accessible.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Rescue building accessible.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Swimming pool building accessible.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Medical building accessible; contains medical equipment and personal medical files.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low	Although this is not a physical hazard, contents of the building can subject the company to large privacy exposure.	
				Heavy Equipment Warehouse accessible through unlocked door on the north side.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Mens staffhouse accessible.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Apartment building accessible.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Single car garage building accessible.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Church building in poor condition; accessible.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Elsa School was accessible.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		
				Flat Creek residences #1 & 2 accessible.	PWGSC Baseline Assessment	Low	Unusual	Possible	0.3	Low		

note:

cell pattern indicates site has been mitigated or partially mitigated.

Technical Study

HYDROCARBON CONTAMINATION

Date:

June 2008 – March 2009

Performed By:

Access Consulting Group

Introduction:

From the result of 75 years of mining activity in the Keno Hill Silver District, the property contains a large volume of hydrocarbon impacted soil. Since 2000, several studies and investigations have identified potential locations that may contain hydrocarbon impacted soils in the district. These sites were identified from past practices, Underground Storage Tanks (USTs), and above ground storage tank locations, fuel and containment spills.

These potential locations that had been identified in the district containing hydrocarbon impacted soils had not been thoroughly investigated, sampled or delineated.

Objective:

The objective of the Hydrocarbon Contamination assessment was to conduct a thorough investigation of the potential hydrocarbon impacted sites that have been identified in the district. The investigation was to include detailed soil sampling to confirm the presence or absence of hydrocarbon impacts, characterize the contaminants of concern (if any) and delineate the areas impacted with hydrocarbons. The assessment also was to estimate the total volume of hydrocarbon impacted soils in the region as well as identify areas for a potential land treatment facility (LTF) in the district.

Facts\Description of Study

In August and September/October 2008, ACG conducted hydrocarbon and LTF field assessments throughout the Keno Hill Silver District. The assessments consisted of a visual inspection and soil sampling program (which included test pitting) of all the potential hydrocarbon impacted areas identified in the previous reports as well as all any new disturbed areas that were safely accessible.

Soils were logged and field-screened for potential contamination. Based on field observations and VOC screening results, twenty three (23) soil samples were submitted for laboratory hydrocarbon analyses and eleven (11) samples were submitted for metal analyses.

Test pits were excavated to 3 m in eight potential LTF locations during the field program as part of the LTF site selection process.

Results/Conclusions

All the objectives and assessment tasks outlined in the assessment were completed. Previous data was reviewed, complied and verified. A hydrocarbon field program was conducted and soil samples were submitted to an approved laboratory for characterization and confirmation analysis. Detailed results are presented in the Access Consulting Group March 2009 report entitled "*Elsa Reclamation and Development Company Keno Hill Mine Site Investigation and Improvements, Special Projects Hydrocarbon Contamination"*.

The volume of impacted soil in the Keno Hill Silver District is estimated to be 6,950 m^3. This includes several areas with special waste impact (30,000 ppm or higher).

Eight potential LTF locations were assessed and identified during the LTF field inspection. Five of the eight LTF locations are optimal due to the proximity of the majority of contamination within the district, including: the old Elsa school yard, the framing/carpentry yard, near bunkhouse 1 and near fuel storage areas 3 and 4 (also located within Elsa). The construction and operation of an LTF will follow guidelines as well as regulations, limitations, permits and specific considerations as prescribed by the Yukon Government (YG).

Deliverables

A final report detailing the results of the hydrocarbon investigation was completed in March 2009 by Access Consulting Group entitled "*Elsa Reclamation and Development Company Keno Hill Mine Site Investigation and Improvements, Special Projects Hydrocarbon Contamination"*. The report characterizes the impacted areas, presents the analytical results in tables, identifies the areas investigated on figures, estimates the volume of impacted soil at each location as well as within the district and identifies potential LTF locations for future hydrocarbon remediation.

Technical Study

HAZARDOUS WASTE

Date:

June 2008 – March 2009

Performed By:

Access Consulting Group

Introduction:

Hazardous wastes include a broad range of materials such as manufacturing residues (e.g. waste acids, contaminated sludges and complex chemicals), waste pesticides, PCBs in transformer and lamp ballasts, asbestos, motor oil, and other hydrocarbon products. As part of the implementation of the closure planning at the Keno Hill property, various buildings require demolition (mill, storage areas, residences, assay lab, bunk houses). Hazardous wastes need to be identified and documented and require special handling in order to reduce adverse effects to water quality and human health from the hazardous wastes generated from the project remediation.

Objective:

The objective of the Hazardous Waste assessment was to characterize and quantify the volume of waste as well as to develop closure alternatives and recommendations for managing hazardous materials. PCB transformers, waste oil, batteries, unknown liquids and materials, lead paint siding and asbestos siding are common wastes found in the district that could be encountered during the demolition of physical hazards.

Facts\Description of Study

Access Consulting Group conducted the hazardous waste assessment on two separate occasions. The first assessment was conducted during August 25th to August 28th, 2008. The second assessment was conducted on January 30th to February 4th 2009.

Buildings were entered and inspected for hazardous waste including any asbestos material, lead paint, chemicals, used oil, PCB ballasts, batteries, etc. Various ballasts from florescent lighting representative of each building were removed and compared to a capacitor/lamp ballast/transformer identification chart to determine if PCBs could be present.

Swabs for metal analysis were collected from dust buildup inside the buildings and paint chips were collected from sections of the buildings to confirm the presence or absence of lead paint.

Thirty-five (35) samples were submitted to a certified laboratory. Based on field observations, the following analyses were conducted:

- Twenty seven (27) samples were analyzed for asbestos types and concentrations.
- Three (3) paint samples from the fire assay office, No. 1 bunkhouse and Keno 700 bunkhouse were analyzed for lead concentrations and two of the three samples were analyzed further for lead TCLP leachate concentrations.

- The three (3) swab samples from the boiler plant, crusher and generator building within Elsa were analyzed for Total Metals using strong acid digestion.

In June 2010 Access Consulting Group submitted a Yukon Environmental and Socio-economic Assessment proposal for the demolition of 17 buildings in the village of Elsa as well as the secondary buildings at Husky and Husky SW. The decision document issued by INAC in September 2010 requested additional paint samples be collected from the buildings and tested for leachable lead and polychlorinated biphenyls (PCBs).

- Two (2) additional samples were analyzed for asbestos types and concentrations.
- Fifteen (15) paint samples were analyzed for lead and lead TCLP leachate concentrations.
- Seven (7) exterior paint samples were also analyzed for PCB concentrations.

Results/Conclusions

All the objectives and tasks outlined in the work plan were assessed and completed. Hazardous waste including batteries, partially full drums with unknown material, asbestos, PCB lamp ballasts, lead paint and containers with unknown chemicals were identified in buildings throughout the district.

August 2008 and January/February 2009 sample results:

- Metals: Antimony, arsenic, cadmium, chromium, copper, lead, silver and zinc concentrations in all three swab samples exceeded applicable CSR standards. Molybdenum concentrations from the boiler plant sample and selenium concentrations from the mill/crusher building sample also exceeded the CSR levels.
- Lead Paint: two of the three paint samples submitted for lead analysis exceeded CSR criteria. Two samples were submitted for TCLP lead leachate and did not exceed applicable criteria.
- Asbestos: Chrysotile or Amosite asbestos fiber concentrations were identified in nineteen (19) of the twenty seven (27) samples submitted for analysis.

September 2010 sample results:

- All leachable lead and PCB concentrations in the paint samples were either below the reportable detection limit or did not exceed the applicable criteria.
- One asbestos sample collected from an overhead utilitdor contained Amosite asbestos.

A WCB approved site specific demolition plan was developed outlining worker safety and the handling of hazardous materials. The plan focuses on the protection of workers, the public and the environment as well as outlines the best management practices to handle hazardous waste. Applicable permits have been obtained that identify the appropriate handling, storage and disposal of hazardous wastes.

Deliverables

A final report detailing the results of the hazardous waste investigation as well as a hazardous waste inventory was completed in March 2009 by Access Consulting Group. The report was entitled "*Elsa Reclamation and Development Company Keno Hill Mine Site Investigation and Improvements, Special Projects Hazardous Waste Assessment"*.

Technical Study

LANDFILL REQUIREMENTS

Date

May 2008 – March 2009

Performed By

Access Consulting Group

Introduction

There are a number of old buildings, structures and related construction materials that are located throughout the Keno Hill Mine property that will require disposal. The property buildings and structures were inspected and waste types, volumes and non-hazardous materials were documented and reported for the Keno Hill Mine property. Wastes were divided into either *hazardous waste* or *landfill waste.* The mitigation work is different for each waste category; therefore, there were two work plans for dealing with each type of waste generated. This work plan assessed potential non-hazardous waste landfill sites and determines estimates of the types and volumes of waste to be expected during demolition.

The historic landfill on the Keno Hill Mine property near the town of Elsa was deemed "*out of commission*" and required assessment for closure options.

Objective

The objective of this assessment was to develop estimated quantities of materials including volumes and types necessary to be land filled or handled as non hazardous or hazardous wastes during decommissioning. The identification of a suitable location for a closure landfill was also required. In addition, the old historic landfill (which is no longer in use) required assessment to determine the presence or absence of contaminants and to develop closure approaches.

Facts\Description of Study

In August, September/October 2008 and January/February 2009, ACG conducted landfill field assessments throughout the Keno Hill Silver District. The field program consisted of a building inventory and waste volume estimation, new landfill locations assessment and an assessment of the historic Elsa dump site.

The Yukon Environment Act Solid Waste Regulations was followed with particular attention to Schedule 1 Operating Standards for Dumps. To determine the volume of waste to be buried in Elsa as well as throughout the Keno Hill Silver District, a building inventory was completed along with determining the length and width of each building to calculate the square meter of buildings. The square meters were then multiplied by 1.5, which is a bulking factor used by demolition companies to determine the volume of rubble and waste that requires disposal.

Test pits were excavated during the field program as part of the landfill site selection process. Five test pits were also excavated at the base of the Historic Elsa Dump to identify any potential leachate and/or soil contamination along the toe of the dump.

Results/Conclusions

All the objectives and tasks outlined in the landfill work plan were assessed and completed. In conjunction with the hazardous waste assessment a building inventory and waste volume was estimated, potential landfill locations were selected and the historic Elsa dump site was assessed.

It was estimated that 43,985 m^3 of building waste is required to be buried throughout the district, including Elsa. The estimated volume of building waste to be buried within Elsa was 28,244 m^3. Hazardous waste was assessed under a separate investigation.

Potential locations based on the concentrations of the buildings requiring demolition/disposal include but not limited to: near the old Elsa school yard, near the current houses, near the bunkhouses and on the flat terraces (essentially cut/fill areas). It was estimated that 3 landfills are required in the village of Elsa and one at Keno 700.

All hydrocarbon concentrations did not exceed CSR standards from the historic Elsa dump. All samples from the toe of the dump exceeded CSR standards for arsenic, but were below the background soil concentrations. Cadmium concentrations from one at 3 m slightly exceeded the CSR criteria. The Historic Elsa dump will be decommissioned as per the YG Environment Act Regulations including *Schedule 1 Operating Standards for Dumps, Closure and Abandonment.*

Deliverables

A final report detailing the results of the landfill investigation was completed in March 2009 by Access Consulting Group entitled *"Elsa Reclamation and Development Company Keno Hill Mine Site Investigation and Improvements, Special Projects Landfill Requirements"*.

REGULATORY AND CONSULTATION

Technical Study

CLOSURE PLAN ENVIRONMENTAL ASSESSMENT

Date:

Ongoing

Performed By

Access Consulting Group

Introduction

The Environmental Conditions Report provides a description of the regional setting for the Keno Hill Silver District with respect to the physical, biological and human environments. The descriptions provided in the report are not intended to be interpreted as baseline environmental conditions prior to the start of mining in the area a century ago. The collection of data to describe baseline environmental conditions was not a consideration during early mining development, and as such no baseline data was documented. Over the course of time the local ecosystem has changed, and in some areas adjusted or even adapted to reflect mining activities in the area. The report provides detail on the site-specific conditions in the region, and can be considered an expansion of the description of the regional environmental setting previously documented in the 1996 *Site Characterization Report* (Access Mining Consultants Ltd, 1996). It is based on environmental conditions at the time of writing.

Objective

To provide a description of the regional setting for the Keno Hill Silver District with respect to the physical, biological and human environments prior to mine closure.

Facts\Description of Study

This report details the major physiological aspects of the Keno Hill Mining Region, including:

- Climate (precipitation and evaporation)
- Terrestrial Resources (geology, quaternary geomorphology, physiography and soils)
- Surface Water (water quality of catchments, treatment sites and adit discharges)
- Hydrology
- Groundwater
- Aquatic Resources (fisheries, stream sediments, benthic invertebrates)
- Wildlife
- Vegetation (metals levels, lichen analysis, revegetation trials)
- Heritage Resources

- Land Use Considerations
- Socio-Economic Conditions
- Consultation

Deliverables

Final Report: Environmental Conditions Report Version No. 2 (April 2010)

Technical Study

ANNUAL GEOTECHNICAL ASSESSMENT

Date

Ongoing on an annual basis

Performed By

EBA

Objective

The objective of the annual geotechnical investigation is to assess tailings facility dams and related structures and settling pond facilities at adit treatment sites for geotechnical, physical stability and report the findings. The facilities are routinely inspected on an annual basis by EBA Engineering Consultants Ltd.

Facts\Description of Study

The following tasks are carried out each year as a part of the geotechnical inspections:

- Review 2009 annual inspection with EBA, YG Water Resources and INAC to identify remediate works or actions as necessary
- Review recent geotechnical inspection reports, primarily EBA report summarizing geotechnical inspections and conditions relating to Valley Tailings Area (VTA) dams and associated facilities;
- Discuss previous year's recommendations with YG Water Resources; and
- Undertake physical site inspection of VTA and associated facilities during open weather season and document inspection results.
- Review recent geotechnical inspection reports, primarily EBA report summarizing geotechnical inspections and conditions relating to water treatment settling ponds (Silver King, Galkeno 900, Galkeno 300, Sime sludge pit, Bellekeno 625);
- Discuss previous year's recommendations with YG Water Resources; and
- Undertake physical site inspection of water treatment settling ponds and associated facilities during open weather season and document inspection results.
- Compile information on the state of geotechnical structures and prepare recommendations for maintenance work to be carried out.

Results/Conclusions

Results of the annual geotechnical assessment vary from year to year depending on the previous years' upgrades and site conditions. The results are documented each year in a report issued by EBA.

Deliverables

Final Report: Inspection of Tailings Facility, Water Treatment Ponds and Porcupine Diversion Ditch, United Keno Hill Mines Property, Elsa, YT

Technical Study

WATER TREATMENT CAPITAL IMPROVEMENTS

Date

November 2007 - Present

Performed By

ERDC

Introduction

ERDC is responsible for care and maintenance of the historic environmental conditions and liabilities within the Keno Hill Silver District, including the year-round operation of four water treatment facilities and one seasonal treatment site. Care and maintenance activities are carried out according to the terms and conditions of Water Licence QZ06-074 issued to ERDC in November 2007. There are also contractual obligations for care and maintenance within the Subsidiary Agreement between Canada and ERDC.

Objective

Capital improvements to the treatment sites are a means of reducing overall risk and liability, both for Canada and ERDC, associated with these treatment sites.

The objectives of this water treatment capital improvements work plan include:

- Modify existing treatment facilities to consistently meet water license discharge standards;
- Reduce risk and liability for both INAC and ERDC through upgrading treatment sites for effective and consistent operation and addressing employee health and safety hazards;
- Provide operating efficiency and effectiveness that provides cost sharing reductions for both INAC and ERDC.

Facts\Description of Study

The following tasks will be carried out during the 2010 – 2011 year to ensure continued successful operation of the existing water treatment facilities:

- Task 1 Installation of guardrails around treatment ponds at treatment facilities
- Task 2 Upgrades to the Galkeno 300 Treatment System
- Task 3 Galkeno 300 Adit Repair
- Task 4 Prepare As-Built Drawings

Capital Improvements carried out in previous years include:

- Upgrades to the Galkeno 300 Treatment Facility, including installation of a new clarifier
- Installation of a retention berm at the Sime Pit to add additional capacity

- Construction of a new pond and liner at Silver King 100 Treatment Facility
- Installation of new piping at Galkeno 300, including a pipeline to connect the sludge pond with the Sime Pit for streamlined de-sludging

Deliverables

Activities are documented in the QZ06-074 Annual Reports.

Technical Study

ON-GOING CARE AND MAINTENANCE

Date

November 2007 - Present

Performed By

ERDC

Introduction

On June 1, 2006, ERDC became responsible for day to day care and maintenance at the Keno Hill District through a Care and Maintenance Contract between ERDC and Yukon Government (YG). The Contract has been subsequently transferred to and managed by Indian and Northern Affairs Canada (INAC).

On November 14, 2007 ERDC was issued Water Licence QZ06-074 (WL) and gained title and ownership to the Keno Hill district. Reporting and performance obligations defined during the contract period changed due to new conditions and requirements contained in the WL. The WL and its supporting documentation describe the Care and Maintenance activities that required at the site.

Objective

The objective of care and maintenance activities at the Keno Hill District is to minimize and/or prevent further environmental degradation caused by effluents released from various old mine areas, and to ensure the safety and security of all sites in the Keno Hill District to protect both humans and wildlife.

Description of Activities

Care and Maintenance includes earthworks to enhance or maintain stability of mine structures, physical upgrades to the treatment facilities, replacement and repair of various site items, physical inspections to ensure safety, and any activity the aim of which is to protect the environment and provide safety and security. Water management activities are conducted in accordance with the Adaptive Management Plan (AMP), which provides measures for monitoring, reviewing, and assessing the effects if any, old mine workings are having on the environment. The focus of the AMP, and associated water management activities, is to ensure that negative trends in water quality are assessed quickly, and mitigative response be implemented immediately thereafter. If during regular sampling events it is determined that discharge from the District is out-of-compliance with licence conditions, then specific actions are taken to mitigate any out-of-compliance issues, with a primary focus on ensuring the safety of the environment.

Prevention of environmental degradation at Keno Hill is accomplished largely by the daily operation of lime-addition water treatment systems existing at Galkeno 900, Galkeno 300, Silver King 100, and Bellekeno 625 adits. The Valley Tailings Facility is also treated on an as-required basis during spring and early summer. Performance monitoring (i.e. water quality testing) is undertaken by ERDC, using on-site laboratory facilities for daily and weekly water quality analysis. Monitoring of surface and groundwater sites as well as physical conditions is completed as per WL monitoring schedules.

Deliverables

Annual Reports as per Water Licence QZ06-074 Clause 14

OTHER STUDIES

Technical Study

MACKENO AND WERNECKE TAILINGS ASSESSMENT

Date

Sept 30 – Oct 1, 2008

Performed By

Access Consulting Group

Introduction

Objective

To conduct an investigation at both tailings sites to characterize the tailings in terms of geochemical and physical stability, and potential effect to the environment and to identify and develop remedial and closure options.

Facts\Description of Study

- Three main tasks were carried out in order to complete this study:
    - Historic data review
    - Site inspection
    - Closure option development
- The data review covered the Keno Valley/Dublin Gulch Environmental Baseline Assessment and Baseline Environmental Report United Keno Hill Mines Property
- The site inspection involved the excavation of test pits at both Wernecke and Mackeno. The sites of these pits were sampled and tests run for ICP metals, Acid Base Accounting (ABA), metal leaching and fire assay.
- Physiographic parameters were investigated and recorded at each site including, stratigraphy, groundwater and field screening pH
- Tailings volumes were assessed for closure option development based on estimated spatial extent and thickness of tailings

Results/Conclusions

Site Inspection

- Volume estimates: Mackeno: 4,689m^3 with additional tailings to the north of the main deposit; Wernecke: 1,159m^3 with additional tailings downslope and at the unnamed lake.

- ICP metals showed exceedences in Contaminated Sites Regulations in all test pits at both Wernecke and Mackeno, indicating that the impact of the tailings to the receiving environment and aquatic life may be considerable. The work Minnow is conducting with respect to the LTAMP will recognize the effects from the Mackeno Tailings for the Christal Creek drainage.

- At the Wernecke site, ABA results showed that there is potential for acid-generation in the tailings, and more work is required to better understand acid-generation at this site, particularly because the tailings exist over a larger geographic extent (the tailings have migrated downslope and all the way to an unnamed lake). The Mackeno tailings have real acid generation potential and may be causing detrimental effects to the receiving environment as a result of acid generation.

- Stream sediment quality in Christal Creek at KV-6 (only 150m downstream of the Mackeno Tailings) is degraded, which can almost certainly be attributed to the impact of the Mackeno Tailings upstream of this site.

- Water quality at Christal Creek at KV-6 shows the highest levels of dissolved metals in the creek, also likely attributable to the impact of the Mackeno Tailings

Closure Options

- It would be economically feasible to reprocess the tailings at Wernecke and Mackeno, but only in conjunction with reprocessing of the Elsa Tailings. This will be considered as part of a potential "relocation" scenario for these tailings facilities if the tailings at Elsa are reprocessed.

- Relocation: Tailings would be excavated, placed in haul trucks and taken to the Valley Tailings Area at Elsa. The excavations would be filled with inert soil, resloped and revegetated.

- Stabilization and Cover: Stabilize the tailings areas to prevent erosion, and cover to prevent infiltration of runoff.

Deliverables

Final Report: Mackeno and Wernecke Tailings Assessment

KENO HILL SILVER DISTRICT

DRAFT CLOSURE OPTIONS REPORT

Appendix B-1

Risk Assessment Memo

ALEXCO ENVIRONMENTAL GROUP

December 8th, 2009

Attention: Keno Hill Existing State of Mine Closure Risk Assessment Group

Memorandum: Keno Hill Closure Planning Risk Assessment

This memo outlines the results of the 2009 Keno Hill Closure Planning Risk Assessment. It has led to the selection of preferred closure options for further consultation. The preferred options will be used to shape the final closure plan for the Keno Hill District.

The risk assessment process was completed for eight (8) major sites at Keno Hill, and covered all closure components presently existing at the site including waste rock storage areas, pits, adits and their associated water management and the valley tailings area.

The risk assessment was recorded in a standard risk matrix which logged both the probability and severity of a potential risk, and in turn identified the resulting risk rating. These risks and their ratings are provided alongside this memo in a second file for your review as necessary. For completeness, mine site components that were not expressly addressed, but were peripherally discussed in the risk assessment have been added.

Risk identification and rating was based on the premise that each scenario was an unmitigated measure for closure. In the future, mitigative measures for each closure scenario will be identified and a residual risk assessment performed, leading to selection of a preferred closure option for each mine site component at each mine site.

Mine site areas and mine site closure components (namely, infrastructure) that were not addressed in the initial risk assessment will be addressed in a future assessment carried out by a smaller working group. Moreover, mitigation for each risk will be considered, and a residual risk assessment conducted at that time. During that process, a preferred option will be selected for each site. We will be in contact to determine who the attendees should be, and when the assessment will be carried out. We expect to schedule this assessment in late June/early July 2009.

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Vancouver, BC V6C 1S4

Once preferred options and residual risks are determined, these options for mine site component closure will be taken to the public to undergo a stakeholder and peer review. With the feedback from this process in mind, final options for each mine site component will be selected and used to develop a final closure option for each site.

A description of this process is illustrated in the attached process diagram. Outstanding items for closure planning include further risk assessment on sites previously not discussed, mitigation and residual risk assessment, stakeholder and peer review and selection of a preferred option for each site. These are the next immediate steps in the process to selecting final closure options and to developing the Closure Plan.

We appreciate your participation in the risk assessment and closure planning process and look forward to continuing our work towards development of a plan for the district. Should you have any particular questions or have feedback on the attached risk summary please contact me.

Sincerely,

Dan Cornett

President

Access Consulting Group

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KENO HILL SILVER DISTRICT

DRAFT CLOSURE OPTIONS REPORT

Appendix B-2

Risk Assessment Summary

ALEXCO ENVIRONMENTAL GROUP

KENO HILL EXISTING STATE OF MINE
CLOSURE OPTIONS RISK ASSESSMENT
SUMMARY AND RESULTS
DECEMBER 2009

Closure Option Risk Assessment Process

A Description of the Process Leading to the Risk Results Herein

1. An area of the site is introduced and a closure option is described.
2. For each component of the option, the group is asked to identify scenarios or conditions leading to risks. Each scenario or condition is followed through to a consequence shown on the Consequence Severity matrix. For example, if a "dam failure" scenario is suggested, the group is asked to work though the subsequent chain of events, such as "tailings release leading to severe long-term contamination."
3. The group then agrees where the consequence lies on the C-S scale. In the above example, it would likely be a "Major" or "Critical" consequence in the "Environmental" category.
4. The group then assesses likelihood. It is important to understand that the likelihood in question is that of the final consequence. Again using the above example, the likelihood of a dam failure is one quantity, but the quantity we need is the likelihood of a dam failure leading to tailings release leading to a "Major" environmental consequence.
5. Other consequences of the given risk scenario or condition are then examined in the same manner. The above example would certainly also have "Consequence Costs." It would also have "Legal" and "Community/Media/Reputation" consequences.
6. The next risk scenario or condition for that option is examined in the same manner.
7. Repeat for next closure option and continue until all options are addressed.
8. Once all options are assessed, the group returns to very high risks where mitigation measures are available, and discusses the mitigation measure and its costs. This will invariably lower the risk rating, and that new risk rating is applied to the scenario.

Example Risk Matrix Results Table

Component & Option Description					
	Consequence Severity				
Likelihood	Very Low	Minor	Moderate	Major	Critical
Almost Certain	Moderate	Moderately High	High	Very High	Very High
Likely	Moderate	Moderate	Moderately High	High	Very High
Possible	Low	Moderate	Moderately High	High	High
Unlikely	Low	Low	Moderate	Moderately High	Moderately High
Very Unlikely	Low	Low	Low	Moderate	Moderately High

Groupings for summary presentation of risk results

1 Risks associated with **WRSA** closure options
Risk of waste rock contamination
Risks associated with physical stability
Aesthetics

2 Risks associated with **adit closure** options
Risk of adit failure/collapse

3 Risks specific to each alternative, including cost risks
Risks of engineering and system design failures
Risks of non-catastrophic maintenance failure
Risks that biological treatment or in-mine treatment systems do not perform adequately
Risks of structural failure of diversions, pipelines, slopes, etc.
Risks of implementation costs being higher than estimated
Risks of operating, maintenance and repair costs being higher than estimated
Quality assurance/quality control risks

WRSA Closure Options Risks

WRSA Closure Option - Do Nothing

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely	2E	1E, 3R			
Possible					
Unlikely					
Very Unlikely					

	Physical Stability Risks
1E	WRSA Leave as is: Failure of the waste rock dump or load out, leading to blockage of creek and washout or
2E	WRSA Leave as is: Failure of the waste rock dump or load out, leading contamination of the stream.
	Community Concerns
3R	WRSA Leave as is: Results in disagreement with public or community groups about whether it is aesthetically

WRSA Closure Option - Reslope 2.5:1 & Revegetate

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely					
Possible		1E, 2E, 3E	4R		
Unlikely					
Very Unlikely					

	Risks of waste rock contamination
1E	Resloping WRSA will cause short-term, one-time only increases in load over steady state conditions. Impacts on water quality
2E	Resloping WRSA will cause short-term, one-time only increases in load over steady state conditions. Impacts produces contaminated dust
3E	Resloping WRSA will cause short-term, one-time only increases in load over steady state conditions. Impacts on natural footprint
4R	The physical look of the waste rock piles reflects the heritage and mining past of the region and is preferable to some inhabitants of the area. Inhabitants may oppose altering the physical character of the WRSA, leading to public concern and unrest

Open Pit Closure Options Risks

Pit Closure Option - Berm and Sign

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely					
Possible			1H		
Unlikely					
Very Unlikely					

1H	Access to the pits is not effectively prohibited, leading to inadvertant access and injury.

Adit Closure Options Risks

Adit Closure Options - Adit Bulkhead, Plug, or Rock Pile

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely			2E		
Possible		1C			
Unlikely					
Very Unlikely					

	Risk of adit failure
1C	Collapse of the adit/workings leads to an inability to manage the water discharging from it, obscuring or hindering the performance of the plug
	Risk of plug/engineering failure
2E	Catastrophic failure via strength loss and plug fails, leading to a significant flux of water into the receiving environment

Galkeno 900 Adit Water Treatment Options Risks

Galkeno 900 Option 1 - Ex-situ Bioreactor with Lime Treatment Contingency

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely			4R		
Possible			3E		
Unlikely			6H	5H, 7H	
Very Unlikely			1E, 2E	8H	

Risks of bioreactor system failure/design flaws

1E	Wholescale failure of bioreactor treatment facility at a slow rate, leading to release of contaminants into the environment.

Risks of the natural environment

2E	Increase in the levels of zinc from the linked workings of Hector-Calumet, leading to exposure of the receiving environment to additional contaminants.
3E	Uncontrolled seepage from the seeps in the hillside leading to contamination of the hillside, and ultimately the receiving environment.
4R	Uncontrolled seepage from the seeps in the hillside enter the Christal Creek receiving environment, leading to negative public perceptions about the quality of water in the Christal Creek watershed, and ultimately, the South

External health and safety risks of reagents/chemicals

5H	Release of H_2S from the bioreactor with human exposure leading to serious illness or a fatality.
6H	Line leak (as a result of vandalism) leading to expulsion of methanol/ethanol to environment and exposure causing blindness/bodily harm/toxicity effects.
7H	Inability to deliver ethanol/methanol safely to treatment facility at GK900 (once a day frequency), leading to a fatal accident.
8H	Inability to deliver ethanol/methanol safely to treatment facility at GK900 (once a year frequency), leading to a fatal accident.

Galkeno 900 Option 2 - Upgrade Current Treatment System

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely			2R		
Possible			1E, 3C		
Unlikely				4H	
Very Unlikely				5H	

Risks of the natural environment

1E	Uncontrolled seepage from the seeps in the hillside leading to contamination of the hillside, and ultimately the receiving environment.
2R	Uncontrolled seepage from the seeps in the hillside enter the Christal Creek receiving environment, leading to negative public conceptions about the quality of water in the Christal Creek watershed, and ultimately, the South
3C	Significant deterioration in water quality leading to need for capital inprovements for a new treatment system.

External health and safety risks of reagents/chemicals

4H	Human health and safety risk associated with the ability to deliver lime safely on rough roads (once a day frequency)
5H	Human health and safety risk associated with the ability to deliver lime safely on rough roads (once a year frequency)

Galkeno 900 Option 3 - Batch In-Mine Pool Bioreactor Treatment

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely			5R		
Possible			4E		
Unlikely				6H	
Very Unlikely	1E			2H, 3H, 7H	

Risks of bioreactor system failure/design flaws

1E Wholescale failure of bioreactor in-mine pool treatment at a slow rate, leading to release of contaminants into the environment.

Risks of the natural environment

4E Uncontrolled seepage from the seeps in the hillside leading to contamination of the hillside, and ultimately the receiving environment.

5R Uncontrolled seepage from the seeps in the hillside enter the Christal Creek receiving environment, leading to negative public conceptions about the quality of water in the Christal Creek watershed, and ultimately, the South

External health and safety risks of reagents/chemicals

2H Release of H_2S from the bioreactor with human exposure leading to serious illness or fatality.

3H Creation of toxic gaseous conditions behind the hydraulic bulkhead as a result of both the creation of a low-oxygen atmosphere and H_2S gas leading to human exposure and death.

6H Inability to deliver ethanol/methanol safely to treatment facility at GK900 (once a day frequency), leading to a fatal accident.

7H Inability to deliver ethanol/methanol safely to treatment facility at GK900 (once a year frequency), leading to a fatal accident.

Onek 400 Adit Water Treatment Options Risks

Onek Option 1 - In-Mine Pool Treatment

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely			1E, 2E, 6R		
Possible		3E	4H, 5E		
Unlikely				7H	
Very Unlikely				8H	

Risks of system failure/design flaws

1E	Incomplete blocking of flow leads to less effective treatment. The result is poor water quality, leading to degradation of aquatic resources.
2E	Incomplete blocking of flow leads to less effective treatment. The result is soil contamination, leading to degradation of plant species.
3E	Water is backed up in the mine pool above the adit leading to seepage along the hillside.

Risks of the natural environment

5E	Uncontrolled seepage from the seeps in the hillside leading to contamination of the hillside, and ultimately the receiving environment.
6R	Uncontrolled seepage from the seeps in the hillside enter the Christal Creek receiving environment, leading to negative public conceptions about the quality of water in the Christal Creek watershed, and ultimately, the South

External health and safety risks of reagents/chemicals

4H	Creation of toxic gaseous conditions behind the hydraulic bulkhead as a result of both the creation of a low-oxygen atmosphere and H_2S gas leading to human exposure and death.
7H	Inability to deliver ethanol/methanol safely to treatment facility at GK900 (once a day frequency), leading to a fatal accident.
8H	Inability to deliver ethanol/methanol safely to treatment facility at GK900 (once a year frequency), leading to a fatal accident.

Onek Option 2 - Ex-situ Bioreactor

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely					
Possible					
Unlikely			3H	2H, 4H	
Very Unlikely			1E	5H	

Risks of bioreactor system failure/design flaws

1E	Wholescale failure of bioreactor treatment facility at a slow rate, leading to release of contaminants into the environment.

External health and safety risks of reagents/chemicals

2H	Release of H_2S from the bioreactor with human exposure leading to serious illness or a fatality.
3H	Line leak (as a result of vandalism) leading to expulsion of methanol/ethanol to environment and exposure causing blindness/bodily harm/toxicity effects.
4H	Inability to deliver ethanol/methanol safely to treatment facility at Onek (once a day frequency), leading to a fatal accident.
5H	Inability to deliver ethanol/methanol safely to treatment facility at Onek (once a year frequency), leading to a fatal accident.

Onek Option 3 - Natural Attenuation

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely					
Possible			1E, 2E		
Unlikely					
Very Unlikely					

1E	Onek discharge is too high for site capacity for attenuation. Result is increase in concentrations of contaminants of concern in water drainages downstream.
2E	Onek discharge is too high for site capacity for attenuation. Result is increase in concentration of contaminants in soils, affecting the ability to vegetation to naturally flourish.

Hector Calumet Mine Water Treatment Options Risks

Hector Calumet Option 1 - Mine Pool Drain, Centralized HDS Plant in Elsa

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely					
Possible			1C, 2E, 4C		
Unlikely			3E		
Very Unlikely				5H	

Risks of the natural environment

1C Draining the mine results in a variation in the mine pool water level. This leads to exposure of the walls of the workings to oxidation during periods of low water levels, and in turn results in metals flushing and treatment

2E Water quality worsens over the long term, leading to increased metals leaching in the mine pool.

Physical Hazards

3E Failure of the pipeline, leading to discharge of very high contaminant concentration water leaking into the receiving environment.

4C Slope hazard associated with the pipeline occurs, leading to the need for potential mitigative measures to be undertaken on the hillslope and higher construction and/or operation costs.

External health and safety risks of reagents/chemicals

5H Inability to deliver lime safely to treatment facility in Elsa (once a day frequency), leading to a fatal accident.

Hector Calumet Option 2 - Isolate from GK300 by Hydraulic Plug, Centralized HDS plant in Elsa

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain			1E		
Likely					
Possible			5H		
Unlikely			2E, 4C		
Very Unlikely				3E	

Risks of the natural environment

1E Draining the mine results in a variation in the mine pool water level. This leads to exposure of the walls of the workings to oxidation during periods of lower water levels, and in turn results in metals flushing and treatment higher costs. However, because the pool is already filled to the 400' level, there is going to be less oxidation than there would be if the mine pool were drained because there is less exposed surface.

2E Water quality worsens over the long term, leading to increased metals leaching in the mine pool.

Physical Hazards

3E Failure of the pipeline, leading to discharge of very high contaminant concentration water leaking into the receiving environment.

4C Slope hazard associated with the pipeline occurs, leading to the need for potential mitigative measures to be undertaken on the hillslope and higher construction and/or operation costs.

External health and safety risks of reagents/chemicals

5H Inability to deliver lime safely to treatment facility in Elsa (once a day frequency), leading to a fatal accident.

Hector Calumet Option 3 - Isolate from GK300, In-Mine Pool Treatment and Attenuation

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely			1E, 2E. 6R		
Possible		3E	4E, 5E		9E
Unlikely				7H	
Very Unlikely				8H	

Risks of system failure/design flaws

1E	Incomplete blocking of flow leads to less effective treatment. The result is poor water quality, leading to degradation of aquatic resources.
2E	Incomplete blocking of flow leads to less effective treatment. The result is soil contamination, leading to degradation of plant species.
3E	Water is backed up in the mine pool above the adit leading to seepage along the hillside.

Risks of the natural environment

5E	Uncontrolled seepage from the seeps in the hillside leading to contamination of the hillside, and ultimately the receiving environment.
6R	Uncontrolled seepage from the seeps in the hillside enter the Christal Creek receiving environment, leading to negative public conceptions about the quality of water in the Christal Creek watershed, and ultimately, the South McQuesten River.
9E	The attenuation capacity of the site is overwhelmed through release of contaminants in the waters, leading to high levels of zinc and other contaminants in the soils and plants of the highly sensitive permafrost environment.

External health and safety risks of reagents/chemicals

4E	Creation of toxic gaseous conditions behind the hydraulic bulkhead as a result of both the creation of a low-oxygen atmosphere and H2S gas leading to human exposure and death.
7H	Inability to deliver ethanol/methanol safely to treatment facility at Hector-Calumet (once a day frequency), leading to a fatal accident.
8H	Inability to deliver ethanol/methanol safely to treatment facility at Hector-Calumet (once a year frequency), leading to a fatal accident.

Galkeno 300 Adit Water Treatment Options Risks

Galkeno 300 - Option #1 - Current Treatment System

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain			4C		
Likely					
Possible			2E, 5E	3C, 6H	
Unlikely			1E		
Very Unlikely					

Risks of the natural environment

1E	Increased flows to ≈20-30L/s making their way all the way down to Christal Creek, leading to an impact on the receiving environment (influx of large volume of water of poor quality negatively impacts on aquatic resources in Christal Creek).
2E	Discharge route changes over time, leading to waters directly reaching the receiving environment.
3C	Increased base flows leading to increased costs (2x)
4C	Increased sludge production leads to significant increase in sludge handling costs.

Physical Hazards

5E	Collapse of the adit leads to an inability to manage the water discharging from it.

External health and safety risks of reagents/chemicals

6H	Inability to deliver lime safely on rough roads (once a day frequency), leading to a fatal accident.

Galkeno 300 Option 2 - Centralized HDS Plant in Elsa

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely			1C		
Possible			3C		
Unlikely			2E		
Very Unlikely				4H	

Risks of the natural environment

1C	Increased base flows to ≈20-30L/s leading to a need for increased treatment capacity and higher capital costs.

Physical Hazards

2E	Failure of the pipeline, leading to discharge of very high contaminant concentration water leaking into the receiving environment.
3C	Slope hazard associated with the pipeline occurs, leading to the need for potential mitigative measures to be undertaken on the hillslope and higher construction and/or operation costs.

External health and safety risks of reagents/chemicals

4H	Inability to deliver lime safely to treatment facility in Elsa (once a day frequency), leading to a fatal accident.

Galkeno 300 Option 3 - Isolate Hector Mine Pool

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain			3C		
Likely			1C		
Possible		7C	5E, 10C, 11C	8C	
Unlikely		9C	4E		
Very Unlikely			2C	6H	

Risks of the natural environment

1C	Increased flows to ≈20-30L/s leading to a need for increased treatment capacity and higher capital costs.
2C	Increased base flows (2x) leading to increased costs
3C	Increased sludge production leads to significant increase in sludge handling costs.

Physical Hazards

4E	Failure of the pipeline, leading to discharge of very high contaminant concentration water leaking into the receiving environment.
5E	Collapse of the adit leads to an inability to manage the water discharging from it.

External health and safety risks of reagents/chemicals

6H	Inability to deliver lime safely to treatment facility at Galkeno 900 (once a day frequency), leading to a fatal accident.

Risks of system failure/design flaws

7C	Water does not report to Galkeno 900 after installation of the breast-high dam, with an inability even to redirect a small flow down the hillside to GK900 leading to increased costs.
8C	Drain-down is not effective, leading to the need for a bulkhead in the workings and increased costs.
9C	Further changes to the underground flows leads to changes in plans and associated costs (e.g. seeps develop on the hillside).
10C	Pumping requirements at Hector require significant additional expenditures.
11C	Additional treatment requirements at GK900 required if bulkhead cannot adequately isolate water.

Valley Tailings Water Treatment Options Risks

Valley Tailings Area Option 1 - Stabilize in Place - Status Quo

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain			1R		
Likely					
Possible		3C	4E, 5R	2E	
Unlikely		7C			
Very Unlikely				6E	

Risks of tailings dispersion

1R Windblown tailings are dispersed beyond tailings impoundment leading to an impact on community land use

Risks of failure of Porcupine Diversion system

2E Breach or failure of the Porcupine Diversion leading to contamination of the Flat Creek drainage

3C Breach or failure of the Porcupine Diversion leading to need for upgrade/repair/maintenance of the diversion infrastructure

Risks of tailings dam breach

4E Interruption of active care and maintenance for a period of time as a result of a lack of funding, absence of site presence, etc. leading to untreated, raw effluent discharging into the Flat Creek drainage (1-2mg/L Zn discharge for 1 or 2 years)

5R Interruption of active care and maintenance for a period of time as a result of a lack of funding, absence of site presence, etc. leading to untreated, raw effluent discharging into the Flat Creek drainage (1-2mg/L Zn discharge for 1 or 2 years)

6E Major breach of tailings impoundment dams (all 3 dams) leading to large-scale release of tailings downstream into Flat Creek watershed and bog beneath dams.

Risks of contamination of receiving enviroment via tailings porewater

7C Deterioration of porewater water quality by an order of magnitude, leading to a 3-4x increase in treatment costs.

Valley Tailings Area Option 2 - Cover in Place and Revegetate

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain			1R		
Likely					
Possible		7E	4E, 6E		
Unlikely		3C	5E, 8E	2E	
Very Unlikely					

Risk of tailings dispersion

1R	Windblown tailings are dispersed beyond tailings impoundment leading to an impact on community land use
7E	Failure/erosion of the borrow area leads to release of suspended solids to the immediate natural environment

Risks of failure of Porcupine Diversion system

2E	Breach or failure of the Porcupine Diversion leading to contamination of the Flat Creek drainage
3C	Breach or failure of the Porcupine Diversion leading to need for upgrade/repair/maintenance of the diversion infrastructure

Risks of contamination of receiving enviroment via tailings porewater

4E	Drain-down of tailings porewater, leading to contamination of the receiving environment
5E	Deterioration of porewater water quality by an order of magnitude, leading to contamination of the receiving environment

Risks associated with tailings cover

6E	The cover is not thick enough, leading deep-rooted trees to take up contaminants from the tailings below the cover, or, due to wicking action (net evaporation) contaminants are brought up to the cover from the tailings

Risk of lack of QA/QC

8E	Lack of QA/QC during implementation of this option leads to inadequacies in the final product of the work

Valley Tailings Area Option 3 - Consolidate, Cover, and Revegetate

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain			1R		
Likely					
Possible		7E, 11C	4E, 6E, 9C, 10E, 12C, 13E, 15C		
Unlikely		3C	5E, 8E	2E, 14E	
Very Unlikely					

Risk of tailings dispersion

1R	Windblown tailings are dispersed beyond tailings impoundment leading to an impact on community land use
7E	Failure/erosion of the borrow area leads to release of suspended solids to the immediate natural environment

Risks of failure of Porcupine Diversion system

2E	Breach or failure of the Porcupine Diversion leading to contamination of the Flat Creek drainage
3C	Breach or failure of the Porcupine Diversion leading to need for upgrade/repair/maintenance of the diversion infrastructure

Risks of contamination of receiving enviroment via tailings porewater

4E	Drain-down of tailings porewater, leading to contamination of the receiving environment
5E	Deterioration of porewater water quality by an order of magnitude, leading to contamination of the receiving environment

Risks associated with tailings cover

6E	The cover is not thick enough, leading deep-rooted trees to take up contaminants from the tailings below the

Risks of tailings removal/relocation

9C	Wet tailings are not easily handled, leading to increased costs for tailings consolidation.
10E	Tailings berm failures (failure of the pile) during tailings consolidation leading to contamination/destruction of new creek beds and discharge of contaminants into Flat Creek drainage.
11C	Tailings berm failures (failure of the pile) during tailings consolidation leading to contamination/destruction of new creek beds and increased costs of construction and remediation.
12C	Low estimate of the amount of material the needs to be moved results in higher-than-expected costs.
13E	Residual contamination left behind after removal of the tailings leads to adverse effects on the surface water quality of the new creek beds.
14E	Risk of suspended solids loads from the rehabilitated tailings area before the area is established.
15C	Consolidation time on the relocated tailings is longer than estimated, leading to an increase in the overall cost of the operation (wait time, different contractors may have to be acquired over a number of years).

Risk of lack of QA/QC

8E	Lack of QA/QC during implementation of this option leads to inadequacies in the final product of the work

No Cash 500 Adit Water Treatment Options Risks

No Cash Option 1 - In-Mine Pool Treatment

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely		4R			
Possible		1E, 2E	3E, 5H, 8E, 10E		
Unlikely			9E	6H	
Very Unlikely			11E	7H	

Risks of the natural environment

3E	Uncontrolled seepage from the seeps in the hillside leading to contamination of the hillside, and ultimately the receiving environment.
4R	Uncontrolled seepage from the seeps in the hillside enter the Christal Creek receiving environment, leading to negative public conceptions about the quality of water in the Christal Creek watershed, and ultimately, the South
11E	Worsening of water quality over time leading to higher contaminant concentrations

External health and safety risks of reagents/chemicals

5H	Creation of toxic gaseous conditions behind the hydraulic bulkhead as a result of both the creation of a low-
6H	Inability to deliver ethanol/methanol safely to treatment facility at NC500 (once a day frequency), leading to a
7H	Inability to deliver ethanol/methanol safely to treatment facility at NC500 (once a year frequency), leading to a

Risks of system failure/design flaws

1E	Incomplete blocking of flow leads to less effective treatment. The result is poor water quality, leading to degradation of aquatic resources.
2E	Incomplete blocking of flow leads to less effective treatment. The result is soil contamination, leading to degradation of plant species.
8E	In-mine pool treatment fails to achieve target concentrations of contaminants leading to degradation of downstream water quality in the NC wetland
9E	In-mine pool treatment fails to achieve target concentrations of contaminants leading to degradation of downstream water quality in the South McQuesten watershed
10E	Mine treatment produces, over time, a significant enough amount of precipitates/solids, leading to high total metals concentrations in the discharge or blockage of discharge and overflow at the input point

No Cash 500 Option 2 - Centralized HDS

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely					
Possible			1C		
Unlikely			2E, 3C		
Very Unlikely					

Risks of the natural environment

1C	Increased base flows leading to need for increased capacity and increased capital costs

Physical Hazards

2E	Failure of the pipeline, leading to discharge of very high contaminant concentration water leaking into the receiving environment.
3C	Slope hazard associated with the pipeline occurs, leading to the need for potential mitigative measures to be undertaken on the hillslope and higher construction and/or operation costs.

No Cash Option 3 - Natural Attenuation

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely				3L	
Possible	8C		2R, 4E, 6E		
Unlikely			1E, 5E, 7E		
Very Unlikely					

Risks of the natural environment

6E	Increased base flows leading to need for increased capacity and increased capital costs
7E	Worsening of water quality over time leading to higher contaminant concentrations

Risks of system failure/design flaws

1E	Natural attenuation is unsuccessful, resulting in full load from No Cash reaching South McQuesten and leading to 15% increase in contamination in the South McQuesten
2R	Natural attenuation is unsuccessful, resulting in full load from No Cash reaching South McQuesten and leading to public concern
3L	Natural attenuation is unsuccessful, resulting in full load from No Cash reaching South McQuesten and leading to 15% increase in contamination in the South McQuesten and breach of regulation under current WUL
4E	Onek discharge is too high for site capacity for attenuation. Result is increase in concentrations of contaminants of concern in water drainages downstream.
5E	Onek discharge is too high for site capacity for attenuation. Result is increase in concentration of contaminants in soils, affecting the ability to vegetation to naturally flourish.
8C	Rerouting flows into pipe changes natural stream flows which causes glaciation and disrupts highway conditions/travel

Keno 700 Adit Water Treatment Options Risks

Keno 700 Option 1 - No Treatment (Mine Flood) with Water Management

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely				4E	
Possible			1E, 2R	3L	
Unlikely				5E	
Very Unlikely					

Risks of the natural environment

5E Worsening of water quality over time leading to higher contaminant concentrations

Risks of system failure/design flaws

1E Full load from Keno 700 continues to reach Lightning Creek and leads to heightened problems as a result of the high proportion of contamination in Lightning Creek from Keno 700

2R Full load from Keno 700 continues to reach Lightning Creek and leads to heightened contamination in Lightning Creek leading to public concern

3L Full load from Keno 700 continues to reach Lightning Creek and leads to heightened contamination in Lightning Creek leading to breach of regulation under current WUL

4E Installation of bulkhead causes dissolution of oxidation products which increases mine adit discharge loads temporarily during flooding

Keno 700 Option 2 - Bioreactor

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely					
Possible			6C		
Unlikely			1E, 3H, 5E	2H	
Very Unlikely				4H	

Risks of the natural environment

5E Worsening of water quality over time leading to higher contaminant concentrations

6C Increased base flows and/or water quality degradation leading to need for increased capacity and increased capital costs

External health and safety risks of reagents/chemicals

2H Release of H2S from the bioreactor with human exposure leading to serious illness or a fatality.

3H Line leak (as a result of vandalism) leading to expulsion of methanol/ethanol to environment and exposure causing blindness/bodily harm/toxicity effects.

4H Inability to deliver ethanol/methanol safely to treatment facility at Keno 700 (seasonally), leading to a fatal accident.

Risks of system failure/design flaws

1E Wholescale failure of bioreactor treatment facility at a slow rate, leading to release of contaminants into the environment.

Elsa Village Closure Options Risks

Elsa Village Option 1 - Do Nothing

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely			6R	1H, 2E, 3H, 4L, 5C	
Possible					
Unlikely			7H		
Very Unlikely					

1H	Serious accident or fatality in or on a dilapidated building or structure in Elsa
2E	Hazardous chemicals from buildings lead to environmental damage
3H	Hazardous chemicals from buildings lead to health and safety problems
4L	Serious accident or fatality in or on a dilapidated building or structure in Elsa
5C	Serious accident or fatality in or on a dilapidated building or structure in Elsa
6R	Failure to preserve representative heritage values leads to poor reputation
7H	Failure of site infrastructure leads to inaccessibility of roads

Elsa Village Option 2 - Demolish Buildings and Implement Heritage Plan

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely			4E		
Possible			1H		
Unlikely		2E			3H
Very Unlikely					

1H	Hazardous materials and abatement program is ineffective, leading to physical impairment
2E	Hazardous materials and abatement program is ineffective, leading environmental impact
3H	Dismantling of building leads to worker fatality
4E	Demolishing buildings without proper consultation/heritage plan leads to

Mitigated High Risk Closure Options

Likelihood	Consequence Severity				
	Very Low	Minor	Moderate	Major	Critical
Almost Certain					
Likely		3			
Possible		4, 6, 7, 8, 9, 10	1		
Unlikely		13, 14	2, 5		
Very Unlikely		12, 15, 16		11	

Tailings - Status Quo

1	Windblown tailings are dispersed beyond tailings impoundment leading to an impact on community land use
2	Breach or failure of the Porcupine Diversion leading to contamination of the Flat Creek drainage

Tailings - Cover (either with or without consolidation)

3	Windblown tailings are dispersed beyond tailings impoundment during cover construction leading to an impact on community land use

In-Mine Pool Treatment

4	Draining the mine (**Hector Calumet**) results in a variation in the mine pool water level. This leads to exposure of the walls of the workings to oxidation during periods of lower water levels, and in turn results in metals flushing and higher treatment costs. However, because the pool is already filled to the 400' level, there is going to be less oxidation than there would be if the mine pool were drained because there is less exposed surface.

Redirect Hector-Calumet Flow Away from Galkeno 300 to Galkeno 900

5	Drain-down is not effective (Hector Calumet isolation from **Galkeno 300** adit to provide closure for GK300), leading to the need for a bulkhead in the workings and increased costs.

Natural Attenuation (Do Nothing Scenario)

6	The attenuation capacity of the site (from **Hector Calumet**) is overwhelmed through release of contaminants in the waters, leading to high levels of zinc and other contaminants in the soils and plants of the highly sensitive permafrost environment.
7	Natural attenuation is unsuccessful, resulting in full load from **No Cash** reaching South McQuesten and leading to 15% increase in contamination in the South McQuesten and breach of regulation under current WUL
8	Full load from **Keno 700** continues to reach Lightning Creek and leads to heightened contamination in Lightning Creek leading to breach of regulation under current WUL

Conventional (Local) Lime/HDS Treatment at GK 300

9	Increased base flows leading to increased costs (2x)
10	Increased sludge production leads to significant increase in sludge handling costs.

Elsa Village Closure

11	Inability to deliver lime safely on rough roads to remote sites (once a day frequency), leading to a fatal accident.
12	Serious accident or fatality in or on a dilapidated building or structure in Elsa
13	Hazardous chemicals from buildings lead to environmental damage
14	Hazardous chemicals from buildings lead to health and safety problems
15	Serious accident or fatality in or on a dilapidated building or structure in Elsa
16	Serious accident or fatality in or on a dilapidated building or structure in Elsa