ALEXCO ENVIRONMENTAL GROUP

KENO HILL SILVER DISTRICT

CLOSURE OPTIONS REPORT

November 2013

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ACRONYMS

AAM	Assessment and Abandoned Mines
AANDC	Aboriginal Affairs and Northern Development Canada
AKHM	Alexco Keno Hill Mining Corporation
ARD	Acid Rock Drainage
BOD	Biological Oxygen Demand
CDA	Canadian Dam Association
COC	Contaminants of Concern
CWQG	Canadian Water Quality Guidelines
DIAND	Department of Indian Affairs Northern Development
EBA	EBA Engineering Consultants Ltd., a Tetra Tech Company
EC	Environment Canada
ERDC	Elsa Reclamation and Development Company
ESM	Existing State of Mine
FNNND	First Nation of Nacho Nyak Dun
HHERA	Human Health and Ecological Risk Assessment
HHRA	Human Health Risk Assessment
IPRP	Independent Peer Review Panel
ITL	Interralogic
KHSD	Keno Hill Silver District
LTF	Land Treatment Facility
ML/ARD	Metal Leaching or Acid Rock Drainage
MNA	Managed Natural Attenuation
NCC	No Cash Creek
PAG	Potentially Acid Generating
UKHM	United Keno Hill Mines
VTF	Valley Tailings Facility
WQ	Water Quality
WRSA	Waste Rock Storage Areas
WTF	Water Treatment Facility
YESAA	Yukon Environmental and Socio-economic Assessment Act
YESAB	Yukon Environmental and Socio-economic Assessment Board
YG	Yukon Government
ZVI	Zero Valent Iron

1 INTRODUCTION

This updated Closure Options document was created by Elsa Reclamation and Development Company Ltd. (ERDC) with input from three governments: Canada, through the Aboriginal Affairs and Northern Development Canada (AANDC) department, Yukon Government (YG) through the Assessment and Abandoned Mines (AAM) branch, and the First Nation of Nacho Nyak Dun (FNNND) through the Lands and Resources Department. This document discusses options for the closure of the former United Keno Hill Mines (UKHM) and associated facilities within the Keno Hill Silver District (KHSD), and incorporates feedback received from AANDC and input from the expert departments and Independent Peer Review Panel (IPRP) sponsored by AANDC, YG, AAM and the other departments solicited by AAM for input, and FNNND and their consultants. 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 for the mine sites and components of the UKHM liabilities.

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 with respect to their potential receiving environment water quality effects;
- A description of the risk assessment process and preliminary outcomes that guided some of the refinement of options that are presented;
- Discussions on the post-implementation monitoring requirements;
- Initial costing for the proposed closure of the sites; and
- A high level schedule for the remainder of the project.

1.1 KENO HILL SILVER DISTRICT KNOWLEDGE STATUS

Since the initiation of the closure planning process (Access 1996), 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 reclamation and remediation 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 reference list in Section 11 provides a listing of the studies that have been completed on the site, and other relevant studies, both historical and contemporary that

will assist in evaluating the closure options and eventually, selection of the final closure options for the UKHM Closure Plan. Copies of the references have been added to a SharePoint site which access will be provided.

ERDC believes that the current knowledge base is sufficient to advance the identified options to the selection process; however, there are still several studies underway that will further the knowledge of the site environmental conditions or processes. The results of these studies will be incorporated into the design of the selected options as well as used in the Existing State of Mine (defined in the Subsidiary Agreement as the state of the mine, known or unknown, existing prior to Initial Closing) Reclamation Plan (ESM), environmental assessment and water licencing applications. These studies include:

- Soil Assessment of historically and recently, under the Physical Hazards Reduction Program, disturbed areas in and around Elsa, to understand how to reduce the level of contamination and lessen the potential risk for human and environmental health related to these sites as required under the *Contaminated Sites Regulations* (CSR). The second year of this study is currently underway;

- Soil and vegetation metals sampling of background and existing conditions to inform terrestrial closure planning for individual sites within the former UKHM claims is in the third and final year. A comprehensive report is scheduled for completion quarter four, fiscal year 2013/14;

- Ecosystem mapping to better understand the vegetation species that occupy disturbed and undisturbed sites in order to help guide revegetation activities during implementation of the ESM Reclamation Plan is scheduled for completion quarter four, fiscal year 2013/14;

- Characterization of the distribution, thickness, and geochemistry of Wernecke tailings that migrated off-claim. This work began in September 2013 and is expected to inform closure options for these off-site tailings.

- Site specific risk assessment of soil metals in Elsa and other disturbed sites in order to evaluate the endpoint for reclamation activities at these areas will be completed by SENES Consultants quarter four, fiscal year 2013/14;

- Site specific risk assessment and monitoring of dispersed tailings in order to better understand the residual risk associated with pods of tailings within Christal Creek and Flat Creek will be completed by SENES Consultants quarter four, fiscal year 2013/14;

- Cover trial construction at the Valley Tailings Facility (VTF) and Husky Mine to test the performance of covers on tailings and waste rock was constructed in quarter three, fiscal year 2013/14. To ensure plant establishment takes place over the full growing season, soil amendment and vegetation trials application and seeding will take place quarter one, fiscal year 2014/15;

- Seasonal monitoring of water quality of streams draining the UKHM claims within the Keno-Ladue watershed; and

- Annual monitoring of physical extent of tailings migration of Sadie Ladue, Mackeno and Valley Tailings.

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. Power to the property is supplied by the Yukon Energy Corporation from the Wareham Dam, a five megawatt hydro dam located near Mayo. Site access and care and maintenance of treatment facilities at several water producing mine sites is maintained by ERDC under contract with AANDC. The site has been under "Care and Maintenance" by various operators since the cessation of production in 1989.

The Keno Hill Silver District is situated on approximately 827 mineral claims, and on three adjacent mountains, Keno Hill, Galena Hill, and Sourdough Hill and adjacent valleys. The area covered by claims and leases is a 15,000 ha. (37,000 acres) elongate 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.

Many buildings of the old Elsa townsite and old mine workshop, previously owned by Unity Keno Hill Mines Ltd, remain situated on the property. On-going physical hazards reduction (Access 2008b; 2009b; 2009c; 2009h; 2010a) has removed some of the higher risk sites (e.g. accessible open shafts, unstable or collapsing buildings) but the majority of the buildings that were present on site in 2006 remain.

All of the silver deposits are located within a 20 km radius of Elsa, where the UKHM site administration offices were located. Elsa was a company town during the active mining period and the remaining facilities, which are no longer in use, include houses, school, post office, bunkhouses, mine dry offices, warehouse, transport shop, machine shop, carpentry shop and assay laboratory. The former Community Hall and maintenance shop are currently being utilized by ERDC. The remains of 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.





ERDC

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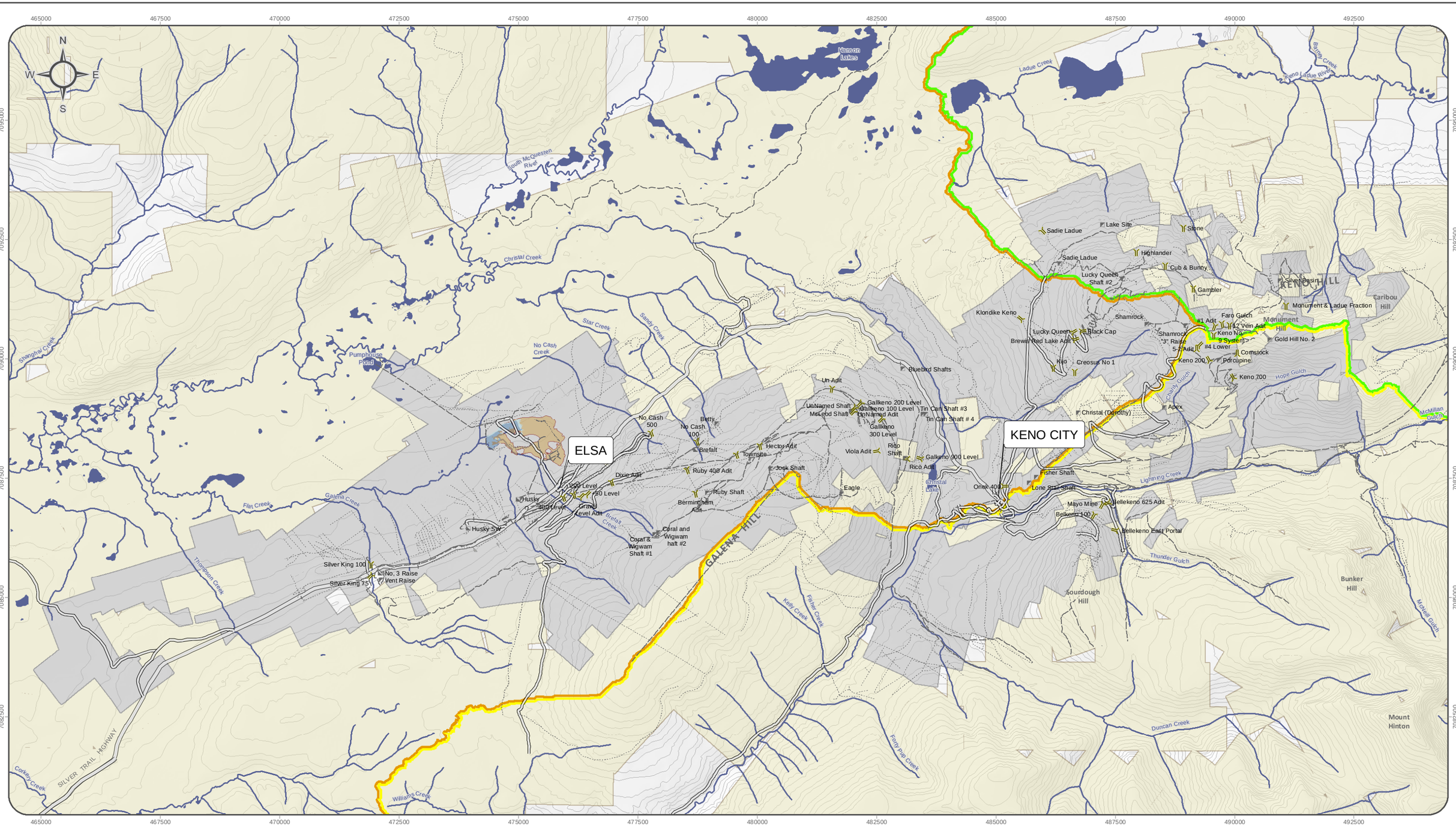
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CLOSURE OPTIONS REPORT

FIGURE 2-1
PROJECT LOCATION

FEBRUARY 2013

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(*Last edited by: mduchame; 11/02/2013/16:00 PM*)



Canvec compiled by Natural Resources Canada at a scale of 1:10,000 - 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. Watersheds derived from Canvec data using ESRI Spatial Analyst and National Hydrology Network.

Quartz claim boundaires and ownership are current as of Mar 26th 2012. Data obtained from Yukon Mining Recorder. Data source: http://geomaticsyukon.ca.

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

1:75,000 (when printed on 11 x17 inch paper)

0 0.5 1 2 3 4 5 Kilometers

- Adit
- Shaft
- Contours (100 ft)
- Watercourse
- Waterbody
- Valley Tailings Ponds
- Valley Tailings
- Other Quartz Claims
- ERDC Owned Quartz Clains

Catchments

- Keno Ladue River
- Mayo River
- South McQuesten River

ERDC

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CLOSURE OPTIONS REPORT

FIGURE 2-2
PROPERTY OVERVIEW

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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 and the Sadie Ladue drainage system is located north-east of the property. The climate is characterized by hot dry summers with peak stream flows mainly occurring in spring due to snowmelt, although increases in stream flow 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 between 1350 m and 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 local ecosystem supports a wide range of biological resources. These resources have been traditionally relied upon by the Nacho Nyak Dun First Nation 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. Of the endangered species listed under SARA for the Yukon, a few Woodland Caribou have been seen occasionally in the UKHM area and droppings have been encountered during soil and vegetation sampling. The Olive-sided Flycatcher is also likely in the area, but a bird survey has not been performed to confirm this. 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.

2.2.1 Hydrology

The Keno Hill Mining District lies within the following three drainage basins which ultimately drain into the Yukon River southwest of the District:

- South McQuesten River
- Lightning Creek/Duncan Creek; and
- Keno Ladue River.

The majority of the Keno Hill Mining District lies within the midsection of the South McQuesten River basin (Figure 2-3). Appendix R presents hydrographs for Lightning Creek, Christal Creek and Flat

Creek which provides an update to Clearwater Consultants Ltd., 2007 report. Appendix S presents meteorological data for three weather stations in the Keno district. The weather stations are located at the valley tailings, on Galena Hill and in the head waters of Christal Lake at Alexco's District Mill.



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Watersheds were derived using the Canvec data with ESRI Spatial Analyst.
Quartz claim boundaires and ownership are current as of Mar 26th 2012. Data obtained from Yukon Mining Recorder.

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

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Road
Watercourse
Waterbody
ERDC Quartz Claims

Cathcments
Keno Ladue River
Mayo River
South McQuesten River

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CLOSURE OPTIONS REPORT

FIGURE 2-3

CATCHMENT AND SITE LOCATIONS

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2.2.2 Regional Water Quality

The area is underlain by mid Paleozoic meta-sedimentary rock over thrust 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 (Minnow 2008). The background concentrations of aluminum, copper, and (marginally) selenium at reference, non-mining impacted sites are elevated compared to water quality guidelines (Minnow 2013a).

Historic mining within the South McQuesten River drainage has resulted in local drainages being impacted by mining activity (Figure 2-4). The Flat, Christal, No Cash and Lightning Creek drainages have been most impacted as indicated by surface water quality and metal loading studies and by fisheries studies (Access 2009a; DOE 1989; EC 1995; ERDC 2010; Fisheries & EC 1978; Minnow 2008; 2009). Zinc and cadmium, in particular, appear to have impacted these streams, supplied by numerous point sources throughout the UKHM property (Appendix M). These have resulted in two fold exceedances of the Canadian water quality guidelines (CWQG) for median zinc and cadmium concentrations in the receiving environment for Flat Creek and the No Cash Bog (Minnow 2013a; Interralogic 2013d). The downstream waters of Christal Creek are more heavily impacted, with median cadmium and zinc concentrations some 4 to 5 fold higher than the CWQG, while the receiving environment of Lightning Creek meets CWQG for the median concentrations of both zinc and cadmium (Minnow 2013a). The temporal changes in total and dissolved metal concentrations for zinc, cadmium and other metals in the receiving environment waters of Flat, Christal, and Lightning Creek drainages between 2005 and 2013 is displayed in Appendix N. Metal concentrations are often highest during freshet, likely associated with runoff from upstream sources and dissolution of secondary minerals formed over the winter, producing a pulse of metal levels (Minnow 2008). Total metal concentrations are also often markedly higher than the dissolved fraction, and while the dissolved zinc and cadmium concentrations are frequently above their respective CWQG, the dissolved fraction of other metals rarely exceeds their CWQG (Appendix N; Minnow 2013a).

These smaller drainages, except for Lightning Creek which is contained within a separate watershed which drains into Mayo River, empty into the South McQuesten River and have historically produced noticeable, but generally slight, changes in this river's water quality. Elevated zinc and cadmium levels were noted to be particularly pronounced during low flow periods. Cadmium and zinc are identified as the primary contaminants of concern (COCs) related to the UKHM complex, while other substances were identified as possible COCs (Minnow 2011a). The extent of sites sampled, the detection limits, and range of parameters tested has been continuously improved based on input from Minnow, and a more recent examination of an optimized data set indicated that cadmium and zinc were still the only COCs, however, ammonia and cyanide are listed as potential COCs due to insufficient data for these constituents (Minnow 2013a; Appendix O).

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 CCME (1999) water quality guidelines established for the protection of freshwater aquatic life (Minnow 2008).

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 2005; Interralogic 2011c; Minnow 2011a). In mid-2007, it was noted that the concentration of various metals including zinc had increased at established water quality monitoring sites on the South McQuesten River. Further examination indicated that the concentrations have been above the CWQG since mid-2006 and that a source upstream of UKHM, likely Cache Creek, was responsible for the increase in water concentrations in the South McQuesten River (Minnow 2011a). Interralogic (ITL) (2011c) suggests the major source of metals to Cache Creek is located in a scree field in the upper headwater region of the watershed in an area off of UKHM claims The Cache Creek drainage has had some minimal surface exploration but no documented substantial mining activity, making this site a limiting factor on the South McQuesten River water quality based on an apparent natural source of elevated metals. There is at the present time no plausible explanation for the recent increases of metals in Cache Creek, but it is so far from the Keno site that further study of the causes of the change in water chemistry in Cache Creek is beyond the scope of this project.

Lightning Creek is wider than the other tributaries (3.5 to 9 m wetted width at time of survey) and characterized by coarse substrate including gravel, cobble and boulder and relatively fast water (> 1 m/s) in some up-stream areas, flowing as riffles and rapids (Sparling 2006). Lightning Creek is situated within a narrow valley flowing from the north side of Sourdough Hill into Duncan Creek, draining into the Mayo River not connected to the South McQuesten River. Lightning Creek has been the site of extensive historical and current placer mining undertakings upstream of Keno City. The Lightning Creek drainage has been affected by localized quartz mining activities; mine adit drainages from Bellekeno 625 and the historical Keno 700 report to Lightning Creek. Background levels of COCs are elevated almost exclusively due to the impact from the Keno 700 adit, and potentially waste rock in that area (Access Consulting 2011; Interralogic Inc., 2013c). Placer mining, which has taken place on Lightning Creek and its tributary Thunder Gulch since at least the 1960s has a significant effect on water quality with respect to suspended solids, but the extent of effects on COCs is not significant, i.e., mass loading of COCs above and below the placer mining activity is roughly equivalent (Access Consulting 2011). Thus this closure planning process is proceeding without any further attention on the effects of placer mining activity on water quality effects in Lightning Creek; although the extent that the Lightning Creek fishery can be optimized will necessarily take into account the placer mining activity.

The Sadie Ladue drainage, northwest-northeast of the UKHM property, has been affected by mining activities that took place between 1921 and 1932. Tailings from the Wernecke Camp Mill are present

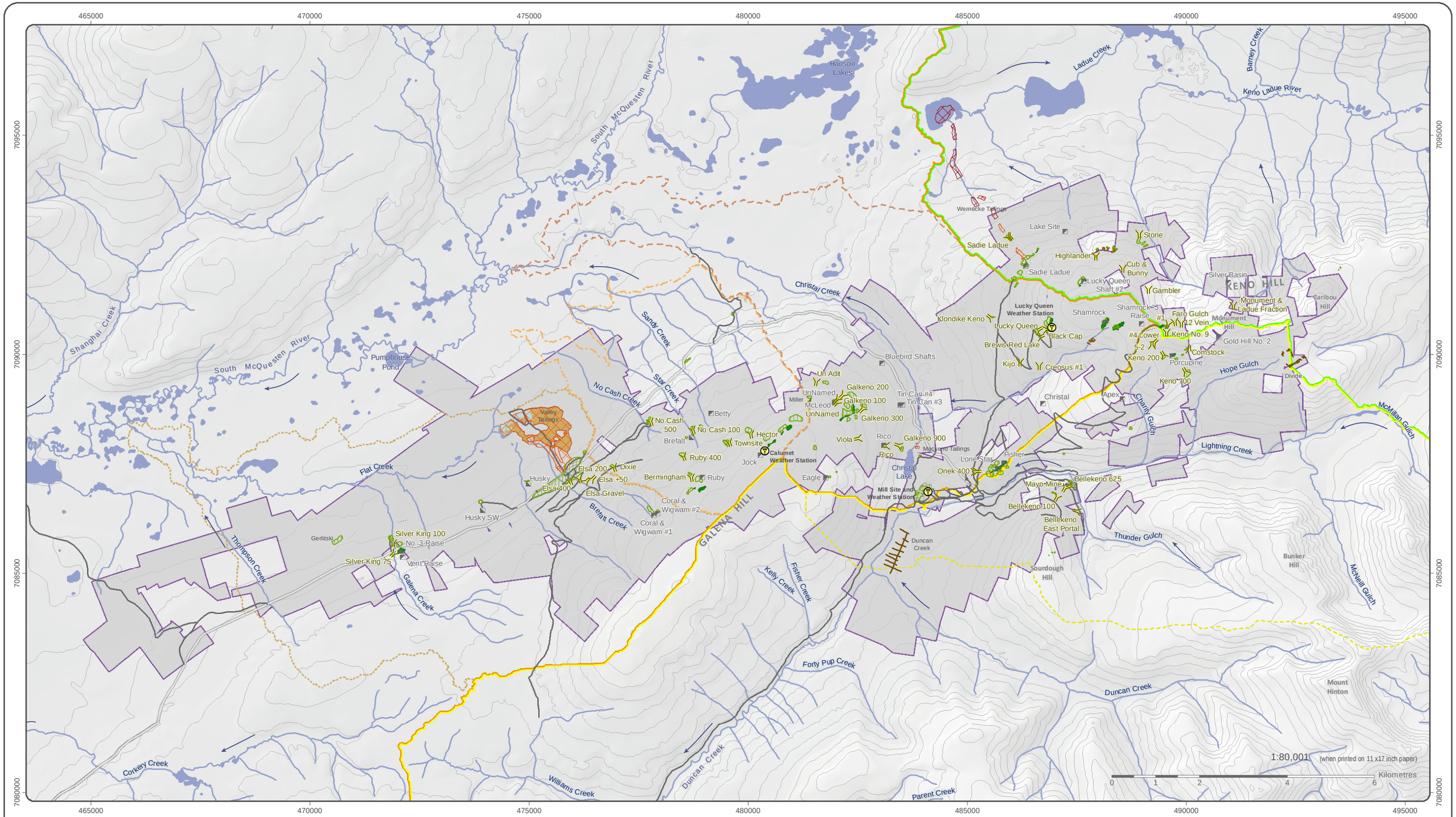
along the length of the drainage to the unnamed lake 2.5 km north-northwest of the UHKM property; however, the UKHM on-site claims are represented in the upper 140 m of the watershed, only 3.5% of its length. Surface water quality in the Sadie Ladue drainage varies roughly one order of magnitude over the length of the drainage from the headwaters at the adit to the mouth of the creek into the unnamed lake (Interralogic Inc., 2012a). In general, metals concentrations varyingly increase and decrease throughout its length which apparently is being affected by tailings that are dispersed along the length of the creek. A synoptic sampling of the Keno Ladue watershed was initiated in late fall 2012, and continues quarterly through 2013. The results of the sampling are presented in Appendix T including a discussion on water quality trends in the watershed.

2.2.3 Keno District Groundwater

There have been several groundwater investigations conducted in the Keno District. These investigations are summarized in the following documents consisting of reports, maps, and borehole logs which are presented in Appendix S:

- Interralogic Inc. Technical Memorandum Update: Keno City Groundwater Evaluation, (March 2012)
- SRK Consulting 2010 Bellekeno Groundwater Program (SRK 2010)
- SRK Consulting 2008 Technical Memorandum Assessment of Groundwater Regime at the Valley Tailings Facility (SRK 2009)
- Map of Keno Basin Groundwater Monitoring Station Locations (Figure 1 in Appendix D of Appendix S)
- Water Quality Results (September/October 2013 results)

The results show the mine sites with the most significant groundwater associated problems include Silver King, Galkeno 300, Galkeno 900, and Onek, where arsenic, cadmium, sulphate and zinc all exceeded guidelines by substantial margins, and in some cases other metals also exceeded guidelines. Sites with minor or no exceedences included Husky and Husky SW,



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Watersheds were derived, where possible, with ESRI Spatial Analyst with hydrography and contours derived from 2006 aerial imagery obtained from Aero Geometrics, Calgary Alberta. Extensions of the watersheds were created with Canvec data and ESRI Spatial Analyst.
Quartz claim boundaires and ownership are current as of Mar 26th 2012. Data obtained from Yukon Mining Recorder.

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

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- Adit
- Shaft
- Weather Station
- Highway
- Secondary Road
- ERDC Quartz Claims
- Off-Claim Tailings
- On-Claim Tailings
- Waste Rock Dump
- Open Pit
- Trenching

Catchments
- Keno Ladue River
- Mayo River
- South McQuesten River

Subcatchments
- Christal Creek
- No Cash Bog
- Flat Creek
- Lightning Creek

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CLOSURE OPTIONS REPORT

FIGURE 2-4

MINE SITES AND CATCHMENT DRAINAGE

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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 ore 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 Hills.

The only mine located on Sourdough Hill is the Bellekeno underground mine which was originally mined by Mackeno Mines from adits at the 100 and 200 levels in the 1950's (Access 1996). The mine is in the Lightning Creek watershed, a tributary to Duncan Creek which drains in to the Mayo River. The Keno Mine was brought into production in 1962 as reserves at the Hector-Calumet and Elsa Mines declined in the early 1960s. 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, and 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 UKHM 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 1996) presents the history, quantities of ore production, waste type, and waste rock quantity for each component or site. The Closure Issues Report (Access 2009e) summarizes the specific closure issues related to all of the individual sites across the District.

The following list 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, via Flat Creek, Christal Creek, and possible groundwater pathways through the bogs on the north side of Galena Hill.

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

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

These properties are located on drainages that go to different watersheds; Sadie Ladue to the Ladue Creek watershed, Keno 700 (which includes Comstock-Keno and Porcupine Mine) to Lightning Creek, and Lucky Queen, Shamrock and Onek to the South McQuesten River watershed via Christal Creek. The Mackeno mill site is located immediately adjacent to Christal Creek.

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.

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 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 competitive 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 Ltd. (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 (Komex 2005). Water Use Licence QZ06-074 was issued on November 14, 2007 for Care and Maintenance activities on the property and has since been renewed and reissued as Water Use Licence QZ12-057. 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, AANDC has entered into a contractual Subsidiary Agreement 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. Elements required to develop the Closure Plan include, but are not limited to: identification of significant reclamation related site issues/components; development of closure objectives; identification of alternative reclamation and closure options; input from the First Nation of Nacho Nyak Dun has been sought; selection of a preferred option; and preparation of plans and other documents required for assessment under the *Yukon Environmental and Socio-Economic Assessment Act* (ERDC; Alexco; Canada; YG 2006). Costs for the development and implementation of the Closure Plan include both funding from Government of Canada, through AANDC, and cost sharing by ERDC.

In the event that ERDC wishes to designate a portion of the UKHM property in order to conduct development and production (a “Production Unit”), agreements between AANDC and ERDC governs which party is responsible for the costs of reclamation requirements and water related components of that Production Unit. The Bellekeno Mine Production Unit has been removed from the closure planning process as it has been designated as a Production Unit under the agreement, where water treatment liability is entirely ERDC’s responsibility and terrestrial and infrastructure liability of the historic Bellekeno Mine remains with Canada. Discussions are currently ongoing between ERDC and AANDC concerning the proposed Production Units for the Lucky Queen and Onek mines that Alexco is

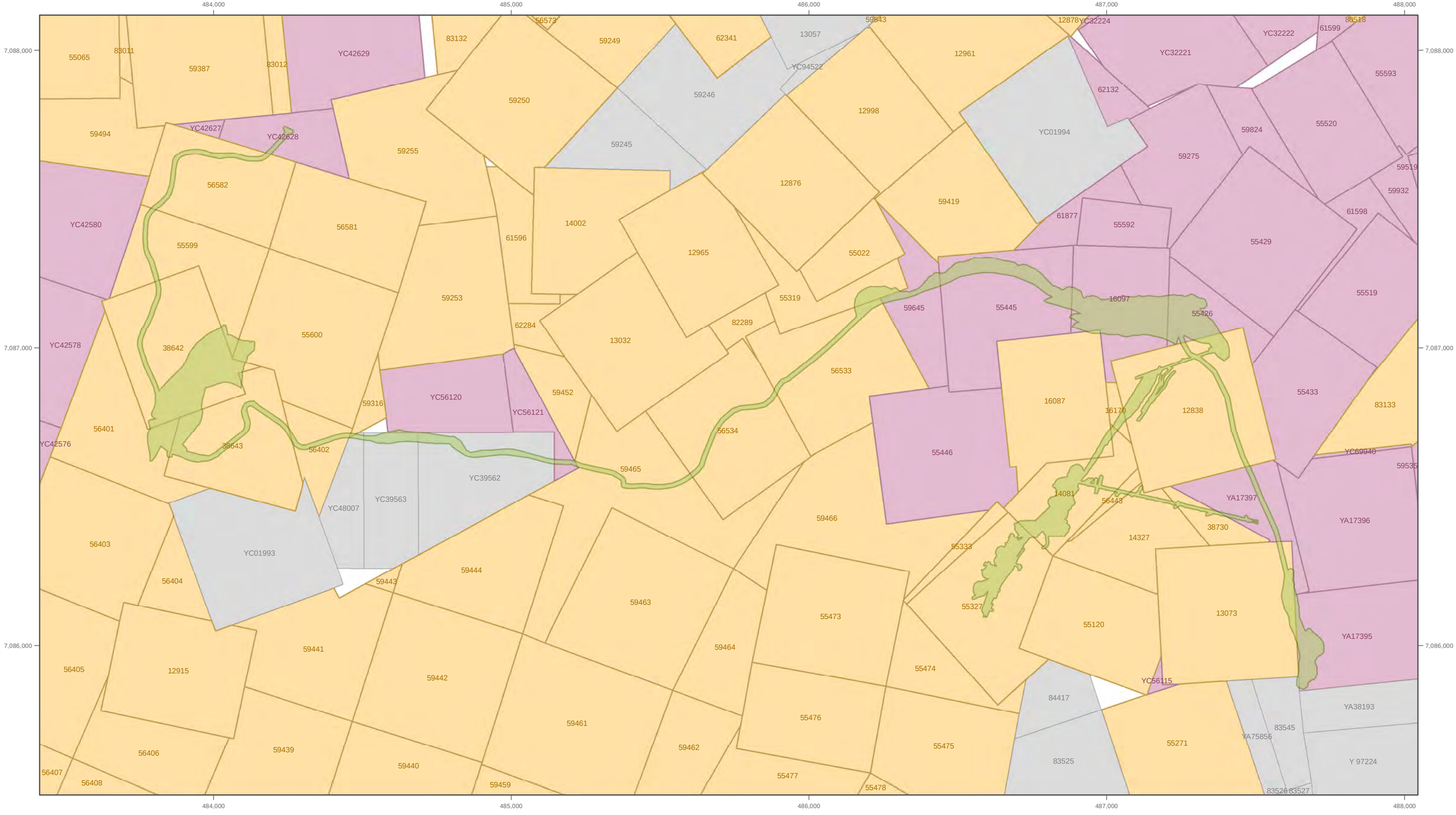
currently seeking to commence operations on. Any overlapping areas between these new Production Units and the historical UKHM claims will be removed from the closure planning process.

This 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, AANDC, YG, FNNND, and consultation with stakeholders, a closure and reclamation plan will be submitted for environmental assessment by the Yukon Environment and Socio-economic Assessment Board 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. The Bellekeno Mine and the Flame and Moth areas are now part of the Alexco operating mine and mill (the Bellekeno Production Unit) and as such these sites are excluded from further consideration in this Closure Options Report. Figure 3-1 shows the Bellekeno Production Unit.

AKHM is currently negotiating with Canada the spatial extent related to the proposed Lucky Queen and Onek Production Units and once such an agreement is agreed to with Canada these units will also be excluded from the closure planning process.



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 ofOctober 12th 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

CLOSURE OPTIONS REPORT

FIGURE 3-1
BELLEKENO PRODUCTION UNIT SUBSIDIARY AGREEMENT

I:\ALEX-05-01\Bellekeno\GIS\mxd\Permitting\Production_Unit_Agreement\Fall_2010\Claims_20101027_modified_20121218.mxd
(Last edited by: mduchame; 11/02/2013/16:14 PM)

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 108 underground working entrances, including adits and shafts (25 adits and 20 shafts on Galena Hill, 39 adits and 18 shafts on Keno Hill and 6 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 2008a). 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 108 underground working entrances, including adits and shafts (25 adits and 20 shafts on Galena Hill, 39 adits and 18 shafts on Keno Hill and 6 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 2008c) 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 build up 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.

3.2.1 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 was thought 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 (up to 1 mg/L zinc) have been observed. These seeps may provide a limited source of zinc and other metals into the headwaters of Christal Creek and Christal Lake. However, it is also 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. Seeps in the KHSD are sometimes elevated as a result of natural mineralization (for example the seepage near the LES-66 sampling site has been recently associated with a newly discovered vein in 2013 (Alexco 2013), and in other cases appears to be a result of untreated mine pool discharge

Other water management facilities at the site are generally associated with treatment facilities at the adits and at the Valley Tailings. The Galkeno 300 adit has undergone significant improvements to the water management program (Access 2010b). In 2010 and 2011, a complete adit overhaul took place and a seacan is now in place as the new secure adit entrance. The area around the structure was covered with soil to help with water seepage and provide insulation. The surrounding ground was landscaped to remove some of the steep walls and to improve and control surface drainage. The corridor leading to the Sime pit, which is used for storage of sludge from Galkeno 300 settling also had some improvements made to its slope. The pipeline in the corridor had service curves installed in key place to manage seasonal shrinkage and expansion.

The Galkeno 900 adit water management system has undergone major repairs. The old adit was removed and a seacan was butted against the rock face. The structure was then covered with soil to help with water seepage and provide some insulating factor.

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, the Porcupine Diversion and a diversion channel (Figure 3-6) on the south and east side of the tailings ("No Cash Diversion" because it discharges into the No Cash bog) are maintained to limit inflows into the Valley Tailings ponds.

3.3 MINE WATER TREATMENT

Metals-laden water discharges continuously from various mine openings throughout the Keno Hill Silver District (Figure 3-2).

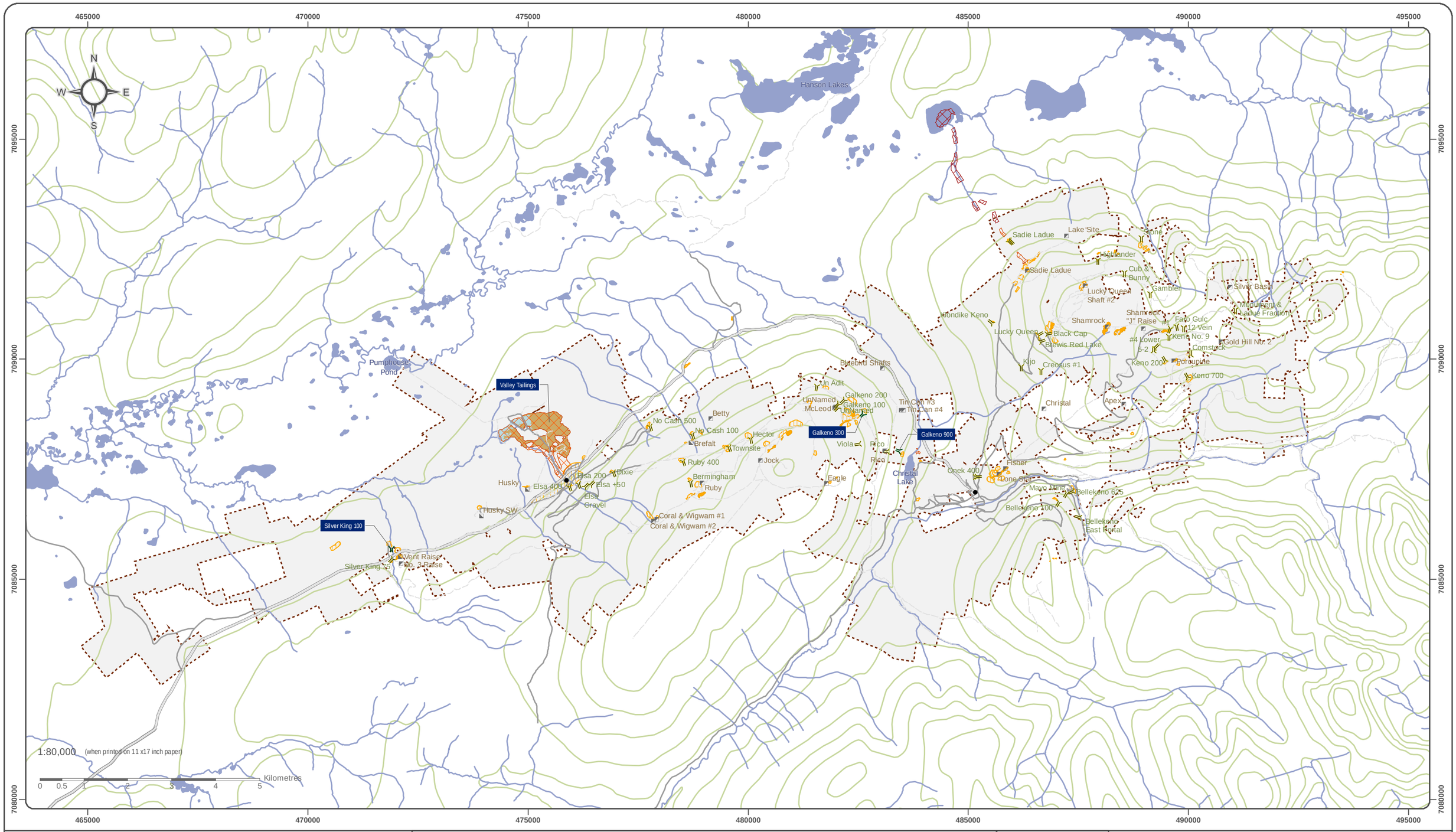
The quality of this effluent in most cases fails to comply with water licence effluent discharge criteria for the site. In order to reduce metals levels, water treatment is required on an ongoing basis.

The treatment system for three existing continuous 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 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 analysed 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 shown a high degree of correlation with the daily assays of the on-site lab facilities (ERDC 2012). Figures 3-7 to 3-9, located in section 3.3.2 show treatment results compared against the water licence effluent quality standards for Galkeno 300, Silver King 100 and Galkeno 900 adits from January 2004 to January 2012. Further information about water treatment operations can be found in annual water licence reports which are submitted to the Yukon Water Board as part of the licencing conditions.

Upon closure, these interim Care and Maintenance facilities will be included in the site clean-up activities at Silver King, Galkeno 300, and Galkeno 900 mine sites. It is not anticipated that any significant Care and Maintenance facilities will be incorporated in a final water treatment system, and consequently decommissioning the sites and closing the sludge handling ponds, removal of tanks etc.,

is included in the costs to close these sites once the selected closure options have been implemented and shown to be operating effectively.



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Treatment Sites

- Town
- Treatment Adit
- Adit
- Shaft
- Highway
- Secondary Road
- Track
- Watercourse
- Waterbody
- ERDC Quartz Claims
- Open Pit,
- Waste Rock Dump
- Off-Claim Tailings
- On-Claim Tailings

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CLOSURE OPTIONS REPORT

FIGURE 3-2
MINE WATER TREATMENT SITES

FEBRUARY 2013

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3.3.1 Existing Treatment Process General Description

Water treatment was initiated in 1993 at three of the adits with direct drainage into creeks (Silver King, Galkeno 900, and Bellekeno 625) due to concerns with metal concentration in adit discharges. Treatment at Galkeno 300 was added at a later time as it was recognized to have become a major source of metals to Christal Creek in the late 1990s and early 2000s. Treatment at the Bellekeno 625 adit is not discussed further in this report as that facility is no longer a part of the closure program. Water treatment is conducted year-round at the Galkeno 900 adit (Figure 3-3) the Galkeno 300 adit (Figure 3-4) and the Silver King 100 adit (Figure 3-5). Treatment is also conducted at the Valley Tailings Facility (Figure 3-6) on a seasonal and as-needed basis, depending on water quality and decant situation -primarily during spring freshet, between May and June. The Valley Tailings Facility has been actively treated four of the last six years, with the other two years not requiring treatment based on excess residual lime already in the system from previous treatment cycles.

In general, the treatment processes for the care and maintenance sites currently involves continuous lime addition to mine portal effluent water at all four adits and on an as needed basis at the Valley Tailings Facility. The treatment objective is operationally to reduce total zinc effluent concentrations to less than 0.50 mg/L, as required under the original Water Use Licence QZ06-074 and the same standards apply under the renewed Water Use Licence QZ12-057. Historic correlations between zinc concentrations and other metals (i.e. arsenic, lead and cadmium) indicate that when the zinc discharge treatment objective is met, the concentrations of these other metals also meet the licence standards. There are other licence requirements for water treatment including suspended solids; when suspended solids exceed the discharge criteria then metals which have been precipitated can remain suspended and exceed the treatment criteria as part of the suspended solids.

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 utilizing internal resources and SENES Consultants (Access 2008a; SENES 2009). This resulted in recommendations for process improvements to both the treatment plant and the sludge management systems at the site which were carried out as Phase I and II of the 2008 and 2009 ERDC Care and Maintenance Special Projects Workplans. 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.

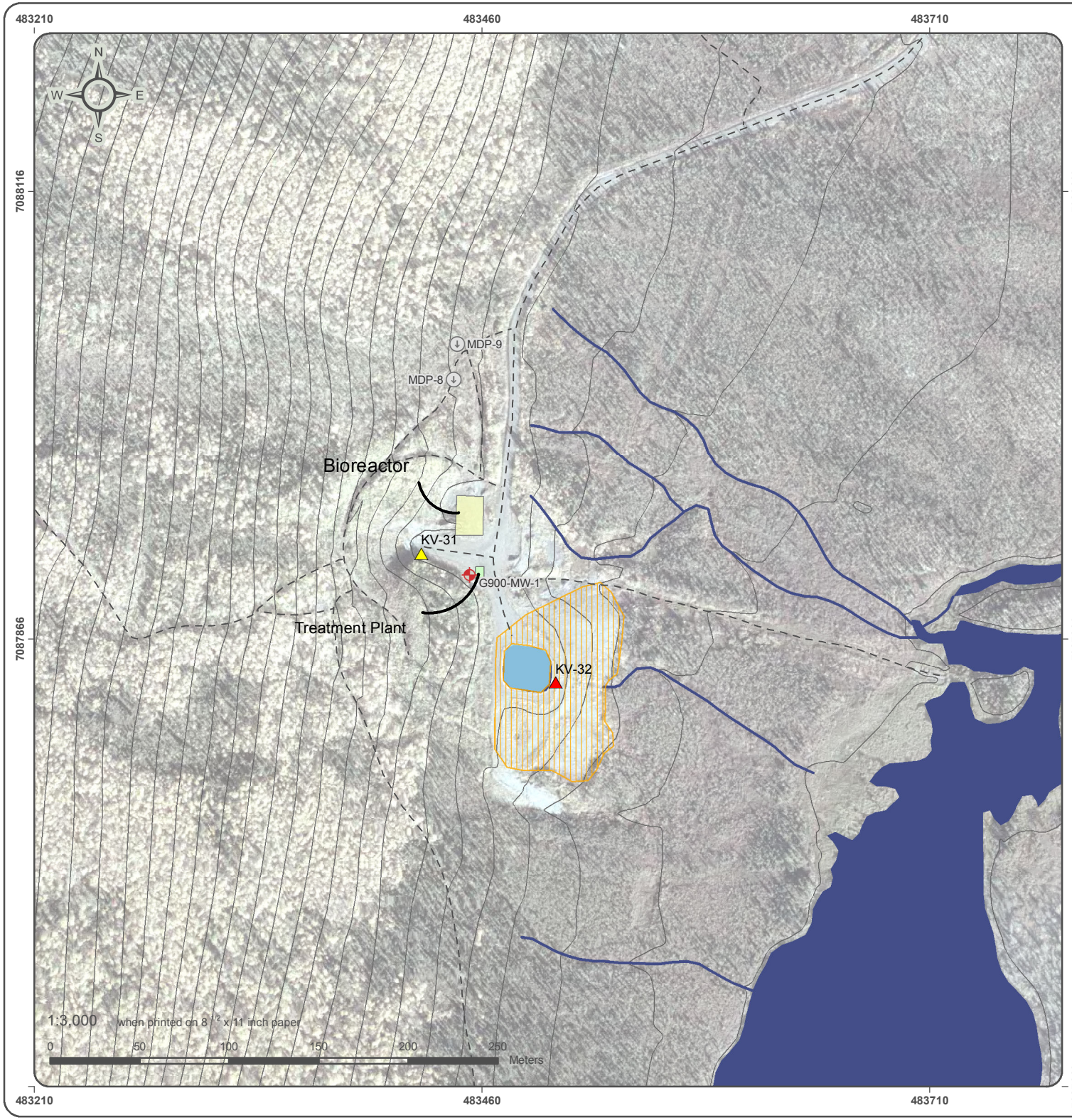
Overall, these changes have been positive and have allowed the system to operate in compliance with water licence conditions since the changes were implemented in late 2007. The few out of compliance events have been related to power outages resulting in frozen piping, and a very high flow year at Silver King 100 in August 2011, where the flow from the adit more than doubled its historic average for more than 1 month, and peak flows exceeded known historic peak flows by more than 50%.

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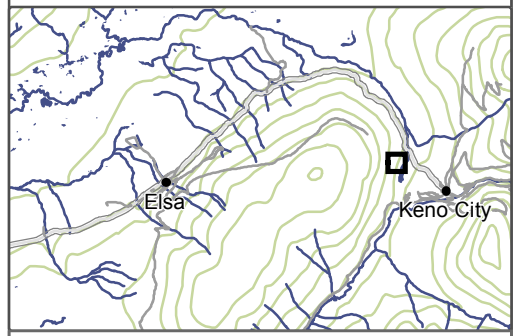
CLOSURE OPTIONS REPORT

FIGURE 3-3
GALKENO 900 SITE PLAN

NOVEMBER 2013



Monitoring Well
Decommissioned Manual Drive Point
Adit Water Quality Station
Monitored Water Quality Station
Track/ Trail
Contour (5m)
Watercourse
Waterbody
Pilot Bioreactor
Settling Pond
Waste Rock Dump
Structures



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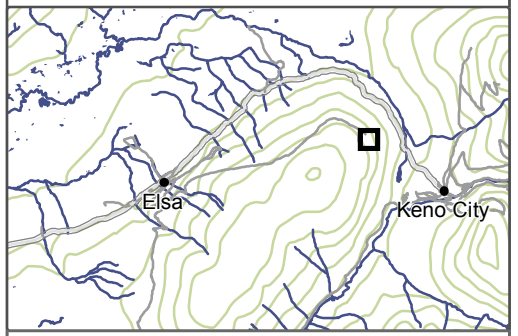
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CLOSURE OPTIONS REPORT

FIGURE 3-4
GALKENO 300 SITE PLAN

NOVEMBER 2013

- Monitoring Well
- Adit Water Quality Station
- Monitored Water Quality Station
- Secondary Road
- Track/ Trail
- Contour (5m)
- Pipeline
- Watercourse
- Waterbody
- Settling Pond
- Open Pit
- Waste Rock Dump
- Structures



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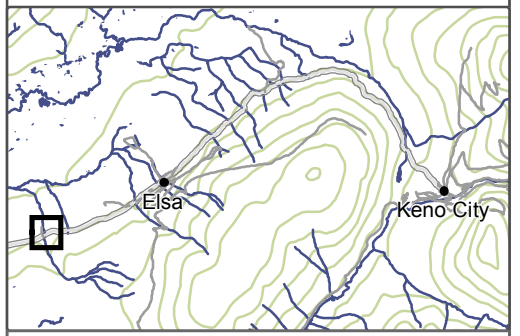
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CLOSURE OPTIONS REPORT

FIGURE 3-5
SILVER KING SITE PLAN

NOVEMBER 2013

- Monitoring Well
- Drill Hole
- Adit Water Quality Station
- Monitored Water Quality Station
- Highway
- Secondary Road
- Track/ Trail
- Contour (5m)
- Watercourse
- Settling Pond
- Open Pit
- Waste Rock Dump
- Structures



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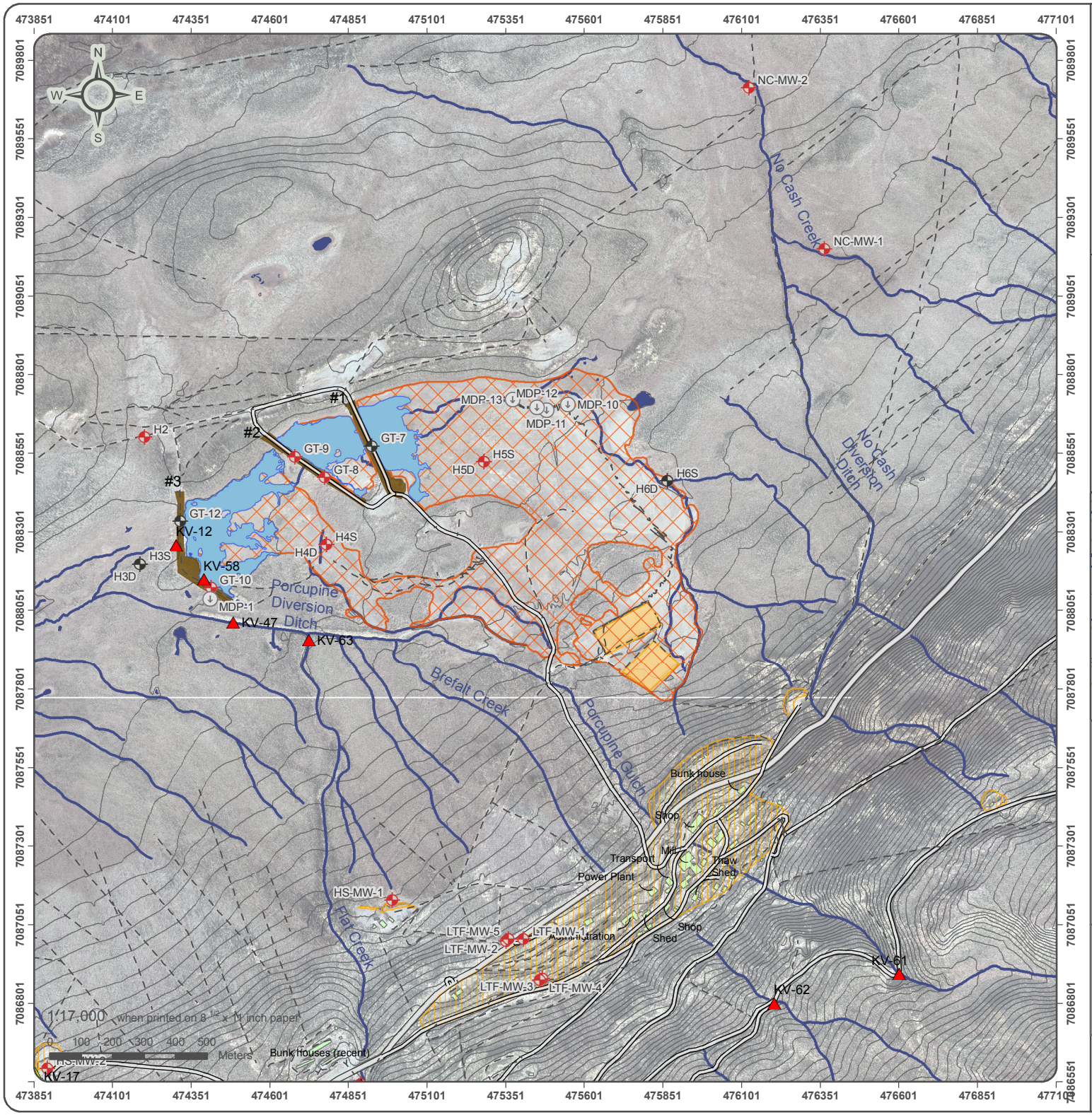
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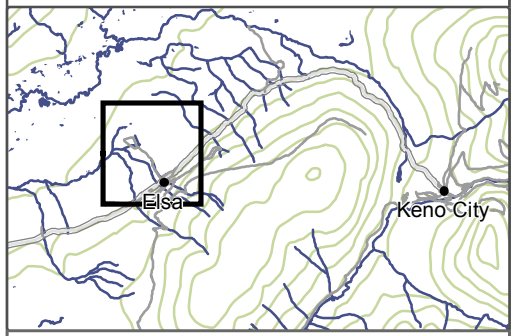
CLOSURE OPTIONS REPORT

FIGURE 3-6
VALLEY TAILINGS AND WATER MANAGEMENT FACILITIES

NOVEMBER 2013



Monitoring Well
Decommissioned Monitoring Well
Decommissioned Manual Drive Point
Adit Water Quality Station
Monitored Water Quality Station
Highway
Secondary Road
Track/ Trail
Contour (5m)
Watercourse
Waterbody
Sludge Storage Cell
Settling Pond
Dam
Waste Rock Dump
Tailings



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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 every 7-9 days, the Silver King system every 8-10 days and the Galkeno 300 system 5-6 times per week. Slurry concentration is roughly 37.4 grams of lime per litre of water, equating to an average consumption rate of 23 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, not including Valley Tailings Facility (approximately 14 tonnes per month).

Figures 3-7 to 3-9 below show the effectiveness of the zinc treatment program carried out at Galkeno 900, Silver King 100 and Galkeno 300 adits from January 2005 to January 2012.

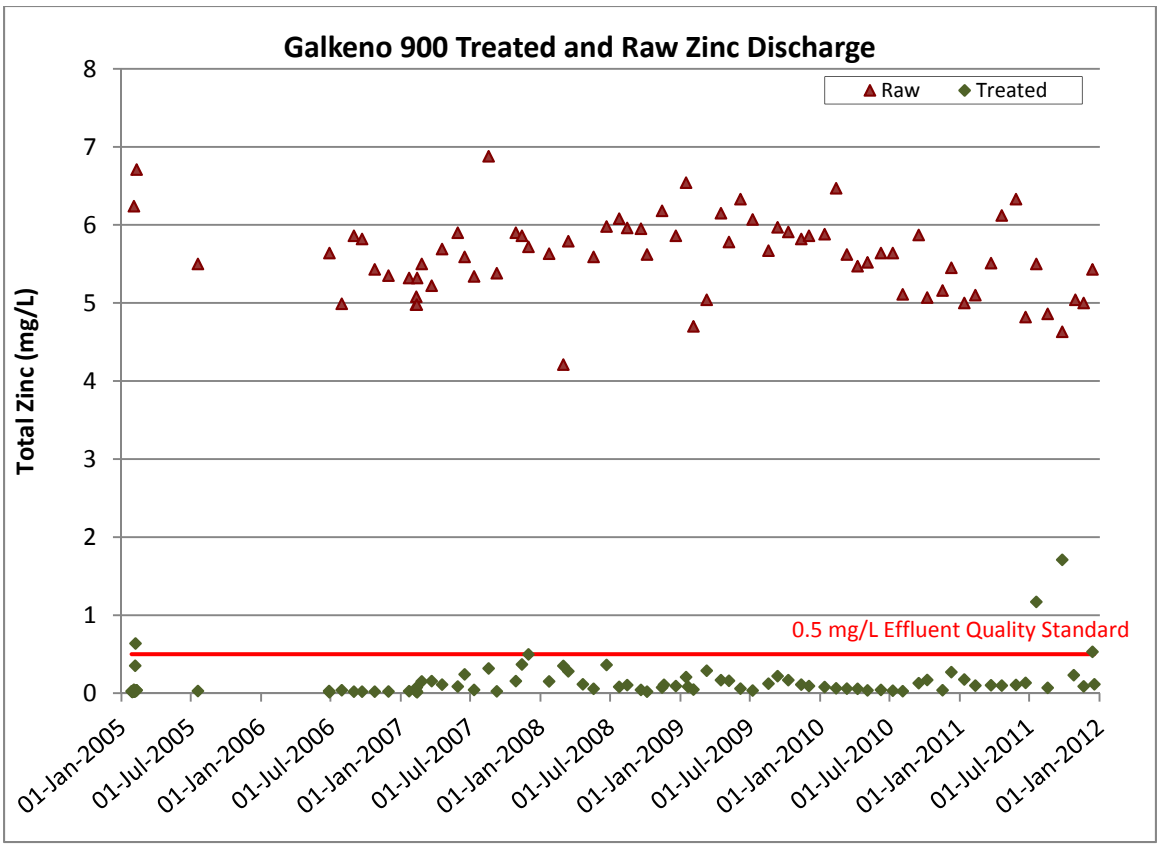


Figure 3-7 Galkeno 900 Treated and Raw Total Zinc Discharge, Jan 2005 - Jan 2012

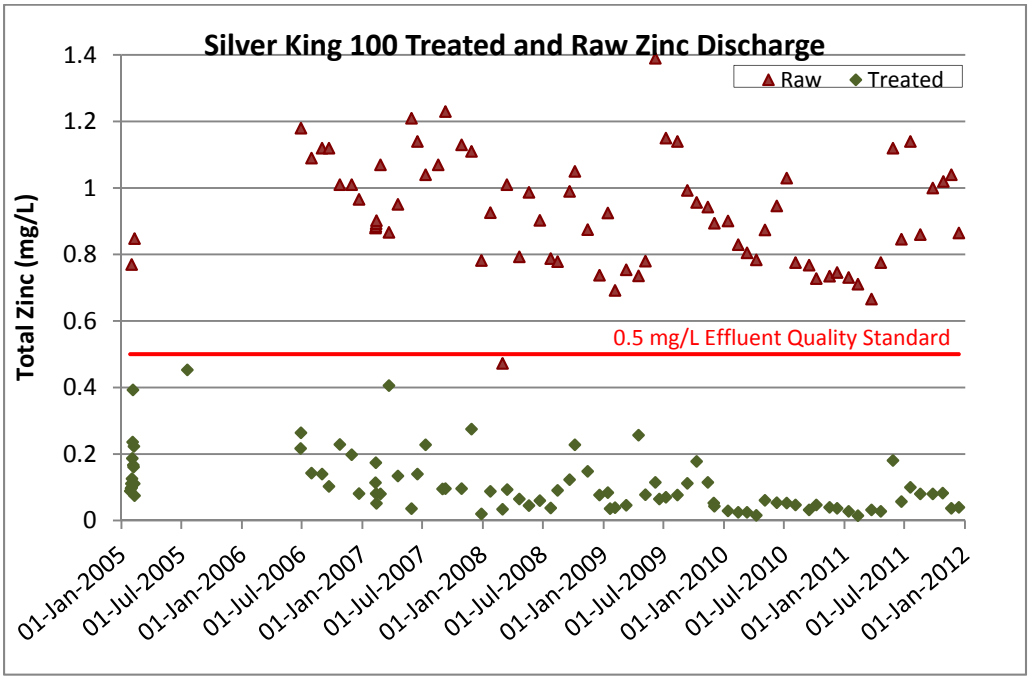


Figure 3-8 Silver King 100 Treated and Raw Total Zinc Discharge, Jan 2005 - Jan 2012

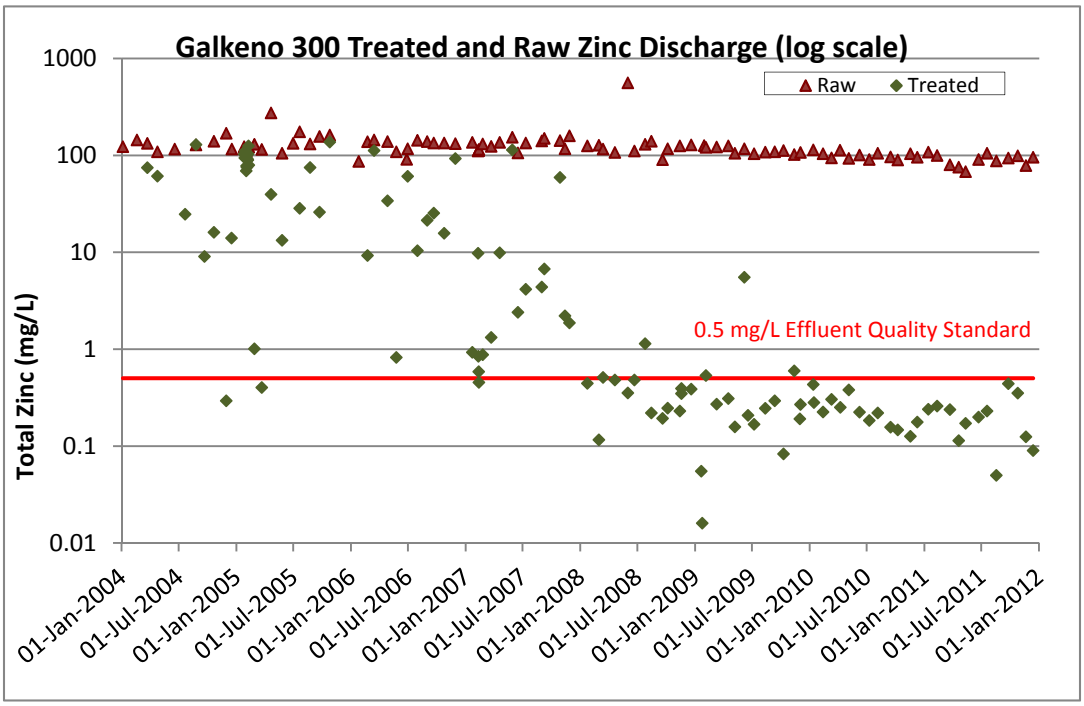


Figure 3-9 Galkeno 300 Treated and Raw Total Zinc Discharge (log scale), Jan 2004 - Jan 2012

3.3.3 Galkeno 900 Bioreactor Cell Pilot Study

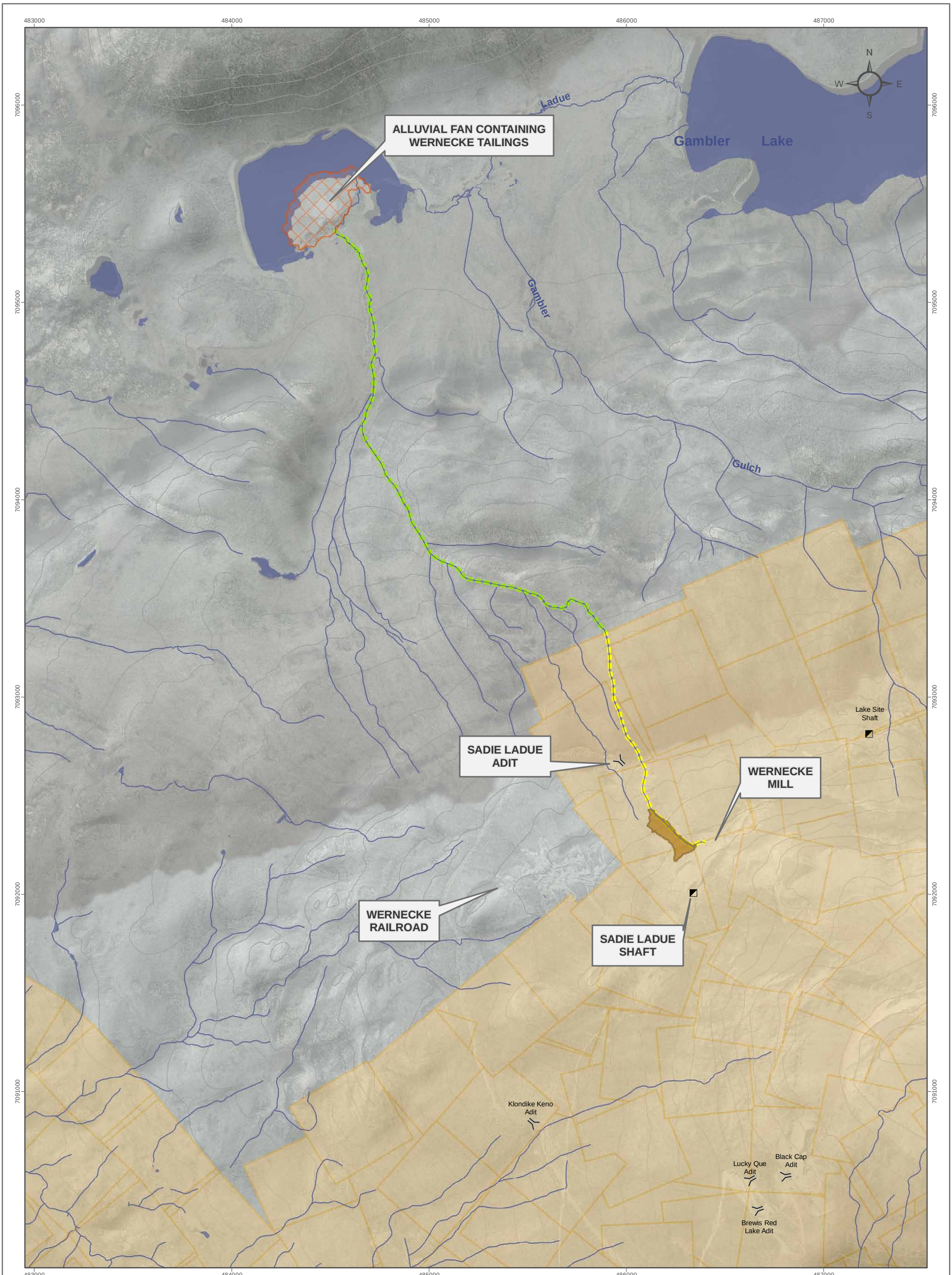
The Galkeno 900 bioreactor is a pilot test of sulphate-reducing bacteria (SRB) technology for treating mine drainage. To create the bioreactor, a 3 m deep pond was filled with streambed gravels, and a baffle installed to direct mine water through the gravels. The mine waters are amended with a soluble organic carbon source mixture, primarily methyl and ethyl alcohols and occasional sugar addition to aid microbial growth. 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 "biofilm" over the gravels which was shown to be comprised primarily of SRB (Londry 2011; 2012). 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. Upon closure implementation, this bioreactor may provide seed material for other bioreactors if they are constructed in the future in the District. Otherwise, the bioreactor could simply be left as is, in a covered and lined state, isolated from the surrounding environment. Further discussion of bioreactors as a closure option is included in Section 5.3.3.

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 completely delineate 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 over more than 6 years of operation, so over 270,000 tons could have been deposited. 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. This tailings area drains north to the Keno-Ladue River. Work began in September 2013 to determine the distribution, thickness and geochemistry of Wernecke tailings that migrated off-claim, allowing closure options to be developed for the off-site tailings. Figure 3-10 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.



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

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- Adit
- Shaft
- Drainage on Historic UKHM Claims
- Drainage off Historic UKHM Claims
- UKHM Claims
- Tailings Fan
- Tailings Deposit

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

0 0.25 0.5 0.75 1 Kilometers

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DRAFT CLOSURE OPTIONS REPORT

FIGURE 3-10

LOCATION OF WERNECKE MILL AND OFF-CLAIM TAILINGS

FEBRUARY 2013

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(Last edited by: mducharme; 11/02/2013/17:36 PM)

3.4.2 Mackeno Tailings

The Galkeno/Mackeno tailings were deposited on land near the northeast shore of Christal Lake (Figure 3-11).

Mill feed was primarily from early Bellekeno and Galkeno workings. Approximately 3,000 to 5,000 tons of tailings were deposited in this area during the operational period of 1953 to approximately 1959, though total production was reported to be far higher (Access 2009f). The main tailings area at Mackeno is approximately 5,500 m^2, with an average tailings thickness of 0.85 m, which equates to approximately 4,700 m^3 or 8,500 tonnes of tailings assuming a tailings density of 1.8 tonnes/m^3 (Access 2009f). This is a conservative estimate given that some 40,000 tonnes of tailings were deposited directly in Christal Creek with additional tailings also thought to have been deposited in Christal Lake (PWGSC 2000). 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 known 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.

483507 483607 483707 483807 483907 484007 484107

7088171 7088071 7087971 7087871 7087771 7087671 7087571 7087471 7087371

Christal Creek

Silver Trail Highway

N W E S

MACKENO TAILINGS ALLUVIAL FAN

MACKENO TAILINGS

MACKENO LOWER MILL SITE

MACKENO UPPER MILL SITE

Mackeno Creek

Christal Lake

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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

Highway
Secondary Road
Track
Trail
Contour 1m
Watercourse
Waterbody
UKHM Claims
Mackeno Mill
Mackeno Tailings
Mackeno Tailings Alluvial Fan

1:2,500 *When printed on 11 by 17 Inch paper*

0 50 100 150 200 Meters

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CLOSURE OPTIONS REPORT

FIGURE 3-11
LOCATION OF MACKENO TAILINGS

FEBRUARY 2013

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(Last edited by: mducharme; 11/02/2013/16:49 PM)

3.4.3 Valley Tailings

The tailings deposited from the Elsa mill are the most recent, and by far the largest deposit. Approximately 3,745,000 tonnes of tailings have been deposited in this facility. The volume of tailings stored in the VTF is an estimated 2,600,000 m^3 which does not include tailings submerged within the ponds (SRK 2009b). 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.

The Elsa Mill tailings impoundment, also termed the Valley Tailings, 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 (Withers 2008b). 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 method to mitigate cost of the entire tailings reclamation project with the selected closure option will be re-considered.

The geotechnical reviews of the Valley Tailings over the years by regulatory authorities, site annual inspection consultants (EBA 2009), 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 (dam 2 was breached to alleviate the need the manage the flow of water across this dam); and,
- failure or slumping of the downstream face of each dam due to steep (over-steepened) slopes.

Based on annual geotechnical reviews by EBA and thermistor data, settling of the tailings dams is no longer occurring and permafrost is non-existent under the dams; however, permafrost occurs at depth (R. Trimble pers. comm. April 2012).

The Valley Tailings contribute metal loading to the property; however, seasonal water treatment occurs each spring reducing the loading to less significant levels in terms of surface water pathways relative to other containment sources (ERDC 2012). Concentration trends of zinc in water samples in the tailings ponds indicate when treatment of the Valley Tailings is required.

Metal loadings to the receiving environment through the groundwater underneath the tailings appear to be less significant than even treated tailings pond discharges, likely due to the presence of a 0.5 – 3.3 m thick peat layer that appears to underlay all of the tailings area (SRK 2008a; Interralogic 2012d). Twinned wells screened in the tailings and screened beneath the peat layer show 3 or more orders of magnitude decrease in concentration, despite many years of oxidation that appears to have migrated more than halfway into the tailings (SRK 2008b; SRK 2009a). This was recorded in an area where tailings have been present for at least 50 years, demonstrating the longevity of this attenuation process. Furthermore, calculations suggest that in the very unlikely event that the entire Zn inventory of the VTF is mobilized, the peat layer may be expected to attenuate all the Zn through sorption processes alone (SRK 2009a). This disregards additional attenuation mechanisms (sorption on Fe/Mn oxyhdroxides in tailings and underlying soils/peat; immobilization as ZnS under sulphate reducing conditions in peat) and assumes that the tailings do not become strongly acidic (tailings mineralogy, combined with NP and AP measurements indicate that the development of strongly acidic conditions is not expected (SRK 2009a)).

The long-term sustainability of the peat layer to provide treatment of elevated metals in pore water is an area that is receiving ongoing study, however, several lines of evidence point to long term sustainability of this layer, especially if the tailings are reclaimed. ERDC conducted an Attenuation Column Test Program in 2010 which studied metal removal mechanisms in representative soil conditions of the site. The column studies showed that the contact time of 3.5 days in a peat layer of similar thickness as what underlays the Valley Tailings was sufficient to achieve essentially complete removal, consistent with literature values of half-lives of metals sorbing to peat in a matter of seconds (Alexco Environmental Group 2011). Two metre columns (30.5 cm diameter HDPE) were packed with peat and operated under (i) saturated conditions, where water flowed upwards from the bottom, filling the column and was sampled at the top; and (ii) unsaturated conditions, where water was added to the top and allowed to percolate through the column before collection at the base. Water from the Galkeno 900 adit was passed through the columns, which contained initial zinc and cadmium concentrations of 5.79 and 0.0014 mg/L, respectively. Two pore volumes of water were passed through the columns per week and 54 pore volumes were run in total. Zinc and cadmium removal by the peat column was >99% and 94%, respectively, for both saturated and unsaturated experiments for the entirety of the experiment. Significant manganese removal (94%) was also observed for the unsaturated column, with minimal loss of sulphate (<2%), suggesting that aerobic processes such as co-precipitation with manganese (oxyhydr)oxides may have been the primary driver of zinc and cadmium removal, alongside sorption on organic matrices. In the saturated column, manganese removal was much less pronounced (16%), while 22% of the sulphate was removed, indicating that microbial sulphate reduction and the associated precipitation of zinc and cadmium as sulphide phases may be a prominent sequestration process in this column. 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, and it appears that the peat layer underneath the tailings has the attenuation capacity to be a significant part of this sustainable solution.

Other features of a tailings solution will be discussed in the options descriptions in later sections, but it is appropriate to mention that in concert with any benefits associated with the peat layer water management around the tailings to limit transport of metals in pore water to the peat layer and to limit erosion of tailings from the ponds to the downgradient environment, geochemical amendments such as lime to treat existing dissolved metals in the tailings pore water, and covers are all considered appropriate additional closure features that will extend the benefits associated with the existing peat layer.

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 (EDI 2008a; 2008b; 2010). 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.

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 to contain some of the tailings that were lost and to provide a location for treatment. The surface flow of Flat Creek downstream of Dam No. 3 occurs in defined channels as well as through bogs, wetlands, lakes and other associated water features. The volume of tailings located directly downstream of Dam No. 3 estimated from previous work and identified in historical aerial photos are approximately 60,000 m^3 (Interralogic 2012a). 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 (Figure 3-12) 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. Figure 3-12 below includes water management facilities in and near the Valley Tailings.

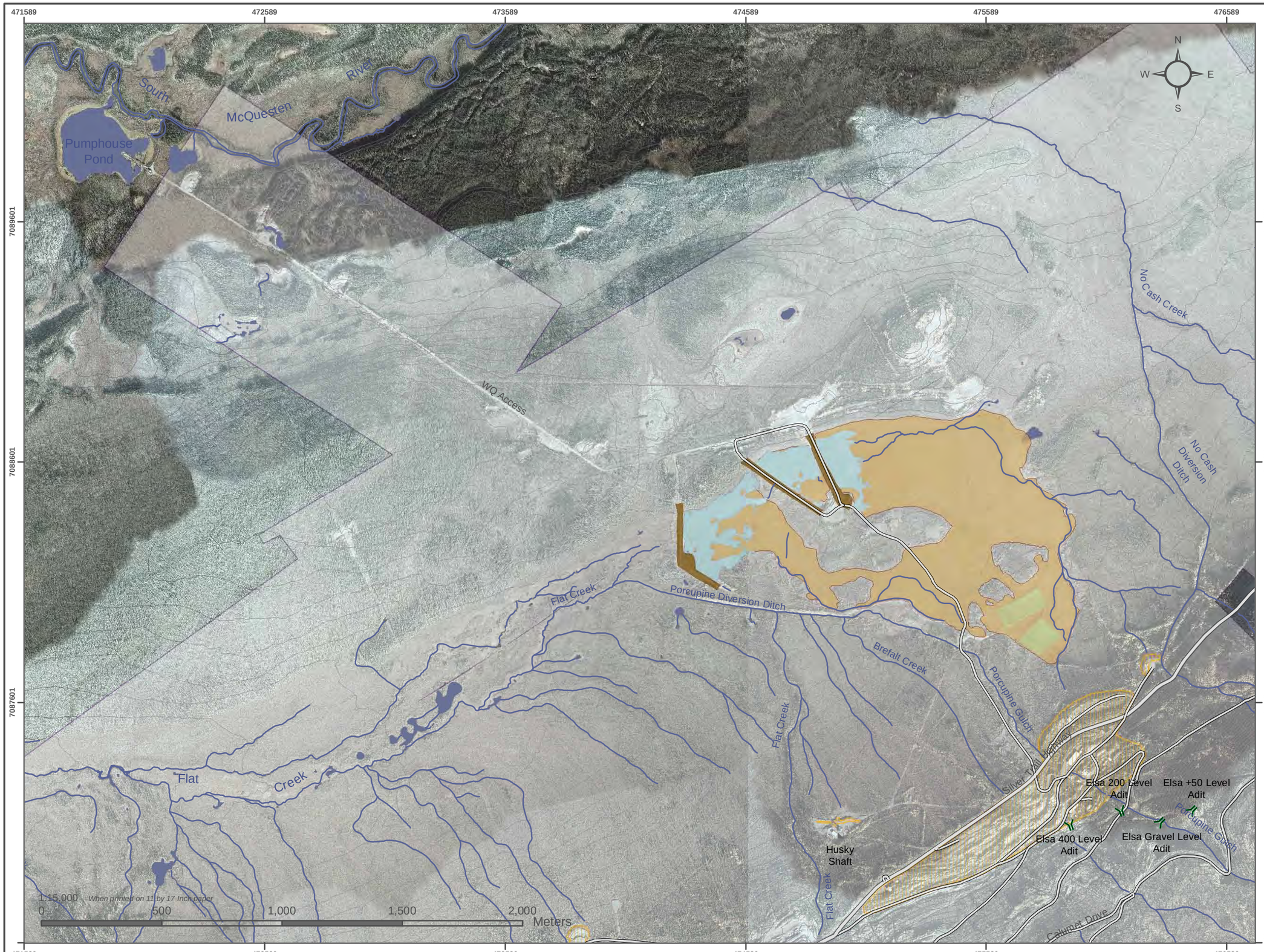
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CLOSURE OPTIONS REPORT

FIGURE 3-12

VALLEY TAILINGS AND WATER MANAGEMENT FACILITIES

FEBRUARY 2013



- Adit
- Shaft
- Highway
- Secondary Road
- Contours (5m intervals)
- Watercourse
- Waterbody
- Valley Tailings Sludge
- Valley Tailings Dam
- Valley Tailings Ponds
- Valley Tailings
- Open Pit
- Waste Rock Dump
- UKHM Claims

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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.

Quartz claim boundaires and ownership are current as of Mar 26th 2012. Data obtained from Yukon Mining Recorder.

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(*Last edited by: jlindeman;26/02/2013/12:05 PM*)

3.5 WASTE ROCK

Generally, waste rock storage areas (WRSAs) are associated with each mine working. Approximately 70 WRSA sites have been identified within the District, and of these, there are 16 sites with pits (SRK 2009a). 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 as the closure and reclamation plan for these sites fall under separate mining authorizations. There are also other waste rock facilities in the Keno District that are not related to any UKHM disturbance, but instead are associated with other operators that also worked in the District. This closure planning process only is concerned with the UKHM disturbances.

Surveys performed for the baseline environmental report did not note any mass failure of any waste rock sites, although minor instabilities have been noted at some waste rock piles (SRK 2007). The WRSAs are located on hillsides generally away from major roads, water courses, and human habitation. 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 adit waste rock site at the Onek 400 adit has also experienced significant erosion from several historic blowout events. The potential for future blowouts have since been mitigated, but the historic events did cause migration of adit waste rock a substantial distance from the adit.

A major distinction between two types of WRSAs (SRK 2009a) 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. Historic drifting was often along vein structures. 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 on a percentage basis. 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 (SRK 2009a). In general, WRSAs do not have springs or seeps associated with them except when adits drain through adit WRSAs (e.g. No Cash 500). With a few notable exceptions (two small WRSAs, Husky and Townsite), no significant Acid Rock Drainage (ARD) issues have been identified (Access 1996; Broughton 1996; Altura 2008; SRK 2009a). The assessment of closure options therefore primarily focuses on the WRSAs associated with adits from a neutral metal drainage 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. There are extensive abandoned power lines throughout the Keno area; many of which have been removed as part of interim reclamation and a number still remain. Unused power lines will be removed consistent with reclamation standards.

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, near the Hector Calumet and Keno 700 mines. The Hector Calumet townsite was removed while most of the Keno 700 camp has been removed under the interim reclamation/physical hazards reduction program (Access 2010a). Although the Elsa townsite has largely been dismantled, infrastructure at the site remains and consists of the mine offices, mill, shops, warehouses, bunkhouses, roads 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. These include seven aboveground storage tanks with an approximate combined capacity of 195,000 L and two underground storage tanks with an approximate combined capacity of 4,500 L (PWGSC 2000; SRK 2007; Access Consulting 2009d). Two more underground storage tanks of unknown size are suspected to be present beneath the school while further tanks may be encountered as the physical hazard reduction program advances. The hydrocarbon remediation program was assessed under the *Yukon Environmental and Socio-economic Assessment Act* (YESAA) in 2011 and permitting is in place to construct and operate a Land Treatment Facility with the capacity to treat an estimated 5900m^3 of hydrocarbon contaminated soil located on the former UKHM site.

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 but are on land that subsequently became UKHM property.

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 removed by demolition, stabilized for use by Alexco as part of production units, or preserved as heritage sites. The physical hazards risk register in Appendix A lists the structures that have been demolished to date and those remaining. A YESAA assessment was conducted on demolition of some structures in Elsa in 2010, and demolition of these sites was completed in 2011. A Project Description for demolition and/or preservation of all remaining structures in the District submitted to YESAA for assessment in 2011 resulted in AANDC issuing a Decision Document in support of the completion of a Heritage Impact Assessment, which is currently underway, to be used as a guiding document in the development of a District Wide Heritage Plan, to be prepared during fiscal year 2013/14. 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 6 documents 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 25. The hamlet draws its drinking water from a ground water well in the centre of town and operates a solid waste disposal site in the headwaters of Christal Creek. The well generally provides good quality water, however, turbidity exceedances are regularly observed. Occasional exceedances with respect to Fe, Mn, Cu, Pb, Zn and nitrite have also been recorded sporadically, with little correlation to each other. The historic impact of the Onek mine on the groundwater in the area of Keno City is an area of ongoing study (Interralogic 2012b). Preliminary evaluations (Access Consulting 2008a) 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 2010 an investigation in the drainage below the Onek 400 adit showed complete infiltration within 50-100 meters of the adit (Interralogic 2012b). Other issues in the Keno City area related to the Onek mine include adit waste rock scattered near the adit which exceeds CCME (1999) soil quality guidelines for residential/parkland.

4 CLOSURE PLANNING FRAMEWORK AND PROCESS

4.1 CLOSURE OBJECTIVES

Closure Plan Objectives have been developed through a consultative process with AANDC, 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 will be used to assist with selection of preferred closure options and implementation of the final plan. The Closure Plan Objectives were agreed to by all parties in July 2011 and they are:

Protect Public and Worker Health and Safety

- Prevent, minimize or mitigate any adverse effects on the health and safety of people using the land and water.
- Prevent, minimize or mitigate any adverse effects on the health and safety of people working at the site.

Protect and Restore the Environment

- Prevent, minimize or mitigate adverse effects on the aquatic environment.
- Prevent, minimize or mitigate adverse effects on the terrestrial environment.

Restore Mine Site to a State that Supports Community and Traditional Land Uses

- Minimize access restrictions.
- Reclaim disturbed areas to support future community and traditional land use.
- Preserve identified historical resources.

Maximize First Nation, Local, and Yukon Socio-economic Benefits

- Maximize training, capacity building, and employment and business opportunities for First Nation citizens.
- Maximize training, capacity building, and employment and business opportunities for local residents and Yukoners.

Minimize Project Related Liability and Risk

- Minimize risks associated with project implementation.
- Minimize post-closure residual liabilities.
- Minimize post-closure risks.

Minimize Cost

- Minimize project implementation costs.
- Minimize post-closure operations and maintenance costs.

These Closure Objectives will be used to assess and rank closure options using an evaluation process using both risk assessment and options ranking workshops.

4.2 HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

A Human Health and Ecological Risk Assessment (HHERA) (SENES 2011) and Human Health Risk Assessment (HHRA) on Keno City (SENES 2012) were conducted as part of the planning process for developing the closure options. The HHERA evaluated the various exposure pathways that exist within the former UHKM mining camp by which contaminants can be ingested. The HHERA and HHRA used the results of a number of data sources including:

- Meetings with local residents and First Nations to understand how the land is utilized;
- Vegetation metal concentrations;
- Soil and tailings metal concentrations;
- Water quality results;
- Groundwater monitoring results;
- Fish tissue metal concentrations; and,
- Moose organ and muscle metal concentrations.

The metal concentrations and exposure pathways were then evaluated following a standardized methodology for HHERA studies to evaluate whether there were potential risks to humans who occupy or utilize the area. The results of the HHERA (2011) and HHRA (2012) state that residents of Keno City are not currently at risk from consuming drinking water, local berries and locally caught moose and fish; however, consumption of moose liver and kidney should be limited to avoid potential risk from cadmium exposure which is known to accumulate in organ meat. In addition, exposure to soil via dust inhalation or direct contact is not a cause for concern.

4.3 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 (i.e. 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 state of the ecosystem. Closure options will be assessed on their performance to achieve environmental benefits to collective ecosystem receptors. In this way closure planning can prioritize addressing 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, but rather include consideration of down-gradient effects.

An illustration of this type of evaluation process is the adit drainage component of 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 (Interralogic 2012c). 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 allowing for prioritization of remedial timing and allocation of funding.

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, stream sediments mixed with various fractions of tailings and natural detritus, 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, and thus very little preparation for closure was brought into the mine development processes;
- There is more than 20 years of ongoing placer mining activity within Lightning Creek watershed; and
- There are known to be other off claim influences on local receiving environment water quality within the South McQuesten River watershed, especially the upgradient influences from Cache Creek.

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 makes restoration to pre-mining conditions a difficult goal to define.

To compound this issue, there are no studies of the pre-mining natural environment. This is typically important 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 modern mining practice requires that 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.

The closure framework that is the basis of the closure planning process is therefore an approach that integrates closure options' environmental benefits across watershed areas or other defined ecosystem units. Thus information about contribution of each site component on these watersheds is required to evaluate the options to remediate the effects of the past mining activities.

4.3.1 Cadmium and Zinc Point Sources

From a mass loading perspective, flowing adits provide the greatest potential mine component sources that require treatment in this closure planning process. To understand the range of issues in these adits, 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, because the range of potentially appropriate technologies will be different for each classification. 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 4-1 through 4-3 summarize metal loads from the key adits in the KHSD. Figures showing water quality data for a range of metal(loid)s from 2007 to 2013 are shown in Appendix M.

Table 4-1 Annual Adit and VTF Discharge in the KHSD

	Annual average of continuous flowmeter measurement (m^3)					
	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 (m^3)					
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					
Valley Tailings Facility**	422,511					

* 2008 Data

Table 4-2 Zinc Concentration and Loading from Adits and VTF in the KHSD

	Total Zinc (mg/L)					Loading (kg)				
	2007	**2008**	**2009**	**2010**	**2011**	**2007**	**2008**	**2009**	**2010**	**2011**
Galkeno 300	130	156.3	113	100	90.1	45,382	53,848	43,623	33,107	24,745
Galkeno 900	5.54	5.71	5.82	5.57	5.28	577	517	501	451	465
Silver King 100	1.01	0.859	0.946	0.827	0.898	188	185	227	141	114
Valley Tailings	0.152	0.187	0.135	0.015	0.030	-	-	-	-	-
	Average of 2006-2011 data (mg/L)					**Average of 2006-2011 data (kg)**				
No Cash 500	10.06					1746				
Onek 400	78.6					5234				
Keno 700	1.51					162				
Bermingham	3.56					217				
Ruby	1.33					41				
Husky SW Shaft	1.05					14				
UN Adit	0.286					4				
Sadie Ladue Adit	0.697					168				
LES-66 Natural Spring	0.121					10				

Table 4-3 Cadmium Concentrations and Loading from Adits and VTF in the KHSD

	Total Cadmium (mg/L)	Annual Loading (kg)
	Average of 2006 – 2011 data	Average of 2006 – 2011 data
Galkeno 300	0.309	107.65
Galkeno 900	0.0014	0.17
Silver King 100	0.0101	2.48
No Cash 500	0.109	18.87
Onek 400	1.49	99.48
Keno 700	0.0136	1.46
Bermingham	0.179	10.88
Ruby	0.0150	0.46
Husky SW Shaft	0.0154	0.20
UN Adit	0.0017	0.02
Sadie Ladue Adit	0.00409	0.99
LES-66 Natural Spring	0.00181	0.14
Valley Tailings Facility	0.00076	0.084*

**Simulated long-term future metal load contributions under baseline conditions (ITL Flat Cr Load Model, 2012)*

4.3.2 Cadmium and Zinc Nonpoint Sources

The Keno District has a variety of non-point sources that have been recognized to play a potential role in the mass balance understanding for the primary COCs. These sources generally fall into these categories:

- Springs and seeps where site groundwater comes to surface (includes both within stream bottoms and on hillsides).
- Dispersed tailings, which are now both in pods of reasonably pure tailings, as well as intermixed with other sediment.
- Waste rock deposited near or within streams.
- Residues from dewatering activities or from untreated drainage which discharged over hillsides or down creek channels. It is likely that many of these metals are tied up now in site soils, with metals fractions that are more or less labile.

In assessing the relative importance of point sources vs. nonpoint sources for allocation of remediation priority, there is one over-riding consideration: if the mass of contaminant point sources are totalled for each drainage, they account for a substantial excess of the mass that can actually be measured in the stream at the property edge for all streams with the exception of Flat Creek. As an example, Interralogic (2013b) states "Overall, the comparisons of simulated and observed loads indicate there is significant loss of Cd and Zn in the transport pathways between potential sources of metals and

Christal Creek." This observation led to the utilization of attenuation factors to allow observed loads to match simulated loads.

An accurate assessment of dispersed or non-point source terms is very difficult to be done when the point sources alone are more than sufficient to account for all of the mass leaving the site. When balancing the mass loading models, the professional judgement was made to allocate no mass to these dispersed sources, while recognizing in actuality the non-point sources will have some load, which will likely only be measureable when the point sources are remediated and the system stabilizes. The residual loading from these non-point sources will be evaluated post implementation to determine if action is required.

4.3.3 Watershed Management

The critical ecosystem components in the Keno area were recognized to be the surrounding waters of the South McQuesten River, Lightning Creek, and the Ladue River headwaters and associated aquatic resources that these systems support. 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 vegetation 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 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 No Cash Bog, and Lightning Creek which flows into the Mayo River system. The Keno Ladue River has had a seasonal monitoring program initiated to better understand potential loadings from the sources on the northern end of Keno Hill and their effect on the receiving environment. The relative loading of metals and amount of disturbance within this watershed is primarily related to tailings produced from the Wernecke Mill.

4.3.4 Watershed Goals

Water quality goals have been the subject of several workshops in 2011, 2012 and 2013, and will ultimately be finalized in consultation with FNNND, EC, and YG after the preferred options are selected. Interim water quality benchmarks sufficient for options selection have been established for cadmium and zinc, the primary COCs, and are provided as loading values for each sub-watershed (Flat, Christal and Lightning Creeks) for the evaluation of closure options. Once the preferred option or combination of options has been selected, concentration based water quality goals will be established for the long-term assessment of closure performance. While water quality is not expected to achieve CCME in the downstream sub-watersheds, water quality goals will be established to provide conditions that will allow for the re-establishment of a viable benthic community and the protection of all life stages of resident fish populations within the affected watersheds.

4.4 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 (AANDC, YG and FNNND) in addition to a site owner and operator (ERDC) that have a role in the development and ultimately implementation of this plan. 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 AANDC providing a significant part of the funding and having a significant decision-making role. The three governments (AANDC, 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 input and 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 (Appendix B-2). The risk assessment was completed for eight major mine sites or components and Elsa townsite and covered all closure components existing at the sites including waste rock storage areas, pits, adits and their associated water management and the Valley Tailings area. After review of the first draft of the Closure Options Report (ERDC 2011) the closure options have been further refined based on review comments. 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 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 refine and 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 focusing 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 10 kg/yr zinc (by way of comparison, a natural seep in the Keno District associated with an unmined orebody “LES-66 Seep” has approximately 10 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 10 kg/yr zinc (Table 4-2 above), waste rock dumps with potential large zinc loading (SRK 2009a), and the tailings facilities (Valley Tailings, Wernecke, and Mackeno). This ended up retaining all flowing adits except the UN adit, which only flows seasonally with generally low metals concentrations; all tailings sites, and the largest adit waste rock site in the district, Hector 400 adit dump. All other waste rock sites were estimated to have too low metals loading rates to create a similar threshold of concern (SRK, 2009a), but these other dumps will still be remediated, but with less specific focus on metals-loading or watershed impacts.

Based on this screening, the complex site components for which greater closure planning focus has been prioritized are:

Flat Creek Watershed:

- Husky SW Mine (shaft)
- Silver King Mine (100 level adit)
- Valley Tailings

No Cash Bog:

- Bermingham Mine (200 level adit)
- Ruby Mine (400 level adit)
- No Cash Mine (500 level adit)
- Hector 400 WRSA

Christal Creek Watershed:

- Galkeno Mine (300 level adit)
- Galkeno Mine (900 level adit)
- Mackeno Tailings
- Onek Mine (400 level adit)

Lightning Creek Watershed:

- Keno Mine (700 level adit)

Keno Ladue River Watershed:

- Sadie Ladue Mine (600 level adit)
- Wernecke Tailings

These 14 sites are recognized to be the primary potential source of environmental effects to the aquatic ecosystem and therefore, the closure planning process is mainly focused on these sites. 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.

4.5 CLOSURE OPTION SELECTION 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 including AANDC, ERDC, FNNND and YG participated in the development and assessment of risks associated with options for

site component closure (Appendix B-1, B-2). 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, all of which are located in the South McQuesten watershed or ultimately drain into the South McQuesten river, except for Keno 700 which is located in the Lightning Creek watershed, were assessed and are representative of the major contaminant loads, risks and challenges across the District:

Flat Creek Watershed:

- Valley Tailings Area
- Elsa Village

No Cash Bog:

- No Cash 500

Christal Creek Watershed:

- Galkeno 900
- Onek 400
- Hector Calumet*
- Galkeno 300

Lightning Creek Watershed:

- Keno 700

*Note: The Hector-Calumet mine area sits on the surface water divide; Hector mine areas primarily are located in the South McQuesten watershed with flow into the No Cash Bog that appears not to have any surface water discharge; Calumet mine areas primarily are located in the Christal Creek watershed which ultimately drains into the South McQuesten River watershed.

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, which included AANDC, FNNND and YG as part of the process, 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 Appendices B-1 and B-2, along with the original technical memorandum to the working group outlining the process and results.

Review and comments on the initial Draft Closure Options Report (ERDC 2011) has led to a further refinement of the options. The discussions with the closure planning participants for how this report will be used to select options has led to the following process to be proposed as the options selection process:

- A final version of the Closure Options Report is used as the basis for consultation with the FNNND, and for internal briefings within the other governments.
- A risk assessment workshop, followed closely by an option evaluation workshop, will be used as a format to solicit feedback from all closure planning participants on an equal basis. A professional facilitator will be used to allow ERDC to participate exclusively as a participant in those workshops.
- The facilitator will produce a workshop report which will form the basis for further consultation with FNNND and internal briefings within the other governments.
- A consensus options selection process utilizing senior representatives of all of the closure planning participants will then be performed.
- For any site(s) where consensus cannot be reached, ERDC as proponent and AANDC as majority funder will alternatively select the options for that site(s) only, and combine that selection with the other sites already selected by whole group consensus.

After the preferred options for closure have been selected, an Engineering Risk Assessment process will be performed to evaluate any technical risks associated with the overall project as selected by the options selection process. This Engineering Risk Assessment process will identify residual risks and required mitigations to ensure that adequate detail is included in the Preferred Options Report, and ultimately the Project Description to be submitted to YESAB for assessment. These mitigations will also be used to refine the project-level Adaptive Management Plan so that in the judgement of the scientific/engineering professionals performing the Engineering Risk Assessment that implementation of the preferred options will achieve an acceptable level of residual risk, and so that the appropriate mitigations are planned for all significant residual risks.

4.6 PREFERRED CLOSURE OPTION PROCESS

Canada and ERDC have agreed that the following elements must be adequately addressed in the development of an "ESM Reclamation Plan" project proposal for the UKHM liabilities:

- Identification of significant reclamation related site issues/components;
- Development of closure objectives;
- Identification and analysis of alternative reclamation and closure options;
- Identification of Post Active Reclamation Activities;
- Consultation with the First Nation of Nacho Nyak Dun has been sought;
- Input from relevant communities has been sought;
- Peer review of options;
- Selection of a preferred option; and
- Preparation of plans and other documents required for assessment under YESAA and for other regulatory requirements.

In the development and implementation of the ESM Reclamation Plan it is expected that the following process will be followed:

- Notice of ESM Reclamation Plan approval by Canada granted after all internal Canada formalities satisfied, including independent peer review;
- Submission of the proposed ESM Reclamation Plan by ERDC pursuant to YESAA;
- Issuance of decision document, pursuant to YESAA, allowing the Project to proceed;
- Application by ERDC for all necessary regulatory authorizations (including a Water Use License);
- Grant of all necessary regulatory authorizations;
- Development and approval by Canada of the ESM Reclamation Plan (with costing developed to a Substantive Level);
- Development of the Submission by Canada with the assistance of ERDC;
- Submission, to Treasury Board, of the Submission;
- Receipt of Effective Project Approval and notice from Canada to ERDC of such approval
- Calculation of ERDC Sharing Percentage based upon the agreed and approved ESM --Reclamation Plan costing;

- Implementation of the ESM Reclamation Plan;
- Active Reclamation Completion; and
- Post Active Reclamation Activities.

This report, when accepted, satisfies the identification and analysis of alternative reclamation and closure options requirement. After this revised report has received review and input from AANDC, FNNND and YG the preferred options selection process described above 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 the ESM Reclamation Plan will be finalized and submitted as a project proposal to YESAA.

5 CLOSURE OPTIONS

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 leading to the refinement of some of the options. A package of information was presented for the purposes of the risk assessment, including the following:

- Summary of the mine area component;
- Description of each option;
- Summary table of closure issues associated with the mine area component;
- Visual depiction of the closure options; and
- High level closure cost estimate comparisons for each of the options.

As was discussed in Section 4.4 the sites being considered for closure were separated into simple and complex sites based on a combination of the significance of environmental impact associated with the site. The definition of significant environmental impacts was sites that are or have the potential to contribute greater than 100 kg/yr of zinc to the receiving environment. This classification resulted in the identification of 14 complex site components which are discussed in greater detail in Section 7 of this report. It is important to note that under this classification system there are individual sites that contain both simple and complex components that require closure.

The classification of a site component as being simple indicates that the components will be closed using standard reclamation measures that have been developed for the range of conditions found in the District. Standard reclamation measures have been developed for the various infrastructure units including adits, shafts, waste rock dumps and open pits and are discussed in greater detail in this section of the report.

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 engineering after the preferred closure option has been selected.

5.1.1 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 closure studies completed (Appendix A). Additional studies are listed in Section 11 of this report.

5.1.2 Design Criteria for Closure Option Development

ERDC retained Interralogic to prepare a list of design criteria that would be used in the development of the closure options for individual sites. The design criteria that were developed were based on a review of accepted standards and practice for engineering design being conducted in Canada. Where there was not a specific standard then professional judgment was used by Interralogic to recommend a standard. The design standards that are being proposed by ERDC are included in Appendix C. These standards have been previously reviewed by ERDC and AANDC but not by other stakeholders on this project.

It should be noted no major population centres are located near the Keno Hill Silver District. Mayo, the largest community, population 460 (Bureau of Statistics 2012), is located 45 kilometres south west of Elsa. The unincorporated community of Keno City is located 15km east of Elsa has a population of around 25 permanent residents and 28 seasonal residents (M. Mancini pers. comm. Nov 2011). There are no communities or residents living below the Elsa Valley Tailings facilities.

5.2 VALLEY TAILINGS FACILITY

The Valley Tailings Facility is located in the valley just north of the town site of the townsite of Elsa. 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; and
- Long-term maintenance of man-made structures, including dams and diversions.

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

5.2.1 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 5-1). 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. Based on annual geotechnical reviews permafrost soils under all three dams have thawed since construction, resulting in an unknown amount of subsidence of the dams; however, based on recent measurements, subsidence of the tailings dams is no longer occurring (R. Trimble pers.com. April 2012). For purposes of discussion, Figure 5-1 illustrates two areas, a hillside area where tailings are discontinuous and are partially covered by vegetation and tailings areas that are continuous. Below tailings dam No. 3, a large but unknown amount of tailings has been released and are found in small pods along Flat Creek all the way down to the South McQuesten River. In the area located directly downstream of Dam No. 3 there are approximately 60,000m^3 (Interralogic 2012a) of tailings that will be addressed in closure work for the Valley Tailings. Other dispersed tailings beyond the immediate Valley Tailings area that are dispersed down Flat Creek will remain undisturbed. Reclamation activities within the disturbed areas downgradient of Dam 3 will be targeted to mitigate against further tailings migration by a combination of geotechnically stabilizing or relocating actively eroding pockets of tailings within the stream channel and encouraging revegetation of barren patches of tailings that are susceptible to erosion due to wind and rain.

Water quality in Porcupine and Flat Creek upstream of the Valley Tailings area shows zinc concentrations below 0.03 mg/L, while Flat Creek immediately downstream of the Valley Tailings shows concentrations often exceeding 0.4 mg/L. Based on these data, the VTF is the largest source of metals in Flat Creek.

Dam No. 2 (which has since been breached) 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 ponds during freshet and/or as needed 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 behind the dams. Zinc precipitated within these ponds during periods of treatment is currently settling to the bottom and forming a sediment layer over top of the underlying tailings. Improved management of the No Cash and Porcupine Creek Diversions since ERDC has managed the UKHM site has reduced the amount of water requiring treatment, and has also reduced the amount of lime addition required.

Diversions were also constructed to convey surface water away from the tailings deposits and dams. These diversions (Figure 3-6) include:

- A north diversion channel for diversion of No Cash 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 2008a; 2009b; Interralogic 2012d). All drilled holes and test pits underneath the tailings have shown the organic soils/peat layers, showing that this layer represents a continuous layer underneath the tailings. 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 2007b; SRK 2009a; 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 2009a; 2009c).

The tailings behind Dams No. 1 and No. 3 where wet, have re-vegetated. Some dry tailings areas have also revegetated; however, the dry, sandy, upper part of the tailings deposit is barren. Anecdotal information from former UKHM employees indicates that the areas where revegetation has been successful are a result of cover amendments added to the tailings in the early 1980s, including compost and peat materials, fertilizer, and lime. 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 2008a). However, most paste pH values for the tailings are in the neutral to slightly acidic range (SRK 2008a). 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 2008b). Withers (2008b) 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.

5.2.2 Common Features for Alternatives

The remedial alternatives described in Section 5 have a number of common features with respect to:

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

These common features are described in the following sections.

5.2.2.1 Tailings Areas and Volumes

The distribution of tailings is shown in Figure 5-1. Estimated volumes and areas are provided in Table 5-1. The areas are estimated from interpretations of tailings coverage in Autocad drawings of the VTF and adjacent Elsa hillside. The volumes in Table 5-1 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 not uniformly distributed within the impoundments and on the hill slope. The aerial extent of tailings coverage shown in Figure 5-1 contains some areas where no tailings placement occurred. The tailings are categorized as follows, referring to the coloured areas in Figure 5-1:

- 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

Table 5-1 Summary of estimated areas and volumes of tailings as shown in Figure 5-1

+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

5.2.2.2 Borrow Sources

A potential borrow source for cover material has been identified by ERDC (2007b). The borrow source is located north of Dam No. 3 (Figure 5-1) and is comprised of glacial silty to sandy till, sands, and gravels with a thin layer of organic material at the surface. The gravel extended to 46 feet to bedrock at one location (all dry) and to 68 feet at another location (groundwater encountered at 20 feet). The volume of borrow material in the area outlined in Figure 5-1 has been estimated at 1,523,000 m^3 (SRK 2009b) based on three boreholes drilled in the area and eleven test pits. Groundwater was not encountered to the depth that yielded the estimated volume. 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 (extensive peat beds have been observed within 5 km of the Valley Tailings) 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.

5.2.2.3 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. Cover trials have been initiated to further refine the details of these covers, but for now the two cover alternatives are used to represent placeholder designs for the cost estimate.

5.2.2.4 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 (2009b) 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 (2009b) 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.

5.2.2.5 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 reduce zinc concentrations to less than the discharge criteria 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. As much of this water will be from dewatering the tailings, the rate of water treatment is estimated at 6.6 L/s with a probable range of 5 to 7 L/s and a total discharge ~35,000 m^3/year based on data for discharge flow measured at the Dam No. 3 decant flume as reported in ERDC (2007a).

5.2.3 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

In all cases, existing wet tailings will largely be kept wet and existing dry tailings will be largely kept dry. The intent is to maintain the tailings in their current state.

Descriptions of the alternatives are provided in the following sections. The alternatives are compared side by side in Table 5-2. In-situ stabilization and minimal relocation of dispersed tailings from the Flat Creek stream channel downgradient of the VTF is considered common to all Valley Tailings reclamation alternatives. The foundation soils in areas where tailings may be relocated are known to comprise competent till and/or bedrock with pockets of discontinuous permafrost. Structures will be designed to accommodate minor differential settlement in the event that some of the permafrost thaws.

5.2.3.1 Alternatives considered but not advanced

The only alternative considered but not advanced is the reprocessing of the tailings as a closure approach (ERDC 2009). 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.

5.2.4 Alternative 1 - Cover in Place

The specific goal of Alternative 1 is to minimize the relocation of tailings; this alternative will also minimize disturbance of stable tailings. The ponds and dams No. 1, No. 2 and No.3 would remain in their current configuration. Figure 5-2 shows a map view with text boxes with additional description of Alternative 1.

5.2.4.1 Tailings Relocation

Alternative 1 would involve relocation of tailings only where necessary to rehabilitate existing drainage ways or place new diversions. The proposed location of diversions is shown on Figure 5-1. Tailings would be removed from areas that are subject to erosion from the eastern end of the south diversion channel and southeastern end of the north diversion channel (green area in Figure 5-2). 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 5-2). These tailings 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 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 5-2). 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 devoid or sparsely vegetated at the current time. Although this area is not necessarily subject to erosion, revegetation best management techniques will be employed to reduce the potential for soil loss through erosion. An approximate total of 138,832 m^3 of tailings will be relocated under this option.

5.2.4.2 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 to enhance the revegetation of these areas. This corresponds to a total cover volume of approximately 686,111 m^3.

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. Approximately 6,572 tonnes of lime are calculated to be required. 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. This assumption is supported by the passage of more than 50 pore volumes of mine drainage similar to tailings pore water through a 2 meter peat layer, without metals breakthrough (see Section 3.4.3; Alexco 2012). 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 to keep existing wet tailings wet. In general, submerged tailings are chemically more benign due to the oxygen limitation that saturated conditions sustain. These dams would no longer be a location of water treatment activities, and due to

the liming and revegetation of the tailings, it is assumed that water treatment activities would only be required during construction and for a few years after construction is completed. 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 enhance long-term geotechnical stability.

5.2.4.3 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 and expanded as necessary to achieve the design criteria for stormwater flow management. Flat Creek will be rehabilitated as required near the area where diversion enters. 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 as per the project design criteria (Appendix C) based on 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 constructed downstream of Dam No. 3 as a short term measure to reduce suspended sediment loads prior to discharge to Flat Creek. An additional sediment pond would be placed on Flat Creek near the Silver Trail Highway to reduce suspended loads downstream in Flat Creek and the Porcupine Diversion. These structures may be removed after the reclamation criteria have been achieved as they will no longer be required.

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. The water treatment plant is only expected to be operated during construction and until reclamation measures have achieved design.

5.2.4.4 Post Construction Requirements

Water treatment would be required for Alternative 1 for an extended period of time (5-10 years). 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 (F. Marinelli pers. comm. April 2012), 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, although a buttress at the toe of the structures would be installed in order to increase

their long term stability. Inspections similar to the geotechnical inspections currently carried out under the Care and Maintenance program will continue as well as any other inspections required under the classification of the dams. Monitoring of the surface and groundwater would be required. Native vegetation and commercial seed mixes developed for the District will be used for reclamation purposes. A seed increaser program will use seeds collected from graminoids and forbs which have adapted and evolved to the local conditions, as breeder stock. Scheduled monitoring of vegetation (time frame and frequency to be determined in conjunction with regulators) would be required to determine the rate of development and succession, and the effectiveness of reclamation work. General maintenance such as routine inspections and regular removal of vegetative debris that would otherwise restrict flow would be required on the diversion channels. The level and time frame of maintenance will be determined during the design phase. It is expected that monitoring frequency will decrease over time.

5.2.4.5 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 (Dams will need to be classified and designed as per Canada Dam Association (CDA)).
- Water treatment may be needed for a long period of time (5-10 years) 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 (Interralogic 2012a).
- Poor cover performance could lead to continued movement of elevated pore water metal content 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.

5.2.4.6 Aesthetic and Sustainability Considerations

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

- The site would remain largely in its current physical configuration, though covered with a revegetated soil cover, which may have an unacceptable visual appeal compared to Alternative 3 which will result in removal and consolidated tailings leaving the area in a more natural configuration.
- Not consolidating the tailings will result in a larger volume of granular materials being required for cover construction and potentially larger borrow area footprint.
- 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.

5.2.5 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 5-3 shows a map view with text descriptions of Alternative 2A.

5.2.5.1 Tailings Relocation

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

- Elsa hillside (blue area on Figure 5-3);
- Area of between the Elsa hillside and valley bottom extending to Pond 3 (green area on Figure 5-3); and
- Unsubmerged tailings on the southeast side of Ponds 2 and 3 (purple areas on Figure 5-3).

The tailings excavated from these areas would be consolidated on top of existing valley bottom area shown on Figure 5-3 as the brown-coloured Consolidation Area to a depth between 1-2 m.

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 the organic soil material that potentially contains elevated metal contents resulting from vertical migration of water through

the tailings into the peat. Although no issues are expected, some cover soil may need to be added to obtain revegetation criteria. The unsubmerged tailings in Ponds 2 and 3 would be excavated to the greatest extent possible and placed on top of existing tailings behind Pond 1; submerged tailings will remain in tailings ponds 2 and 3. Approximately 537,587 m^3 of tailings will be relocated under this option.

5.2.5.2 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 to provide a growing medium for revegetation. The cover material for all areas would be amended with organic material and fertilizer and seed to promote vegetation growth and reduce any potential for soil erosion. Overall, some 443,992 m^3 of cover material will be required.

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. Approximately 6,284 tonnes of lime are calculated to be required for this work. The peat layer underlying tailings in the valley is assumed to provide sufficient capacity to continue to attenuate metals released from tailings leaching processes (see Section 3.4.3; Alexco 2012).

Dams No. 1, No. 2, and No. 3 and Ponds 1, 2, and 3 would remain in their existing configuration and the existing 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, using classification and design to CDA standards (2007) to provide a structural buttress at the toes of these dams to provide certainty of long-term stability.

5.2.5.3 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 and expanded as necessary to achieve the design criteria for stormwater flow management. Flat Creek will be rehabilitated as required near the area where diversion enters. 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 Trail 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.

5.2.5.4 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.

5.2.5.5 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 pore water with elevated metal content 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.

5.2.5.6 Aesthetic and Sustainability Considerations

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

- The site would remain largely in its current configuration, though covered with a revegetated soil cover, 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.

5.2.6 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. Figure 5-4 shows a map view with text descriptions of Alternative 2B.

5.2.6.1 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 5-4); and
- Area between the Elsa hillside and valley bottom extending to Pond 3 (green area on Figure 5-4).

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. Overall, 537,587 m^3 of tailings will be relocated under this plan.

The tailings excavated from these areas would be consolidated on top of existing tailings in the valley bottom area shown on Figure 5-4 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 (Figure 5-6).

5.2.6.2 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. Based on these covers depths and the areas requiring treatment, approximately 748,122 m^3 of cover material would be needed.

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. The 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 and from north to west. Figure 5-6 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. In total, this is estimated to require 7,698 tonnes of lime. The peat layer underlying tailings in the valley is assumed to continue to attenuate metals released from tailings leaching processes.

5.2.6.3 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 and expanded as necessary to achieve the design criteria for stormwater flow management. Flat Creek will be rehabilitated as required near the area where diversion enters. 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 Trail 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.

5.2.6.4 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.

5.2.6.5 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.

5.2.6.6 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.

5.2.7 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. Figure 5-5 shows a map view with text descriptions of Alternative 3.

5.2.7.1 Tailings Relocation

Alternative 3 would involve construction of two lined facilities located northwest of the existing Valley Tailings, or in a similarly close location that is geotechnically suitable. A smaller facility would be used to contain drier tailings excavated from the Elsa hillside (blue area on Figure 5-5), valley edge (pink area on Figure 5-5), and top meter of the thicker tailings east of Pond 1 (green area on Figure 5-5). 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 5-5) 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. Approximately 1,092,343 m^3 of tailings are planned to be relocated under this option.

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, resulting in the addition of approximately 18,361 tonnes of lime. 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 (2009b), and possibly additional test work.

5.2.7.2 Cover

The tailings in the lined facilities would be covered with 1 m of material from the borrow area as illustrated in Figure 5-7. 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. Approximately 686,111 m^3 of cover material would be required for this plan.

5.2.7.3 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 Trail Highway to reduce suspended loads downstream in Flat Creek and the Porcupine Diversion.

5.2.7.4 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.

5.2.7.5 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 will be designed to blend in with natural features in the area, which is expected to increase the aesthetic appeal.

- 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 from the new lined facilities and require long term water treatment to avoid effects to downgradient soils and possibly Flat Creek.

- 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.

*5.2.7.6 **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 will 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.

5.2.8 Summary

The main components, costs, and risks of each alternative are summarized side by side in Table 5-2. 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.

5.2.8.1 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 is entering Flat Creek (Interralogic 2012a), 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, with effective diversions that prevent tailings contact of Flat Creek water with the VTF, 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 avoid contact with the dispersed tailings area.

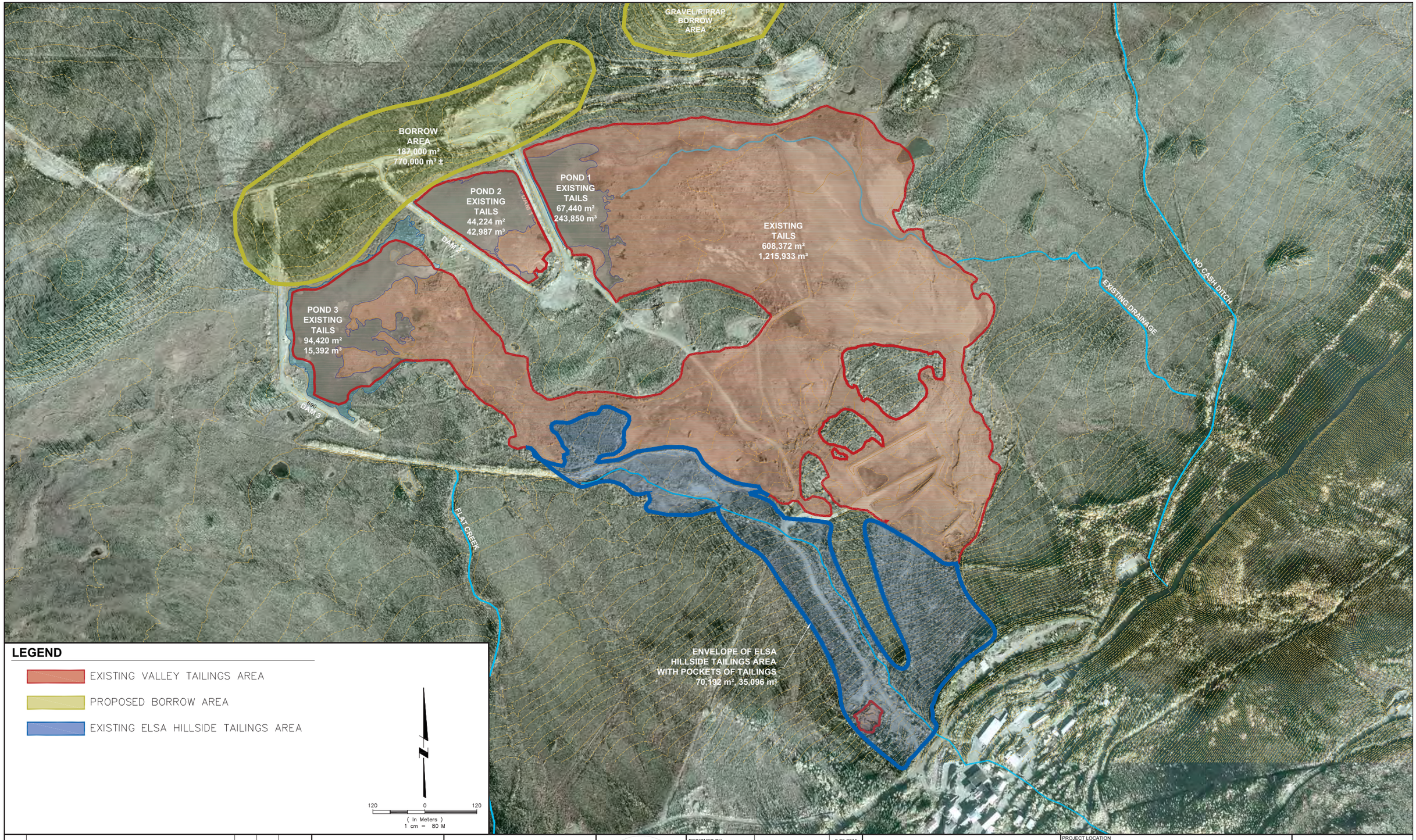
Table 5-2 Summary of VTF Closure Alternatives, Methods, Costs and Risks

	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	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

	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
	surface disruption reduced potential for metal release by oxidation processes compared to other alternatives			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 Trail 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

	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
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
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	Compared to other alternatives, limited amount of lime addition may not appreciable improve	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

	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
	metal release from current rates; failure of containment by peat may result in metal release to groundwater			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


GRAVEL/RIPRAP
BORROW
AREA
BORROW
AREA
187,000 m²
770,000 m³ ±
POND 1
EXISTING
TAILS
67,440 m²
243,850 m³
POND 2
EXISTING
TAILS
44,224 m²
42,987 m³
POND 3
EXISTING
TAILS
94,420 m²
15,392 m³
EXISTING
TAILS
608,372 m²
1,215,933 m³
DAM 1
DAM 2
DAM 3
NO CASH DITCH
EXISTING DRAINAGE
FLAT CREEK
ENVELOPE OF ELSA
HILLSIDE TAILINGS AREA
WITH POCKETS OF TAILINGS
70,192 m², 35,096 m³
690
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

GRAVEL/RIPRAP BORROW AREA

ABANDON EXISTING DRAINAGE COURSE

CONSTRUCTED NORTH DIVERSION CHANNEL

BORROW AREA

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 CREEK

NO CASH DITCH TO BE REHABILITATED AS REQUIRED

NO CASH DITCH

EXISTING DRAINAGE

WATER TREATMENT PLANT

SEDIMENT POND

POND 3

DAM 3

REVEGETATION AREA 10,846 m²

EXCLUSION AREA

EXCLUSION AREA

0.5 (m) HIGH ROCK OVERFLOW BERM

CONSOLIDATION TAILINGS AREA 34,743 m² 73,525 m²

CONSOLIDATION TAILINGS AREA 28,239 m² 60, 57 m²

RELOCATED TAILINGS AREA 59,435 m² 98,586 m²

POINT OF DIVISION BETWEEN THE NORTH AND SOUTH DIVERSION CHANNELS

PORCUPINE DIVERSION TO BE REHABILITATED AS REQUIRED

CONSTRUCTED SOUTH DIVERSION CHANNEL

FLAT CREEK

FLAT CREEK TO BE REHABILITATED AS REQUIRED.

PORCUPINE CREEK

ENVELOPE OF ELSA HILLSIDE TAILINGS AREA, RELOCATE AND PROVIDE REVEGETATION AROUND PORCUPINE CREEK 70,192 m², 10,529 m²

LEGEND

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

TOTAL COVER VOLUME = 662,380 m³

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

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CHECKED BY	B. CARLSON	3-25-2011
APPROVED BY		
PROJECT MANAGER		
CLIENT APPROVAL		
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PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
VALLEY TAILINGS ALT-1

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DRAWING Figure 5.2

REVISION

FILE NAME VTF-CLOSURE-ALTERNATIVE-1

DRAWING PLOTTED: k:\Projects\VTF0000 - Keno-Hoodoo Exp\Admin\VTF-CLOSURE-ALTERNATIVE-1.dwg LAYOUT PLOTTED: ALT-1 DATE: Mar 24, 2011 - 4:39pm CAD OPERATOR: mellon
LIST OF XREFS: [0000000_xTitle] [0000000_xTitle2] [0000000_xLeft] [0000000_xLeft2] [0000000_xLeft3] [0000000_xLeft4] [0000000_xLeft5] [0000000_xLeft6] [0000000_xLeft7] [0000000_xLeft8] [0000000_xLeft9] [0000000_xLeft10] [0000000_xLeft11] [0000000_xLeft12] [0000000_xLeft13] [0000000_xLeft14] [0000000_xLeft15] [0000000_xLeft16] [0000000_xLeft17] [0000000_xLeft18] [0000000_xLeft19] [0000000_xLeft20] [0000000_xLeft21] [0000000_xLeft22] [0000000_xLeft23] [0000000_xLeft24] [0000000_xLeft25] [0000000_xLeft26] [0000000_xLeft27] [0000000_xLeft28] [0000000_xLeft29] [0000000_xLeft30] [0000000_xLeft31] [0000000_xLeft32] [0000000_xLeft33] [0000000_xLeft34] [0000000_xLeft35] [0000000_xLeft36] [0000000_xLeft37] [0000000_xLeft38] [0000000_xLeft39] [0000000_xLeft40] [0000000_xLeft41]

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 m²

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 m²
TAILINGS = 389,439 m³
OVER EXCAVATION = 148,148 m³

EXCLUSION AREA

RELOCATED TAILINGS AREA
10,850 m², 5,425 m³
(ASSUMING TOP 0.5M HAUL, REMAINING SUBMERGED STAY IN PLACE)

RELOCATED TAILINGS AREA
296,295 m²
337,278 m³
(HAUL)

EXCLUSION AREA

EXCLUSION AREA

0.5 (m) HIGH ROCK OVERFLOW BERM

POINT OF DIVISION BETWEEN THE NORTH AND SOUTH DIVERSION CHANNELS

PORCUPINE DIVERSION TO BE REHABILITATED AS REQUIRED

RELOCATED TAILINGS AREA
38,820 m², 11,646 m³
(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 m², 35,096 m³

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 m³

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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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

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DRAWING
Figure 5.3

REVISION

FILE NAME
VTF-CLOSURE-ALTERNATIVE-2

DRAWING FILENAME: S:\Projects\VTF0000 - Keno-Hess\Keno Corp\Exhibits\VTF-CLOSURE-ALTERNATIVE-2.dwg LAYOUT NAME: ALT-2A DATE: Mar 24, 2011 - 4:49pm CAD OPERATOR: andrew
LIST OF XREFS: [b0000_xref0] [b0000_xref1] [b/Images/image-border-Model Fitting]

GRAVEL/RIPRAP BORROW AREA

NO CASH CREEK

FILL OVER TAILINGS IN PONDS WITH BORROW MATERIAL
86,395 m², 172,790 m³
(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 m²

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 m², 131,340 m³
(2m DEEP)

EXISTING DRAINAGE

DAM 2

WATER TREATMENT PLANT

CONSOLIDATION AREA FOR RELOCATED TAILINGS
158,922 m²
TAILINGS = 389,439 m³
OVER EXCAVATION = 148,148 m³

RELOCATED TAILINGS AREA
10,850 m², 5,425 m³
(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 m²
337,278 m³

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 m², 11,646 m³
(ASSUMING TOP 0.3m HAUL, SUBMERGED TO REMAIN)

FLAT CREEK

CONSTRUCTED SOUTH 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 m², 35,096 m³

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

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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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

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DRAWING Figure 5.4 REVISION

FILE NAME VTF-CLOSURE-ALTERNATIVE-2

DRAWING FILENAME: I:\Projects\VA00000 - Reno-Keno\Keno Corp\Models\VTF-CLOSURE-ALTERNATIVE-2.dwg LAYOUT NAME: ALT-2B DATE: Mar 24, 2011 - 4:47pm CAD OPERATOR: andrew
XREF OF DRAWING: [VA00000_xTopo] [VA00000_xLand] [G:\Terra\Logo-Border-Blocks Revised]

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 m²
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 m², 35,472 m³ (PUMP)

WATER TO BE PUMPED AND TREATED, DAMS TO BE REMOVED

RELOCATED SUBMERGED TAILINGS AREA
67,448 m²
243,850 m³
(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 m²
906,995 m³-ALL UNSUBMERGED
1 m THICK
(HAUL & PUMP)

EXISTING DRAINAGE

NO CASH DITCH

RELOCATED SUBMERGED TAILINGS AREA
55,600 m², 1,589 m³ (PUMP)

WATER TREATMENT PLANT

SEDIMENT POND

POND 3

RELOCATED TAILINGS AREA
10,850 m², 7,515 m³
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 m²
308,938 m³
(HAUL)

EXCLUSION AREA

WATER TO BE PUMPED AND TREATED, DAMS TO BE REMOVED

RELOCATED TAILINGS AREA
38,820 m², 13,803 m³
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 m²; 35,086 m³

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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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

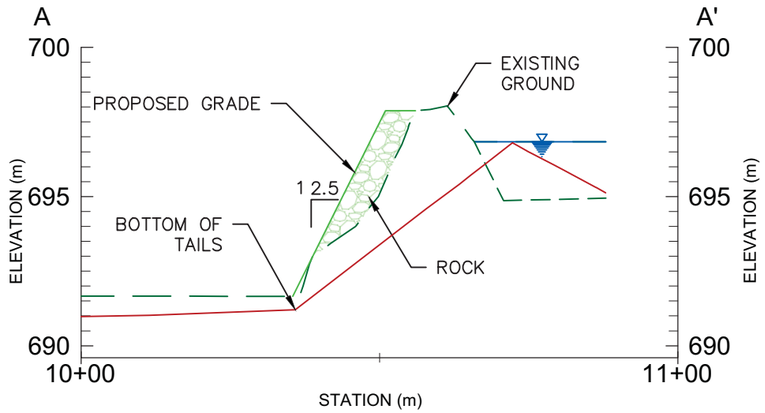
TITLE
VALLEY TAILINGS ALT-3

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DRAWING Figure 5.5 REVISION

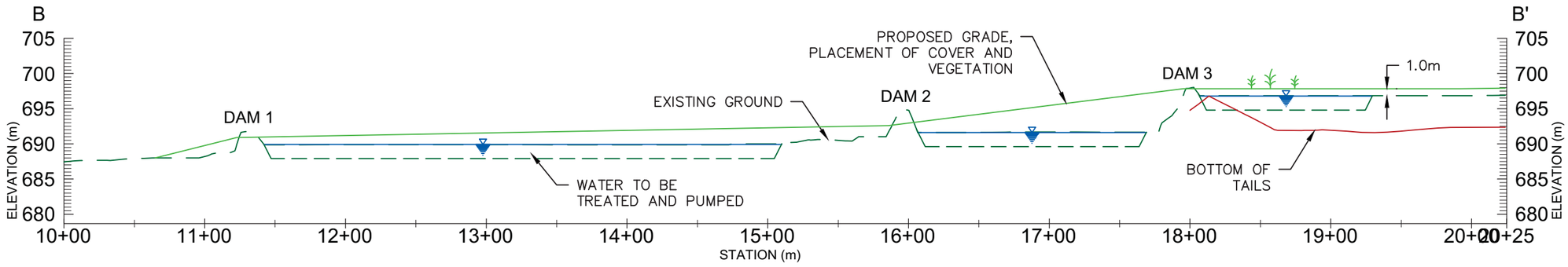
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ISSUED FOR: [X]Design [ ]Review [ ]Information [ ]Approval [ ]Record LAST SAVED BY: ---- ON: Mar 25, 2011 - 4:05pm AUTODESK SHX FILE: [X]Local [ ]XREFS [ ]Add-ins [ ]Fonts [ ]Plot Styles LAYOUT NAME: ALT-3A DATE: Mar 25, 2011 - 4:05pm USER: ---- PATH: [X]Local [ ]XREFS [ ]Add-ins [ ]Fonts [ ]Plot Styles



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)

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CLIENT REFERENCE NO.		

PROJECT LOCATION: KENO,YUKON, CANADA

PROJECT: KENO

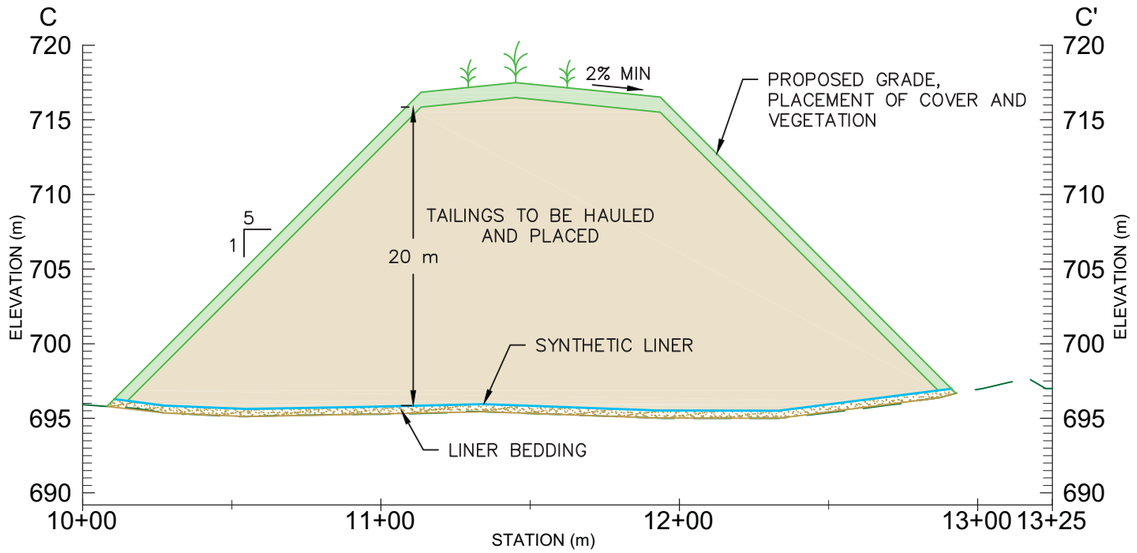
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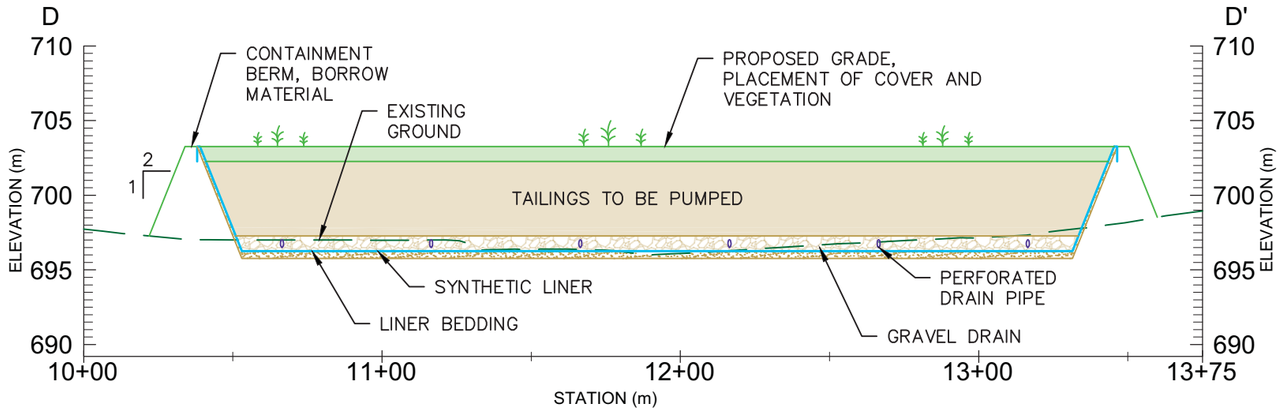
REVISION:

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)

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PROJECT MANAGER		
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CLIENT REFERENCE NO.		

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
VALLEY TAILINGS
PROFILES

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FILE NAME VTF-CLOSURE-SECTIONS

5.3 ADIT/SHAFT WATER TREATMENT

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 utilizing sulphate-reducing processes, where water is discharged from the adit into a lined facility; treatment is accomplished by passage of the water through the lined 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 to provide a low biologic oxygen demand discharge; monitoring is performed at the discharge location prior to the receiving stream.

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 or limited number of annual 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 prior to the receiving stream.

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.

5.3.1 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 some metal 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-alone 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 and/or high concentration adit systems.

5.3.2 Managed Natural Attenuation

Natural attenuation has been studied extensively in the Keno District, and especially 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; 2012c; 2013d; Laberge 2000). The very high efficiency of metals removal by this drainage, and the apparent robustness of the treatment mechanisms make this technology promising for long term closure of water draining from old mines in a passive configuration.

5.3.2.1 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, forming mineral layers around the organic materials (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.

5.3.2.2 Potential Treatment Locations based on Watershed Utilizing Managed Natural Attenuation

The adit locations where the above requirements appear to be possible include the Flat Creek drainage sites (Silver King 100 and Husky SW), and the No Cash drainage sites (No Cash 500, Bermingham and Ruby).

The locations where it appears there is a limiting factor that makes Managed Natural Attenuation not possible are the Ladue River drainage site at Sadie Ladue 600, the Christal Creek sites (Galkeno 300, Galkeno 900, and Onek 400, and the Lightning Creek site at Keno 700.

Sadie Ladue is a low concentration, high flow mine drainage that in an ideal drainage setting could conceivably be a candidate for natural attenuation. However, dispersed tailings along the flow path is

causing elevated metals in the drainage, comingling effects from the adit with metals leaching from dispersed tailings. 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 along the flow path of Lightning Creek.

5.3.2.3 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 location to check that the primary metals attenuation process by aeration 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 is presumed to 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, spring during freshet, summer, and fall).

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.

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.

5.3.3 Sulphate Reducing Bioreactor

Alexco Resource US (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 each test year. The configuration of the test bioreactor was not 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 QZ12-057.

The pilot test was a successful demonstration that this SRB technology, which has been widely employed at many sites in mine pools, wetlands, and bioreactors in a range of climate conditions, can be successfully implemented year-round in a buried pond bioreactor in the cold climate at Keno Hill, where air temperatures of -40^{o}C or colder are common in the winter months, and water temperatures less than 1^{o}C is common in adit discharges requiring treatment. From October 2009 until summer 2011, the bioreactor successfully treated 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 (Table 5-3; Alexco Resource US 2011). In 2010, flow rates of 0.75 and 1.0 l/s were tested, and results showed that at a flow rate of 0.75 l/s consistent zinc and cadmium treatment can be sustained, while a flow of 1.0 l/s treatment of these metals did not always meet standards, with spikes of metal concentrations higher than licence standards observed. The limiting factor appears to be the effective residence time in the reactor with the higher flow rates.

The issue of longevity of the bioreactor and requirements for replacement frequency has been preliminarily evaluated using information from this bioreactor pilot test. Assuming 0.5 l/s flow rate for this scale of a bioreactor, and with a void volume of 910,000 liters, effective treatment could continue until the effective flow increased to 0.75 l/s (effective flow increase is caused by an assumed 33.3% reduction in pore space due to precipitates retained in the bioreactor). Assuming a zinc sulphide density of approximately 4 g/cc, it would take about 19 years for the pore space to be consumed by the precipitate formed within the reactor. While this is a coarse calculation with several assumptions, it does illustrate that replacement or significant flushing of the reactor would not have to occur on a frequent basis. In a full scale design there will be design modifications that will limit dead zones within the bioreactor, increasing the effective hydraulic residence time, and also providing for flushing to extend the life of the bioreactor prior to a need for replacement. The bioreactor technology is discussed in greater detail in the final report on the bioreactor (Alexco Resource US 2011).

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.

Table 5-3 Bioreactor treatment efficiency operating at 0.5 L/s for a range of metal(loids)

	Influent concentration (mg/L)	Bioreactor effluent dissolved concentration (mg/L)	Percent removal
Zinc	6	0.012	99.8%
Cadmium	0.0015	<0.0001	96.7%
Arsenic	0.068	0.029	58.0%[b]
Antimony	0.0025	<0.0005	90.0%
Nickel	0.2	0.005	97.5%

[a] Where the effluent concentration was below the limit of detection, a value of half the detection limit was used to calculate percent removal

[b] As reducing conditions became more established, the arsenic concentration in the effluent progressively decreased to <0.01 mg/L (>85% removal).

5.3.3.1 Sulphate Reducing Bioreactor Treatment Processes

The sulphate reduction bioreactor treatment process which is responsible for the water quality improvements in the bioreactor 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 will 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. Alternatively a passive eductor approach will be used to cause alcohol to be drawn into the reactor proportional to adit flow. 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.

5.3.3.2 Potential Sites Utilizing Bioreactor Treatment

The adit locations where a bioreactor appears to be a feasible technology to be implemented for at least a portion of the treatment requirements include the Flat Creek drainage sites (Silver King 100 and Husky SW), the No Cash drainage sites (No Cash 500, Ruby, and Bermingham), the Christal Creek sites (Galkeno 900, and Onek 400), the Lightning Creek site at Keno 700, and the Ladue River drainage site at Sadie Ladue 600.

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 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.

5.3.3.3 Adaptive Management of Bioreactor Systems

Since this bioreactor design can have active components including a liquid organic carbon substrate addition, 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, to sufficiently aerate the water and remove the residual sulphide or BOD from the drainage.

5.3.4 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. At the present time, drainage from Silver King 100, Galkeno 300, Galkeno 900, and Keno 700 is coming from an existing mine pool. Other mines (Bermingham, Ruby and No Cash 500) could have some mine pool development by the addition of a bulkhead which would retain water at least on the level of the bulkhead.

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 (Alexco US 2012b). Acid mine pools have also been treated successfully in this way (Bilgin et al., 2007). The technology is also similar to mine pit lake treatments that Alexco personnel have a track record of treating. Examples include the Anchor Hill pit lake in South Dakota, where organic carbon treatments lowered dissolved zinc, copper and cadmium concentrations by over 99% (Harrington et al, 2004).

5.3.4.1 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 sludge is typically 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.

5.3.4.2 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 based on mine plan drawings (Alexco Resource US Corp., 2009) and preliminary hydrologic testing (Interralogic 2012e)) and possibly the Galkeno 900 discharge are 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 both the Husky SW and Husky flooded underground mines 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.

5.3.4.3 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.

5.3.5 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 WUL QZ12-057. 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, or power disruption. 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. A discussion of the water treatment plant performance can be found in Section 3.3.

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 primary treatment or 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.

5.3.5.1 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. In general, addition of iron will be required for sites that are low manganese or iron, typically lower than 1-3 moles {iron+manganese} per mole {cadmium+zinc}. Sites that fit these criteria include Onek 400 and Keno 700.

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 nucleation sites for larger precipitates to form;
- an optional filtration system to remove fine particles that were insufficiently removed by the clarification/thickener process; and
- a sludge press, filter bags, or sludge drying process 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 proposed as part of the detailed design phase.

- 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 for the detailed design phase.
- 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 removes 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 for the detailed design phase.

- 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 further re-processing. Preliminary bench-scale tests have shown promising results, and additional larger scale test may be performed during the detailed design phase.

5.3.5.2 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, either as a primary system, or as an adaptive management fall-back process. 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 QZ12-057 discharge standards already.

5.3.5.3 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. For some sites such as Galkeno 300 a mechanical plant is considered to be the default option, due to the high loadings of metals. 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. Source control or in situ treatment options are considered as potential add-on steps to be licenced with the treatment sites as options that could decrease the timeframe an active treatment plant is required.

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 consistent 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 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 considered and 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.

All of these options will be considered during the detailed design phase of the project, after the closure options for each site have been selected.

5.3.6 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.

5.3.6.1 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 QZ12-057. 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.

5.3.6.2 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.

5.4 WASTE ROCK STORAGE AREAS

As shown in Table 5-4 and displayed on Figure 5-8, 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 now Production Unit related operational facilities and not being considered for near-term reclamation of historic terrestrial liabilities under this closure and reclamation program.

Table 5-4 Keno District WRSA and Open Pit Sites

Site Type	Site Name (b)	Waste Rock Tonnage (a)	Selected for WRSA Reclamation	Selected for Pit Safety Berm and/or Optional Backfill	Rationale
Pit	**Flat Creek Watershed**				
	Silver King pit and WRSA	120,000	X	X	WRSA: large, requires regrade
	No Cash Bog				
	Bermingham pit and WRSA	1,500,000	X	X	WRSA: large, requires regrade, tension cracks. Possible pit recharge to Galkeno 900 adit
	No Cash 100 pit and WRSA	6,500	X	X	WRSA: requires regrade. Possible pit recharge to No Cash 500 adit
	Christal Creek Watershed				
	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 asit
	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
	Miller pit and WRSA	63,000		X	May require berm
	Onek pit and WRSA	600,000	X	X	WRSA: large, visible, requires regrade. Possible recharge to Onek 400 adit.
	Shamrock pit and WRSA	9,000		X	Requires berm
	Lightning Creek Watershed				
	Keno No. 9 System pit and WRSA	small piles			No obvious issues on Aerial
	Porcupine pit and WRSA (near Keno 700)	3,400			No obvious issues on Aerial
	Keno Ladue River Watershed				
	Cub & Bunny pit and WRSA	1,350			No obvious issues on Aerial
	Lake pit and WRSA	2,550			No obvious issues on Aerial
	Sadie Ladue (Wernacke) pit and WRSA	24,500	X		WRSA: requires regrade. Possible pit recharge to groundwater
Adit or Shaft	**Flat Creek Watershed**				
	Dixie adit and WRSA	19,800	X		Requires regrade, gullies
	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 intrigue risk 2007 B.E.R.
	Gerlitski adit and WRSA	10,281			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
	Silver King 100 adit and WRSA	43,000	X		Requires regrade. Adit discharge may flow into waste rock
	No Cash Bog				
	Bermingham adit and WRSA	7,000			No significant issues in 2007 B.E.R
	Betty adit and WRSA	none			No obvious issues on Aerial
	Coral & Wigwam adit and WRSA	75,000			No obvious issues on Aerial
	Hector 400 adit and WRSA	198,000	X		Large, requires regrade, visible, potential chemical source
	No Cash 500 adit and WRSA	138,100	X		Large, requires regrade. Adit discharge may flow into waste rock
	Ruby adit and WRSA	28,900	X		Requires regrade. May require diversion to keep surface water away from waste rock.
	Townsite adit and WRSA	14,300	X		WRSA: potential chemical source
	Christal Creek Watershed				
	Blue Bird adits and WRSA	minimal			No obvious issues on Aerial
	Christal (Dorothy) adit and WRSA	minimal			No obvious issues on Aerial
	Divide adit and WRSA	trenching			No obvious issues on Aerial
	Dragon (UN) adit and WRSA	3,200			No obvious issues based on 2007 B.E.R.
	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
	Kijo adit and WRSA	minimal			No obvious issues on Aerial
	Klondike Keno adit and WRSA	2,000			No obvious issues on Aerial
	Lucky Queen 500 adit and WRSA	61,900	X		Requires regrade, visible (above tree line)
	Mackeno adit and WRSA				No obvious issues on Aerial
	Onek 400 adit and WRSA	7,500	X		Adit discharge flows onto waste rock
	Rico adit and WRSA	minimal			No obvious issues on Aerial
	Shamrock King adit and WRSA	16,200			No obvious issues on Aerial
	Shepherd adit and WRSA	minimal			No obvious issues on Aerial
	Lightning Creek Watershed				
	Apex adit and WRSA	trenching	X		No obvious issues on Aerial
	Apex adit and WRSA	minimal			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
	Comstock 150 adit and WRSA	3,100			Listed as adits in 2007 B.E.R.
	Comstock 275 adit and WRSA	3,100			Listed as adits in 2007 B.E.R.
	Croesus No. 1 adit and WRSA	minimal			No obvious issues on Aerial
	Duncan Creek WRSA	none			No obvious issues on Aerial
	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 may flow into waste rock
	Stone adit and WRSa	84,540			No obvious issues on Aerial
	Keno Ladue River Watershed				
	Fox adit and WRSA	trenching			No obvious issues on Aerial
	Gold Hill No. 2 and WRSA	100			No obvious issues on Aerial
	Highlander adit and WRSA	15,000			No obvious issues on Aerial
	Lake View adit and WRSA	trenching			No obvious issues on Aerial
	Lucky Queen shaft and WRSA	5,000			With Lucky Queen 500
	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
	Sadie Ladue 600 adit and WRSA	9,500	X		No obvious issues on Aerial. Possible pit recharge to groundwater.
	Sadie Ladue shaft and WRSA				2007 B.E.R shafts collapsed and backfilled
	Silver Basin adit and WRSA	trenching			No alarms in 2007 B.E.R.

(a) Tonnage- short tons (Source: Primary 1996 SCR, secondary PWGSC 2000 and estimates from SRK inspections)
(b) Bellekeno 625 and Flame & Moth are operating sites that are not being considered for near-term reclamation

Not applicable
Retained for cost analysis

5.4.1 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. To perform these minimal reclamation activities, heavy equipment will most often require access to these sites in order to perform the reclamation tasks.

5.4.2 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; and
- 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); and
- 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 5-4. Table 5-5 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.

Table 5-5 Reclamation Activities

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	5-11	1,500,000	X				X	X	
Black Cap pit and WRSA	5-17	390,000	X				X		
Calumet pit and WRSA	5-19	1,025,000	X				X	X	
Galkeno 300 area pits and WRSAs	5-20	450,000	X				X	X	
Hector pit and WRSA	5-23	110,000	X				X	X	
Miller pit and WRSA	5-25	63,000					X		
No Cash 100 pit	5-14	6,500	X	X			X	X	
Onek pit and WRSA	5-26	600,000	X				X	X	X
Sadie Ladue (Wernecke) pit and WRSA	5-30	24,500	X				X	X	
Shamrock pit and WRSA	5-29	9,000					X		
Silver King pit and WRSA	5-9	120,000	X				X	X	X
Dixie adit and WRSA	5-32	19,800	X						
Elsa +50 adit and WRSA	5-34	1,550			X				
Galkeno 300 adit and WRSA	5-20	150,000	X						
Galkeno 900 adit and WRSA	5-42	20,800	X		X				
Hector 400 adit and WRSA	5-43	198,000	X			O			
Husky shaft and WRSA	5-35	4,600	O (c)			O			
Husky SW shaft and WRSA	5-36	17,000	O (c)			O			
Keno 700 adit and WRSA	5-46	27,500	X	X	X				
Lucky Queen 500 adit and WRSA	5-44	61,900	X						
No Cash 500 adit and WRSA	5-38	138,100	X	X (b)	X				
Onek 400 adit and WRSA	5-45	7,500	O (c)		X	O			
Ruby adit and WRSA	5-39	28,900	X		X				
Sadie Ladue 600 adit and WRSA	5-48	9,500			X				
Silver King 100 adit and WRSA	5-37	43,000	X	X	X				
Townsite adit and WRSA	5-40	14,300	X			O			

Notes

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) Regrading will be performed only if a soil cover is placed

5.4.3 Description of Reclamation Activities for WRSAs

5.4.3.1 Regrading

For indicated WRSAs in Table 5-5, 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).

5.4.3.2 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 undermining. 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.

5.4.3.3 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, Husky SW, Husky 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.

5.4.3.4 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 will be determined during the risk assessment workshop which is the first portion of the preferred options selection. The exact type of cover to be utilized will be refined during Detailed Design based on cover trials being installed in 2013. A native plant seed collection and increaser program is ongoing and is expected to inform the cover design. Should additional seed stock be required, a reclamation grass seed mix has been developed which contains native species. Proper preparation when placing and grading of growth media will enable germination of soil seed banks.

Re-graded WRSA that do not have the potential to a significant chemical source to surface and ground water nor are phytotoxic to vegetation may be reclaimed using physical treatments (such as creating rough and loose micro-site for natural revegetation to occur) in conjunction with establishment of 'environmental resource patches' and/or using soil amendments such as biochar, as recent research trials indicate positive results. Note that the regrading activities at Husky shaft, Husky SW shaft, and Onek 400 adit WRSAs is only necessary if a decision is made to place covers on these WRSAs.

An analysis of the potential for reduced metals loading for Husky SW by preventing the waste rock from contacting the shaft drainage shows that the surface waste rock could make up the vast majority of the metals loading from the site. While no direct measurement of water quality can be obtained within the mine directly due to the ice plug, by the time water from the mine surfaces it has transported through the waste rock and come to surface. Measurement of zinc loading from a Husky SW sample in

SRK (2009) showed 4.2 mg/kg zinc per year. More recently, in preparation for the cover trials at Husky WRSA, waste rock was piled in a lined facility and samples were taken of the leachate or pore water from the waste rock which showed an average of 63.3 mg/L zinc, cadmium of 1.1 mg/L, and iron of 1621 mg/L, with all pH measurements between 2.2 and 3.0. In contrast, the groundwater measurements taken in from the well downgradient from both Husky and Husky SW (in sand and gravels that are downgradient of the mine workings/shaft) showed less than 0.0005 mg/L cadmium, and less than 0.006 mg/L zinc for both sites (Appendix S). This is good, albeit indirect, evidence that the waste rock is contaminating otherwise good quality mine drainage from the Husky SW shaft.

5.4.4 Description of Reclamation Activities for Open Pits

5.4.4.1 Safety Berms

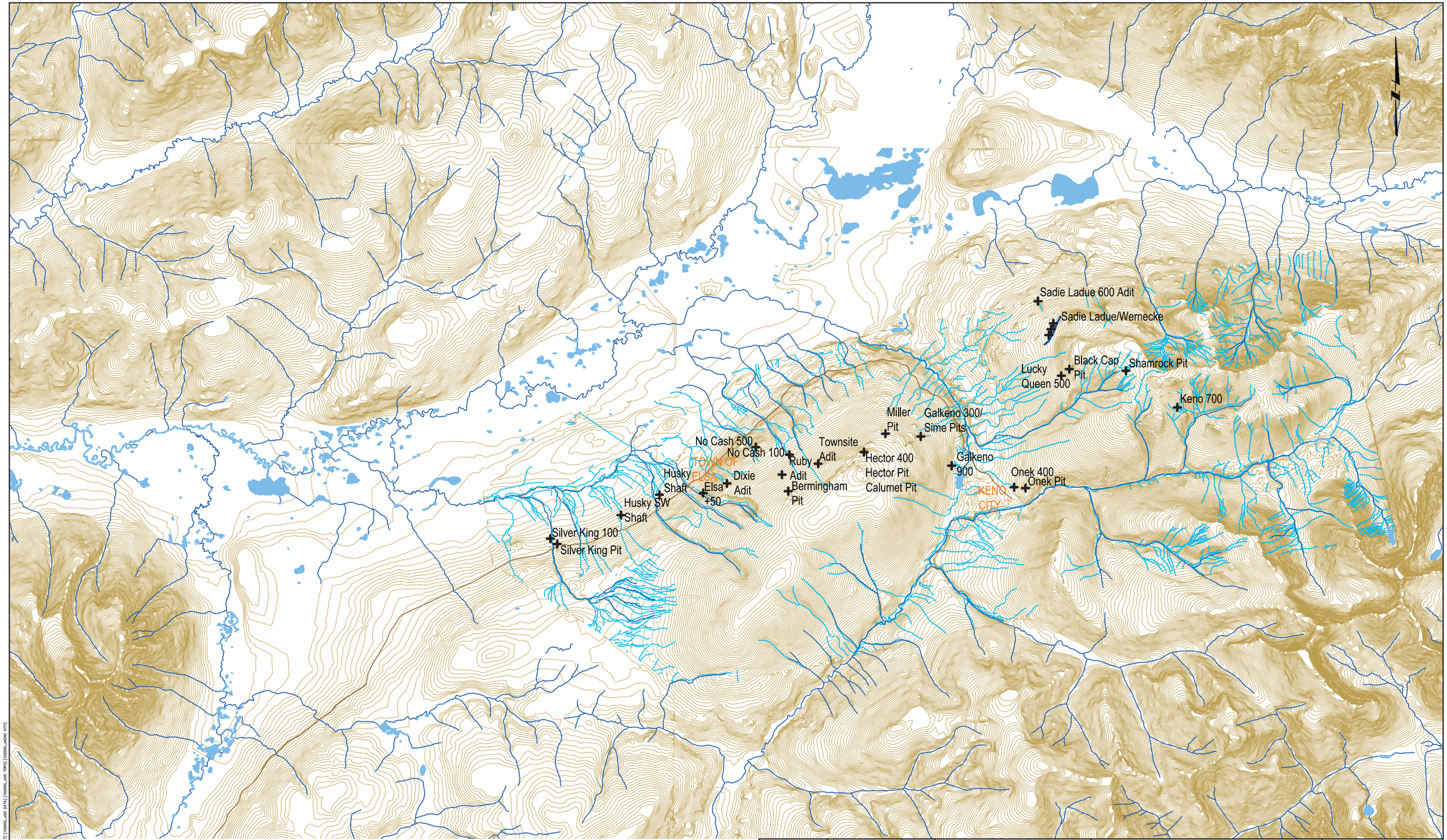
To mitigate the fall hazard for people in vehicles, ATVs, and snow machines, double safety berms will be installed along the perimeters of all pit walls that are higher than 5 m. The first berm will generally be located about 5-15 m from the top edge of the pit wall, constructed to a height of 3 m above 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.

5.4.4.2 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.

5.4.4.3 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 condition 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.



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

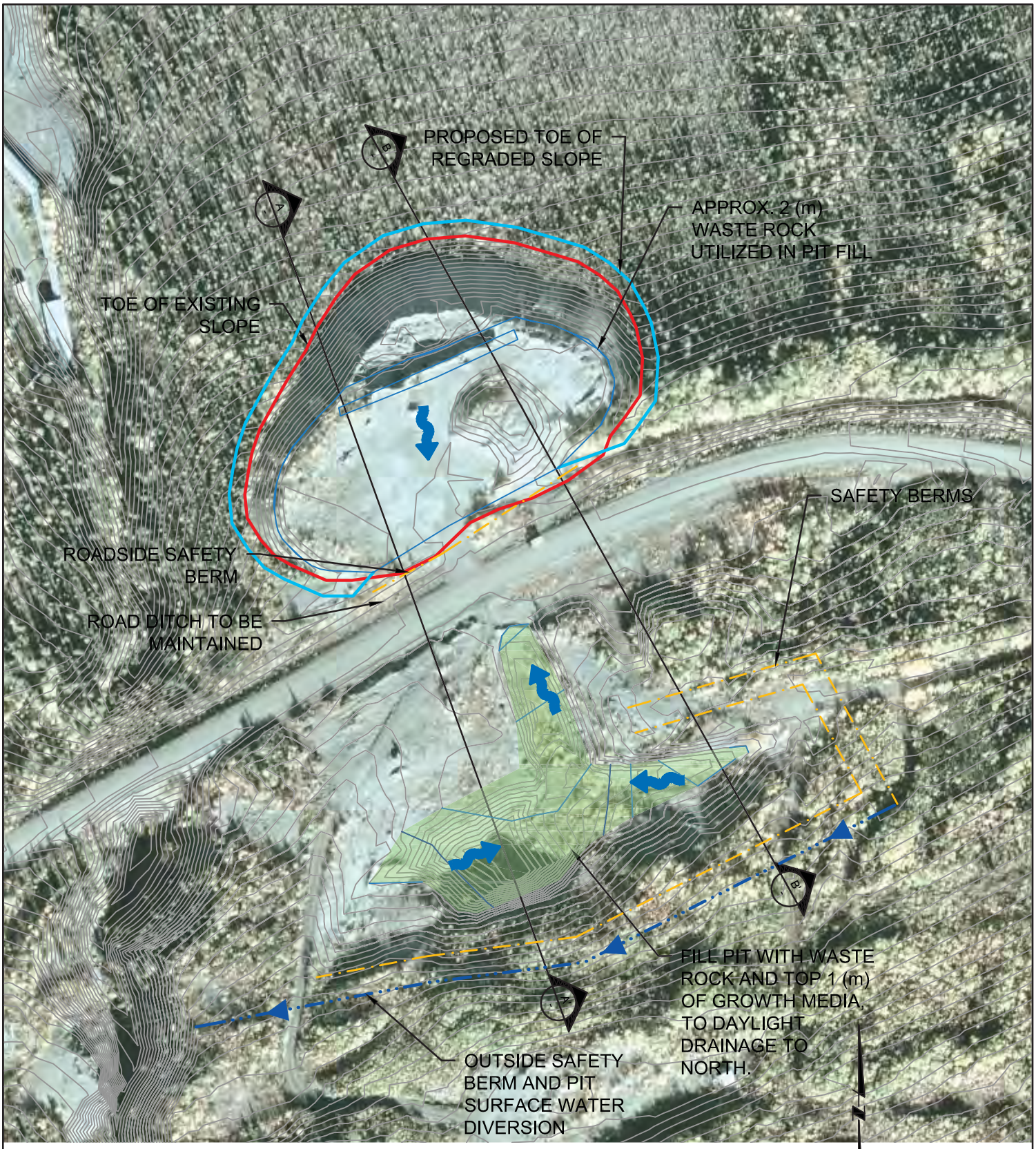
INTERRA CONSULTING
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING Figure 5.8

REVISION

FILE NAME 102000_Overall Map

DRAWING FILENAME: i:\Projects\102000 - Keno-Hecla\Keno Cad\Grad\102000_Overall Map.dwg LAYOUT NAME: Overall DATE: Mar 31, 2011 - 4:35pm CAD OPERATOR: cwelken
LIST OF XREFS: [b'Hard-Light--border-11x17] [102000_GIS DATA] [102000_GIS TOPO] [102000_MISC KENO CITY]



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

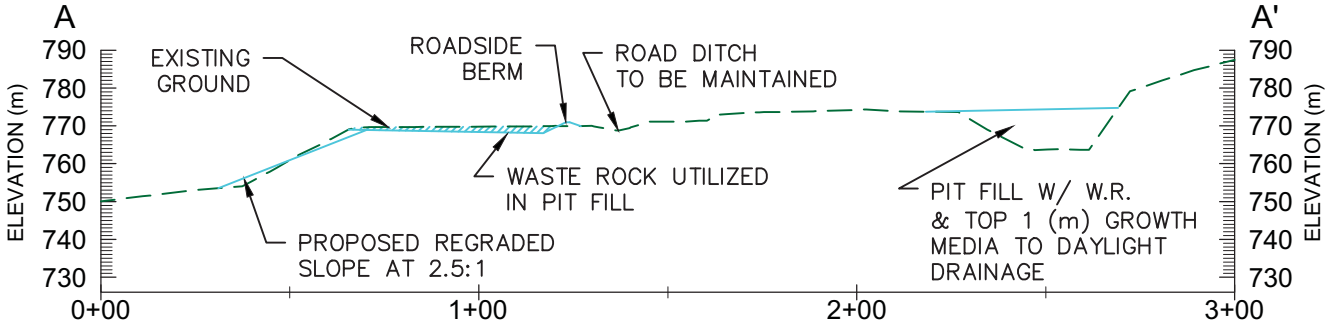
TITLE
SILVER KING PIT PLAN

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

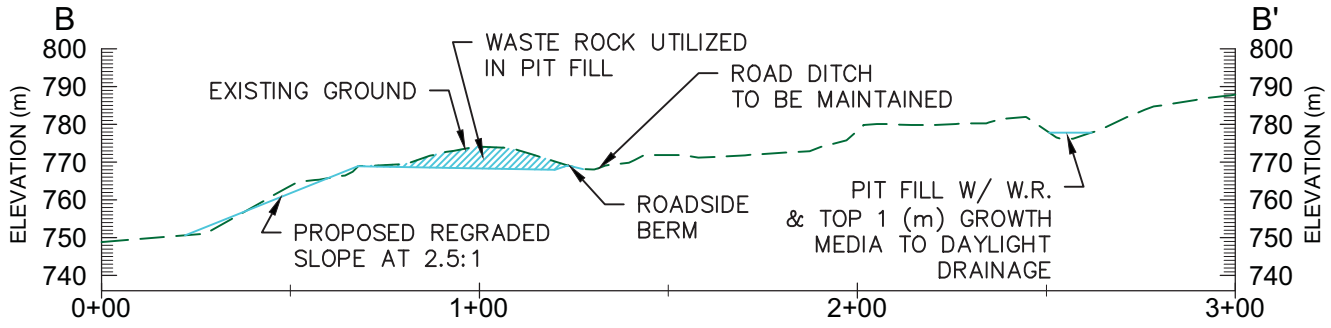
DRAWING Figure 5.9 REVISION

FILE NAME 102000_Silver King

DRAWING FILENAME: i:\Projects\102000 - Keno-Nexus\Keno Coal\Graph\102000_Silver King.dwg LAYOUT NAME: Silver King Plan DATE: Mar 29, 2011 - 4:03pm CAD OPERATOR: ACAD
LIST OF XREFS: [102000_xTOPO_SECTION B] [xTerms\plc-xborder-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

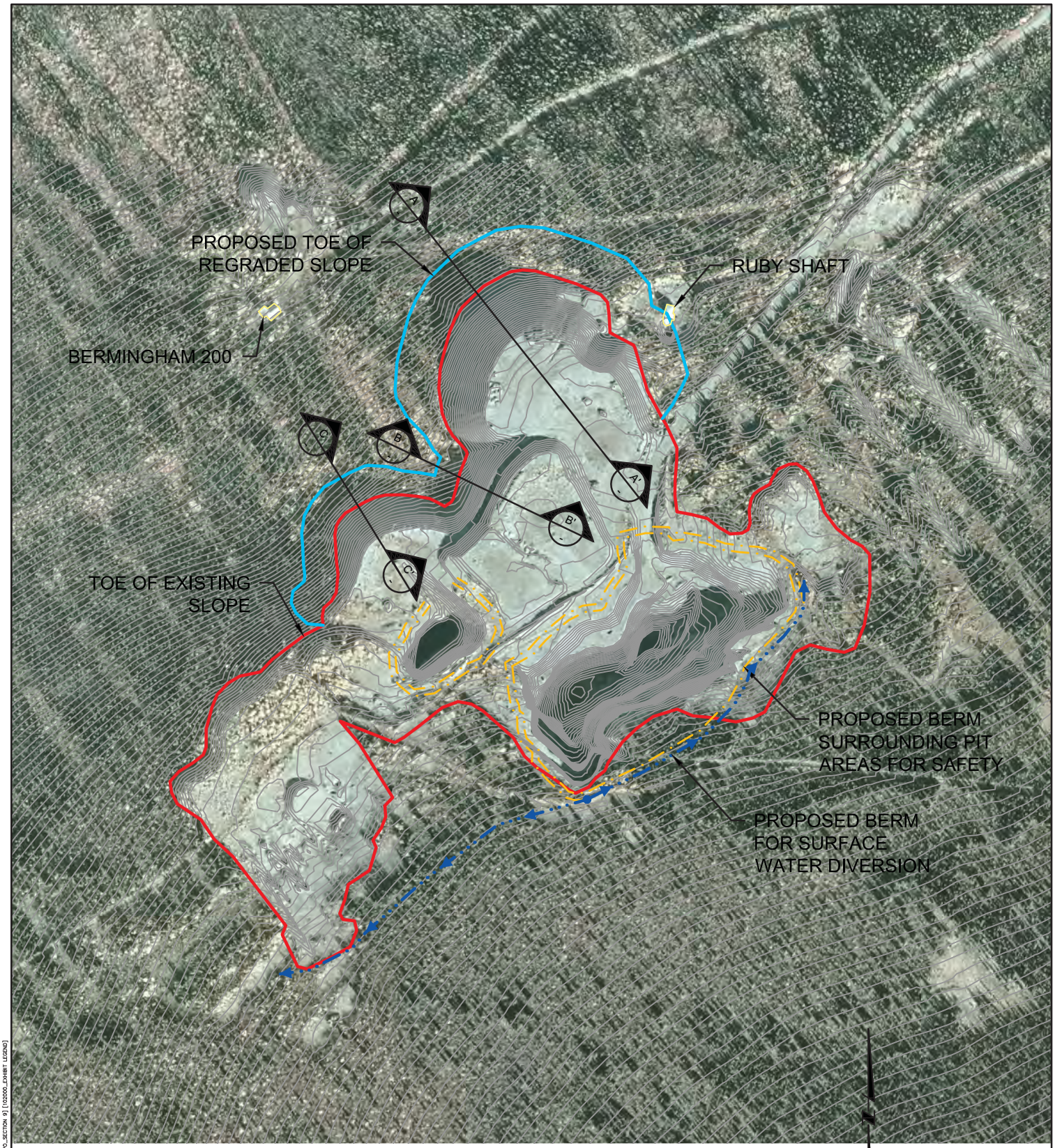
TITLE
SILVER KING PIT
SECTIONS A & B

INTERRA
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Fort Collins, Co 80525
970.225.8222

DRAWING Figure 5.10 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] [InTerraLogic-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.

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

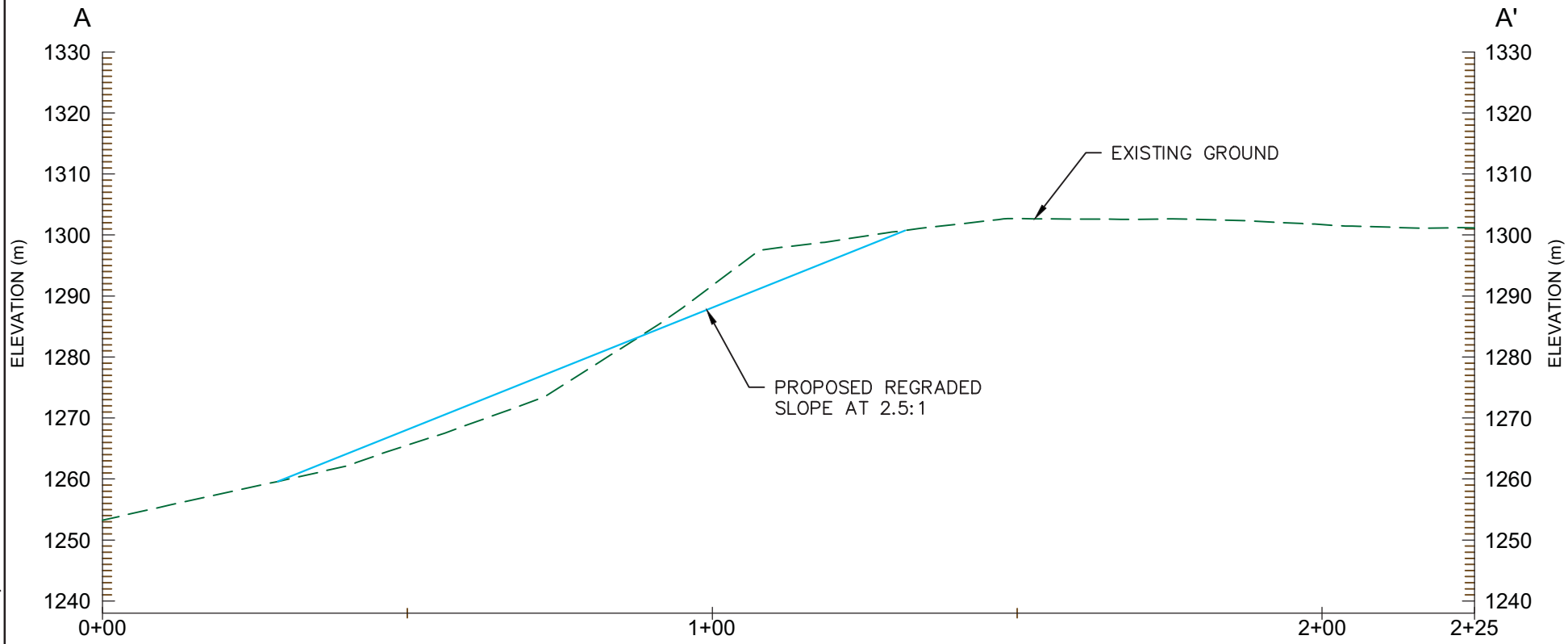
PROJECT
KENO

TITLE
BERMINGHAM PIT PLAN

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

DRAWING Figure 5.11
REVISION
FILE NAME 102000_Bermingham

DRAWING FILENAME: i:\Projects\102000 - Keno-Newco\Keno Coal\Graphics\102000_Bermingham.dwg LAYOUT NAME: BERMINGHAM_PLAN DATE: Mar 29, 2011 - 2:31pm CAD OPERATOR: ACAD
LIST OF XREFS: [n:\terralogic-standards\terralogic-standards_8x11_ansi] [102000_TOPO_SECTION 9] [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 = 10m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
BERMINGHAM PIT
SECTION A

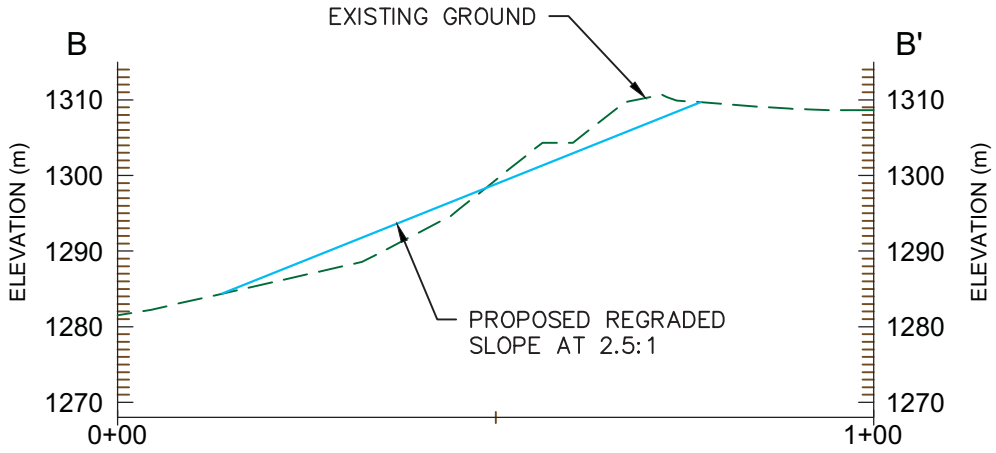
INTERRA
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Fort Collins, Co 80525
970.225.8222

DRAWING Figure 5.12

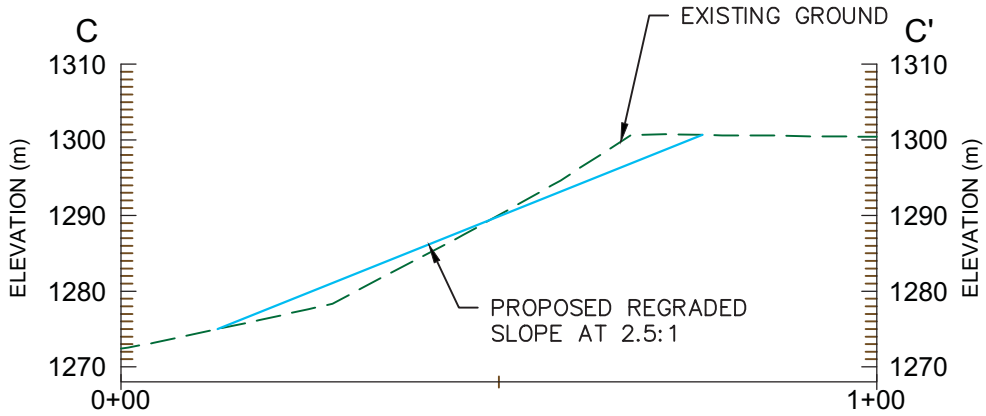
REVISION

FILE NAME 102000_Bermingham

DRAWING FILENAME: s:\Projects\102000 - Keno-Anexco\Keno Coal\Grout\102000_Bermingham.dwg LAYOUT NAME: BERMINGHAM_SECTION A DATE: Mar 29, 2011 - 2:32pm CAD OPERATOR: ACAD
LIST OF XREFS: [b:\Terralogic-xborder-8x11.wmf][b:\Terralogic-xborder-8x11.wmf][102000_xTOPO_SECTION B][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

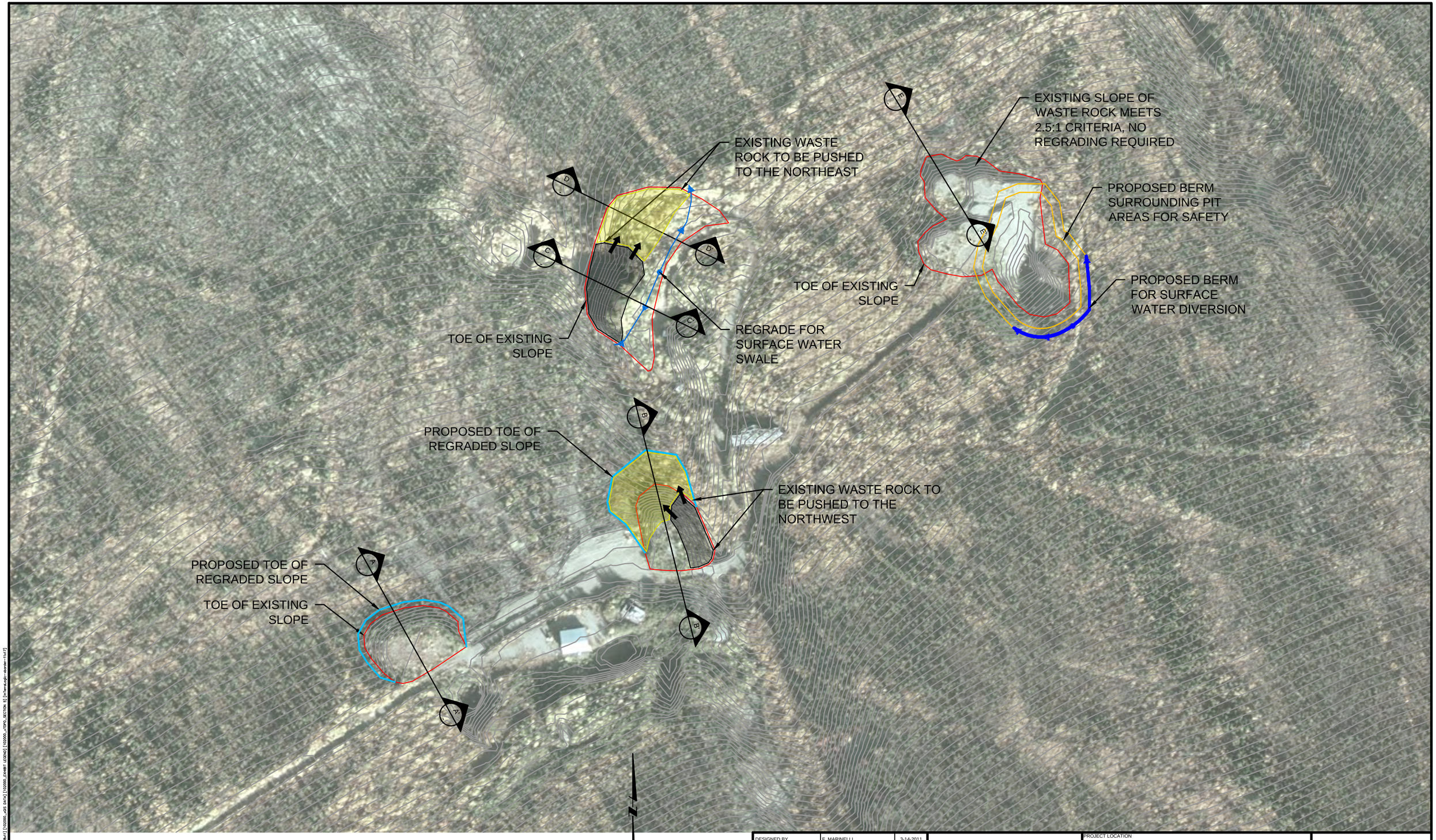
TITLE
BERMINGHAM PIT
SECTIONS B & C

INTERRA
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DRAWING Figure 5.13 REVISION

FILE NAME 102000_Bermingham

DRAWING FILENAME: L:\Projects\102000 - Keno-Nexco\Keno Coal\Graph\102000_Bermingham.dwg LAYOUT NAME: BERMINGHAM_SECTION B_C DATE: Mar 29, 2011 - 2:34pm CAD OPERATOR: ACAD
LIST OF XREFS: [n:\termlogic-xborder-8x11] [n:\termlogic-xborder-8x11_ori] [102000_TOPO_SECTION 9] [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

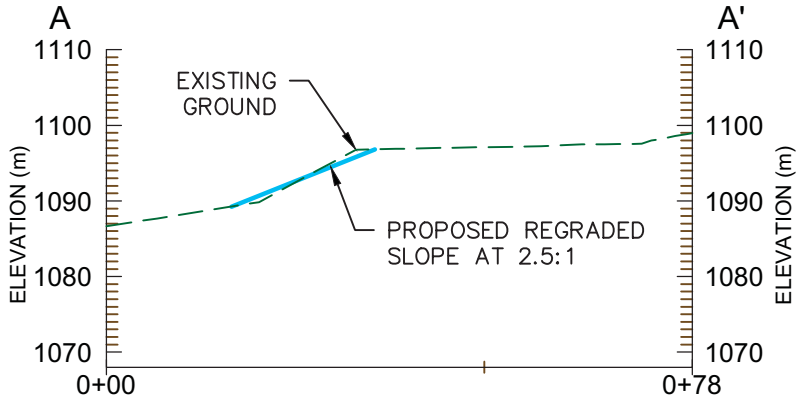
TITLE
NO CASH 100 PIT PLAN

INTERRA
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Fort Collins, Co 80525
970.225.8222

DRAWING FIGURE 5.14 REVISION

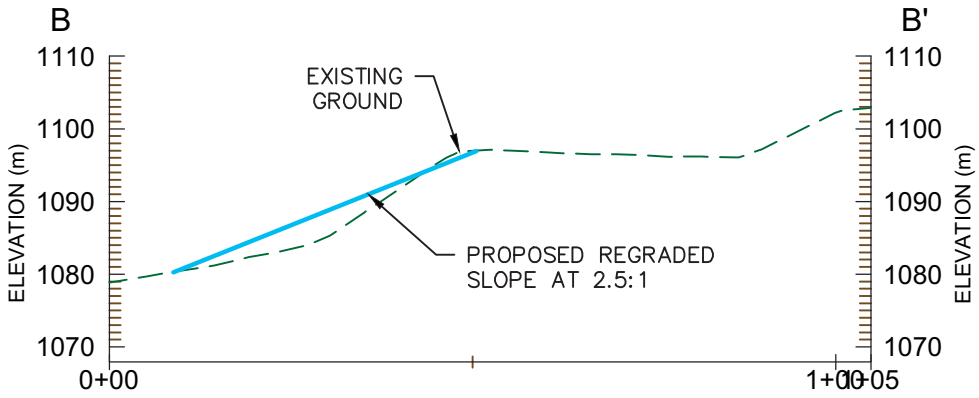
FILE NAME 102000_No Cash 100

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STATION (m)

SECTION A-A'



STATION (m)

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

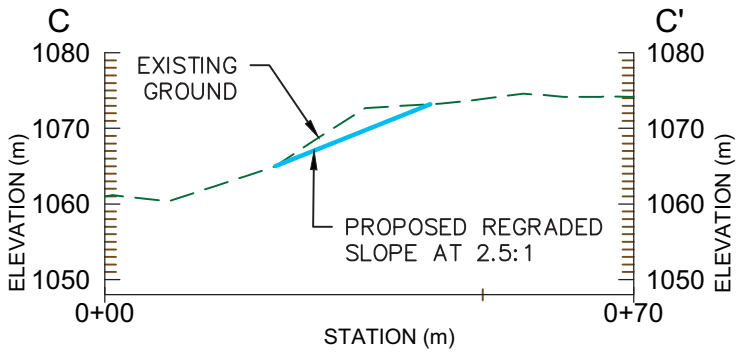
TITLE
NO CASH 100 PIT
PROFILES A & B

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

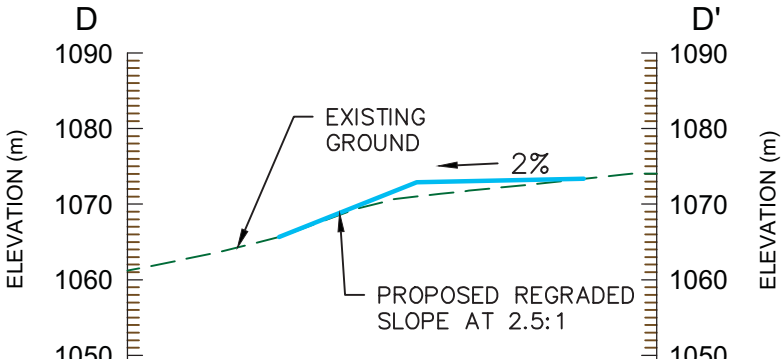
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FILE NAME 102000_No Cash 100

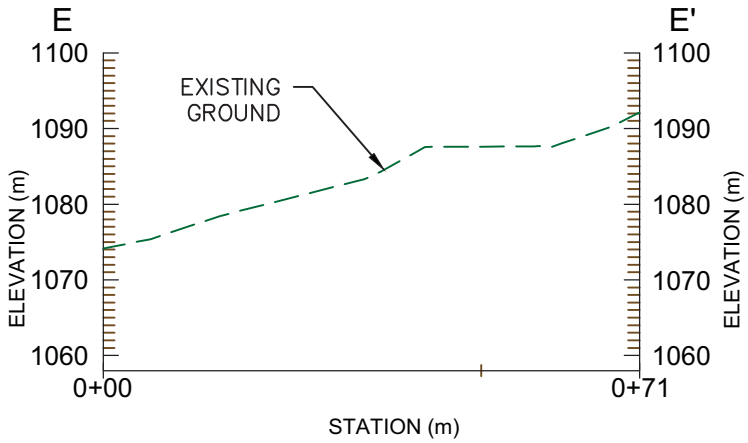
DRAWING FILENAME: L:\Projects\102000 - Keno-Nexco\Keno Coal\Grad\102000_No Cash 100.dwg LAYOUT NAME: NO CASH 100_PROFILE DATE: Mar 30, 2011 - 8:43am CAD OPERATOR: cwelken
LIST OF XREFS: [n:\terradyn--border-8x11] [102000_GIS DATA] [102000_EXHIBIT LEGEND] [102000_xTOPO_SECTION A] [n:\terradyn--border-11x17]



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

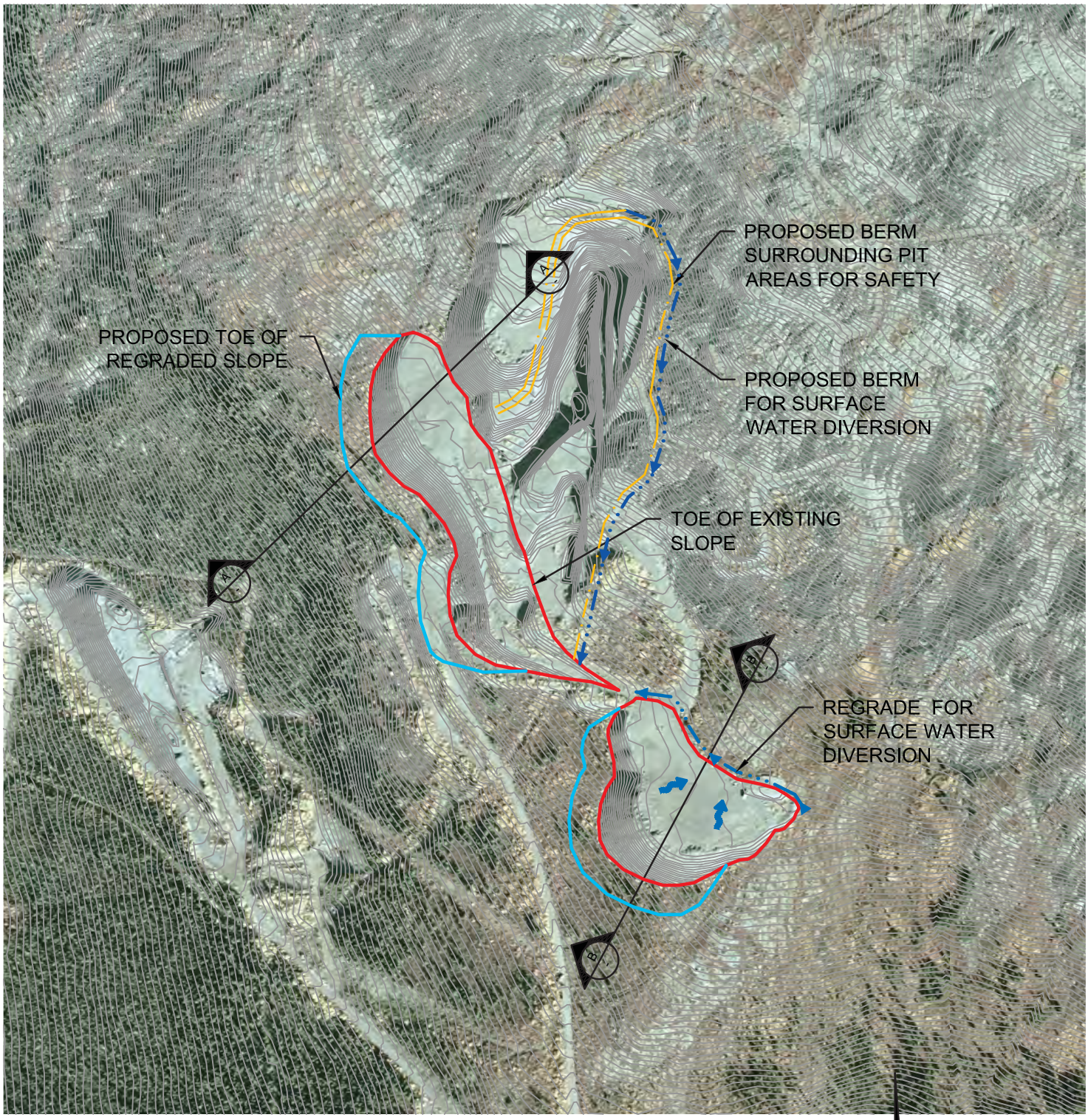
TITLE
NO CASH 100 PIT
PROFILES C, D & E

INTERRA
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Fort Collins, Co 80525
970.225.8222

DRAWING Figure 5.16 REVISION

FILE NAME 102000_No Cash 100

DRAWING FILENAME: i:\Projects\102000 - Keno-Hecla\Keno Cash\Grad\102000_No Cash 100.dwg LAYOUT NAME: NO CASH 100_PROFILE (2) DATE: Mar 30, 2011 - 9:43am CAD OPERATOR: cwelken
LIST OF XREFS: [n:\terradyn--border-8x11] [102000_GIS DATA] [102000_EXHIBIT LEGEND] [102000_xTOPO_SECTION 4] [n:\terradyn--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

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

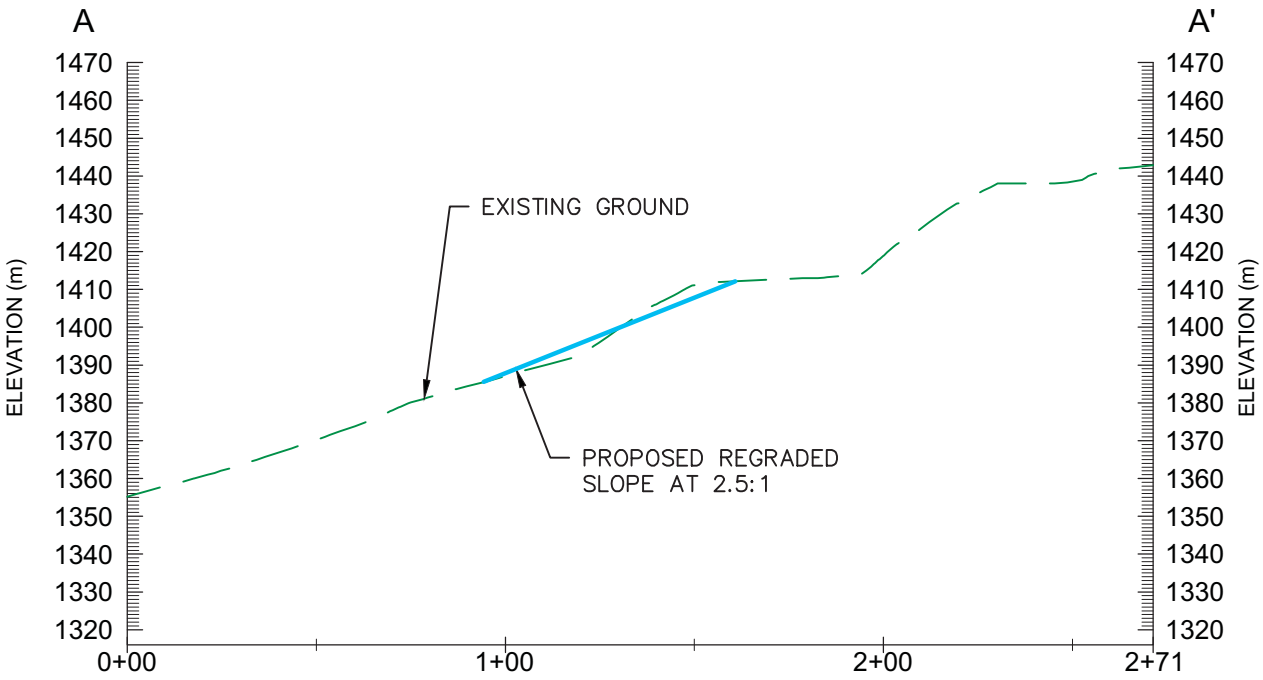
TITLE
BLACK CAP PIT
PLAN

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

DRAWING Figure 5.17 REVISION

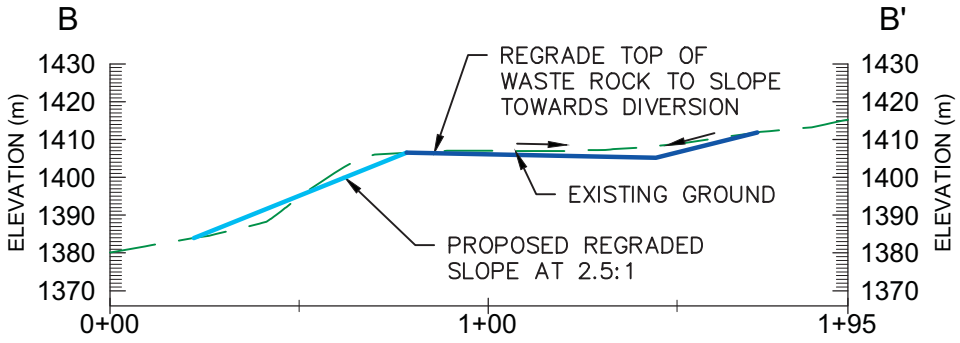
FILE NAME 102000_Black Cap

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 5] [102000_EXHIBIT LEGEND]



STATION (m)

SECTION A-A'



STATION (m)

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

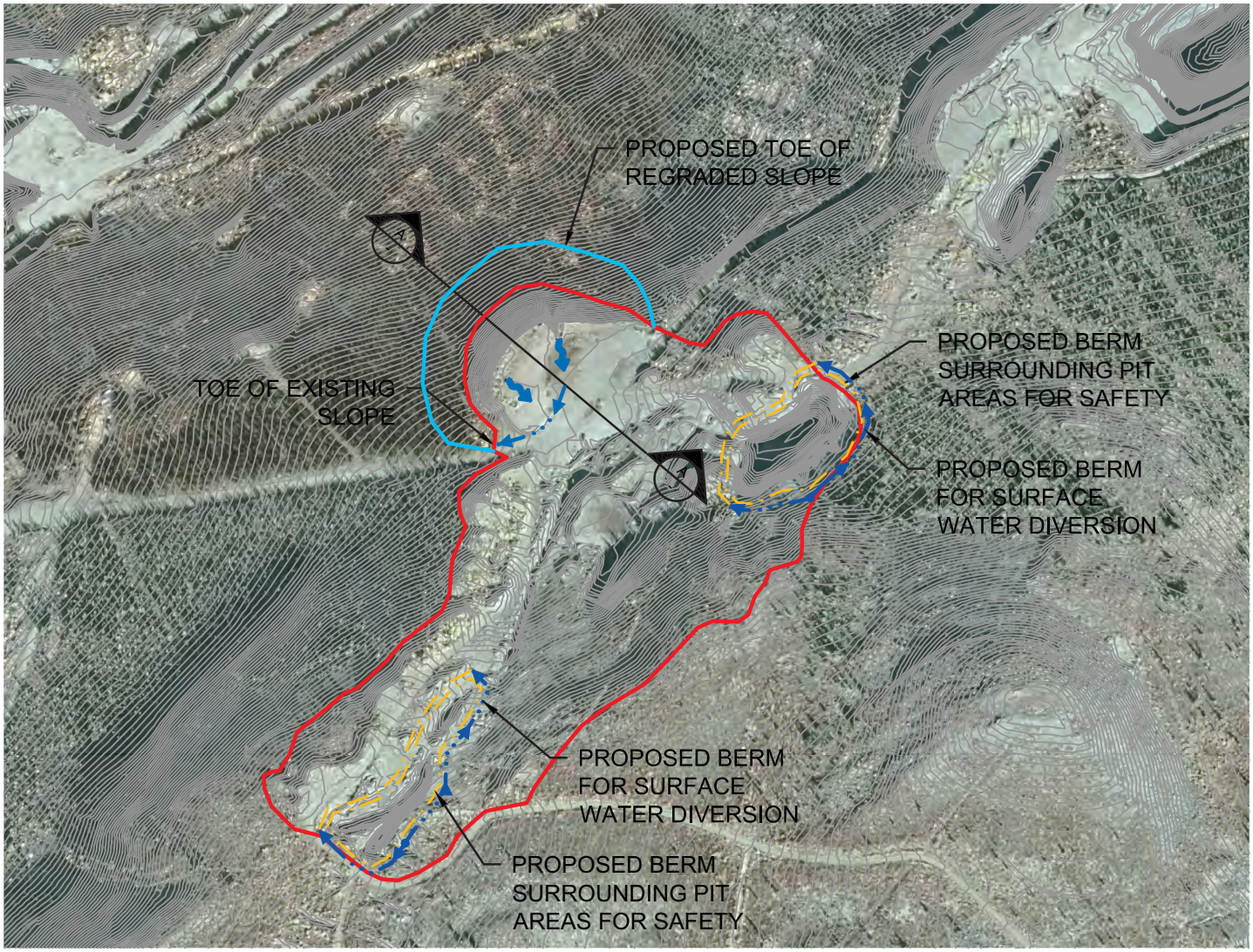
TITLE
BLACK CAP PIT
SECTIONS A & B

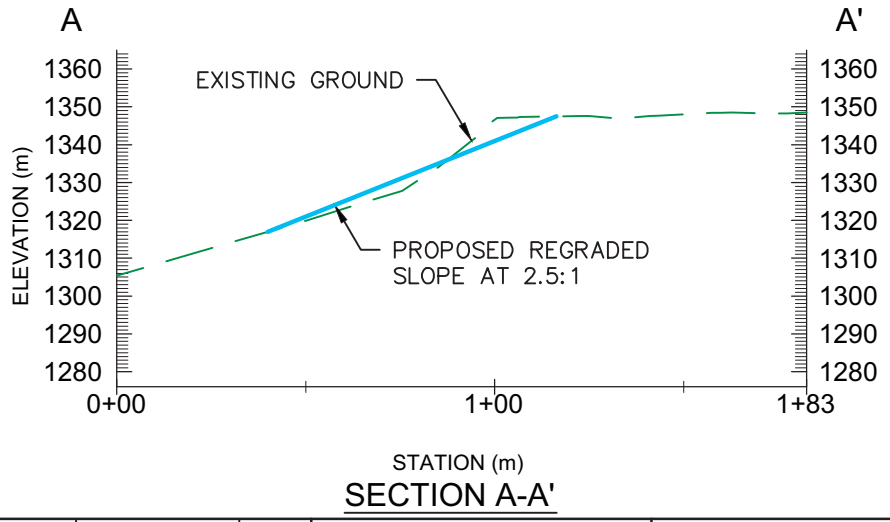
INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING Figure 5.18 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
LIST OF XREFS: [n:\enviro\gis--data\ar-8x11] [102000_xTOPO_SECTION A] [102000_EXHIBIT LEGEND]

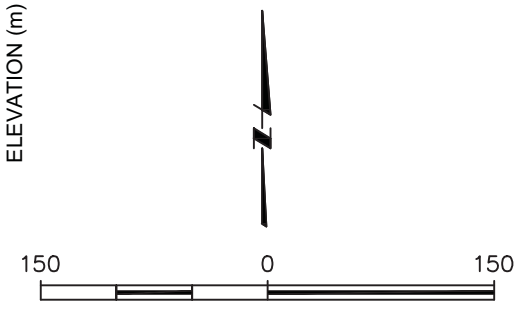




SECTION A-A'

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 = 50 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

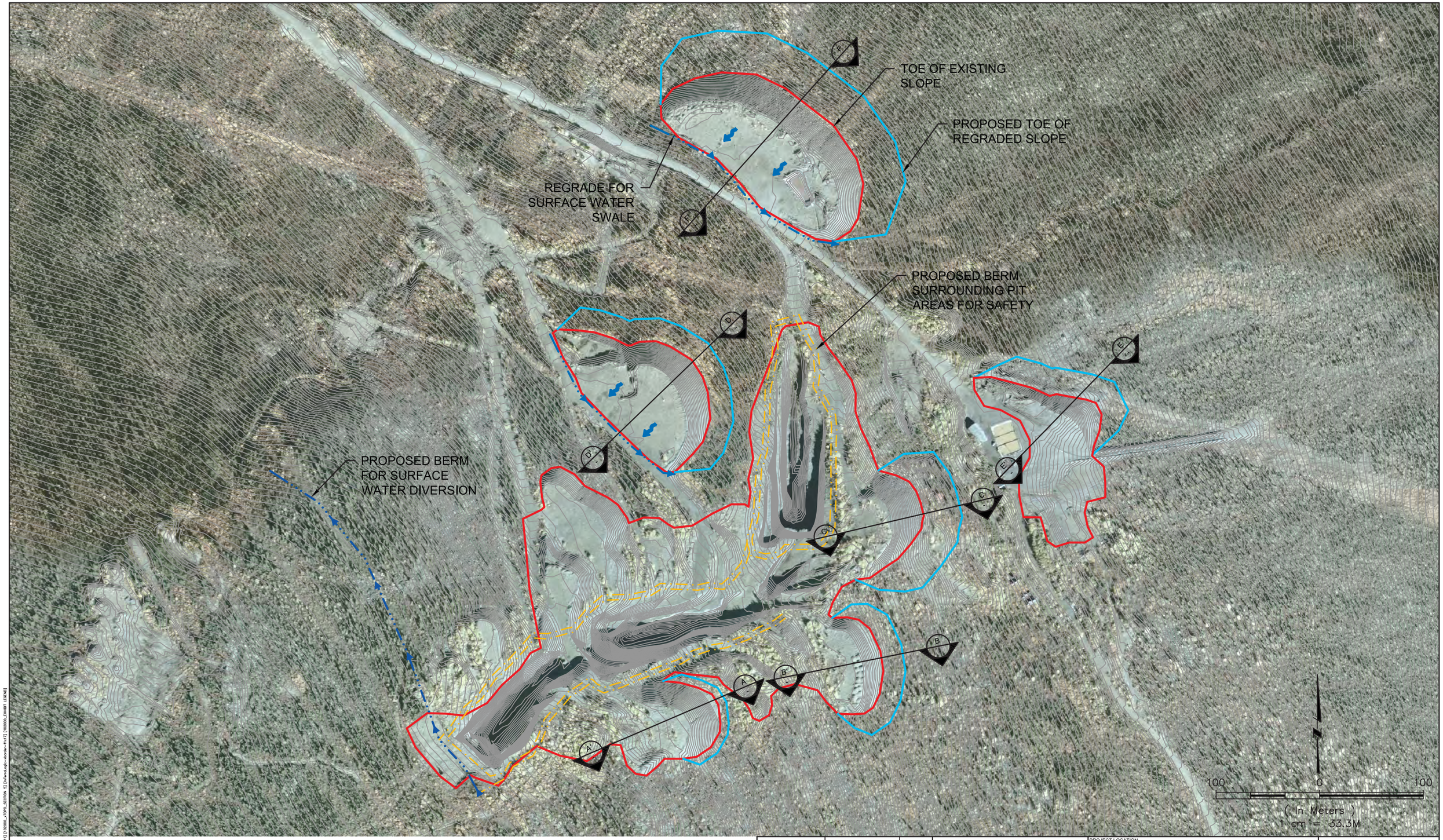
TITLE
CALUMET PIT
PLAN & SECTION A

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

DRAWING Figure 5.19 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

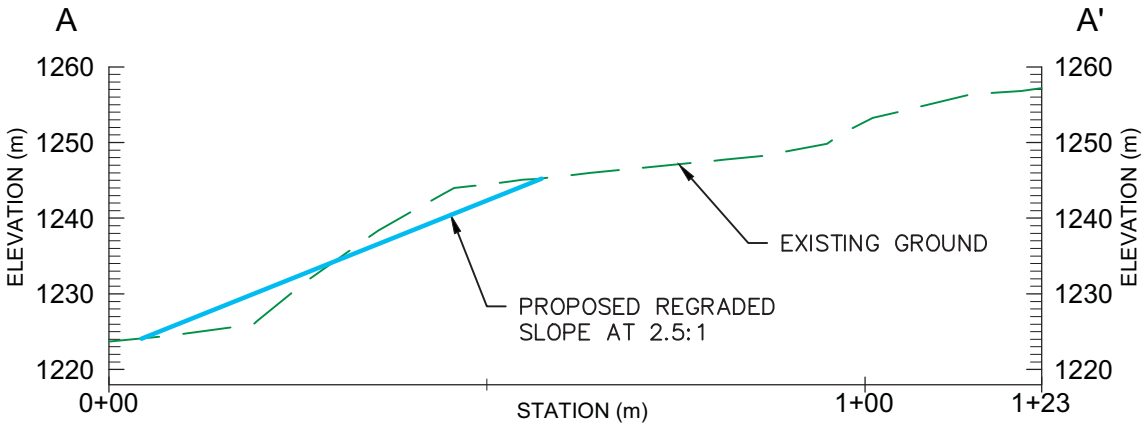
TITLE
GALKENO 300 AND SIME PITS
PLAN

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

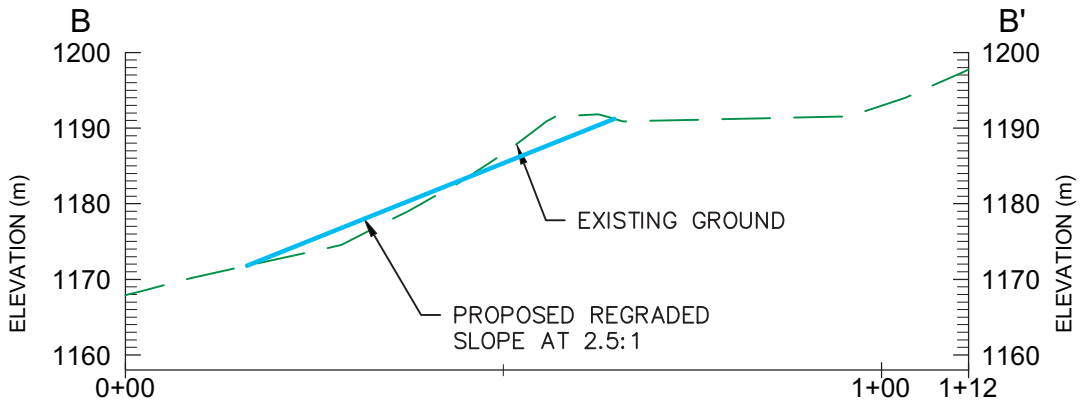
DRAWING Figure 5.20 REVISION

FILE NAME 102000_Galkeno 300

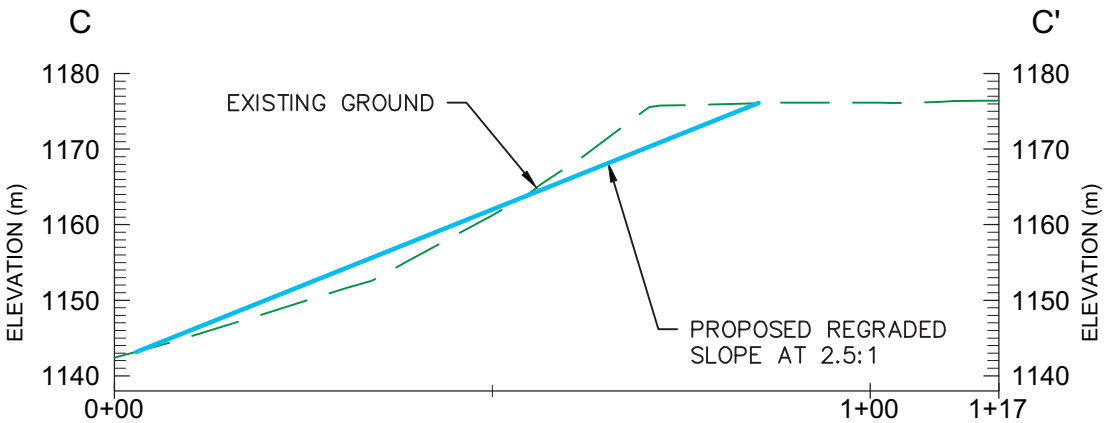
DRAWING FILENAME: I:\Projects\102000 - Keno-Hazel\Keno Coal\Grad\102000_Galkeno 300.dwg LAYOUT NAME: Galkeno Plan and Section DATE: Mar 29, 2011 - 1:55pm CAD OPERATOR: cwelken
LIST OF XREFS: [m:\terra\cgic-aborder-8x11] [102000_XTOPO_SECTION 5] [m:\terra\cgic-aborder-11x17] [102000_EXHIBIT LEGEND]



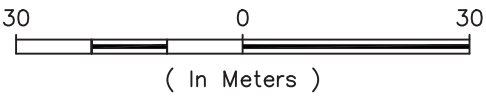
SECTION A-A'



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

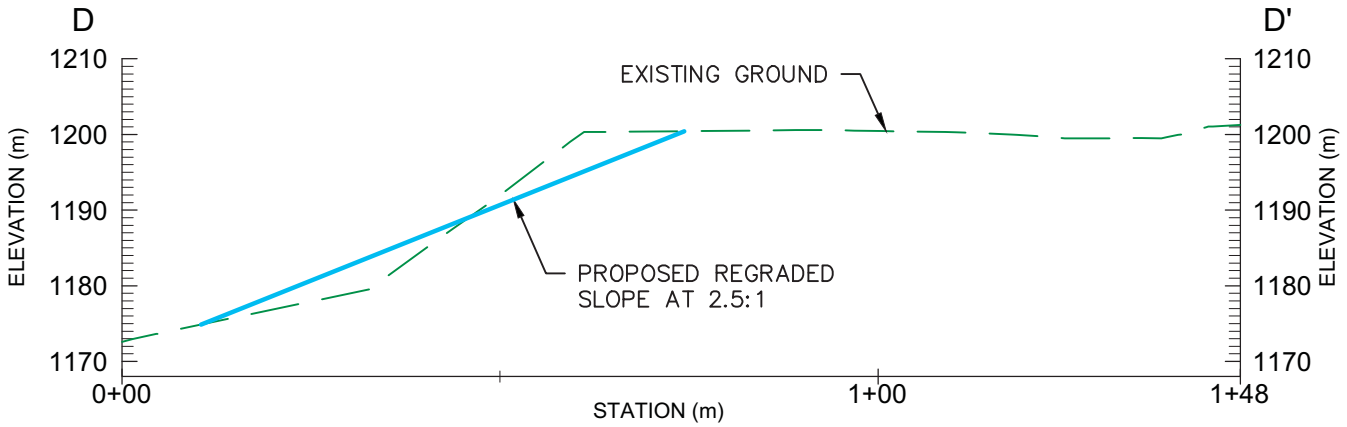
TITLE
GALKENO 300 AND SIME PITS
SECTIONS A, B & C

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

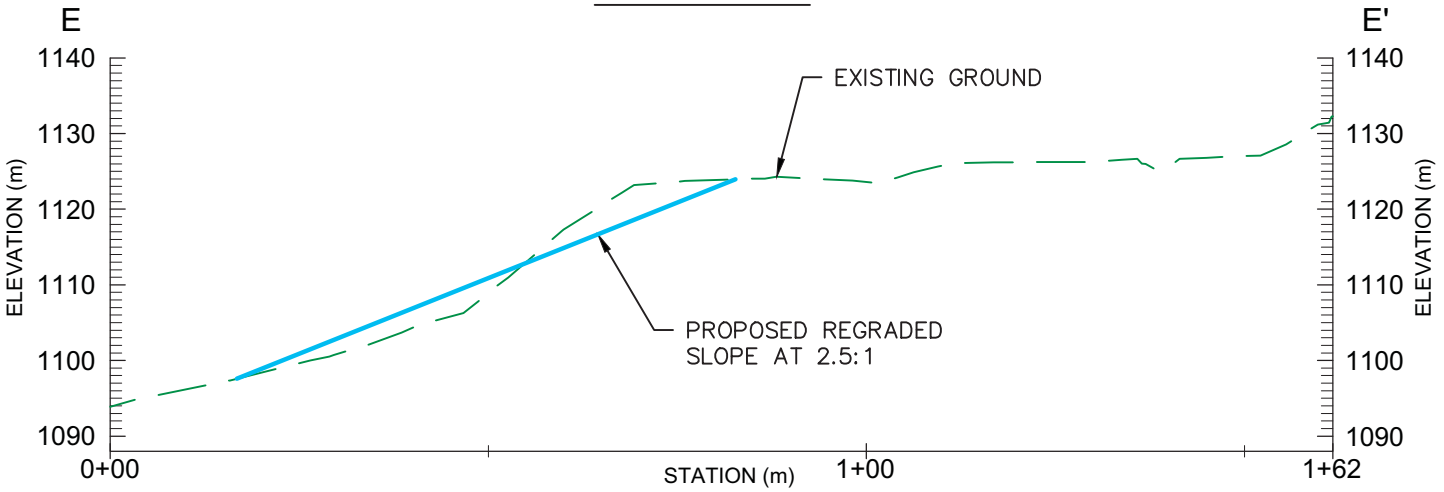
DRAWING Figure 5.21 REVISION

FILE NAME 102000_Galkeno 300

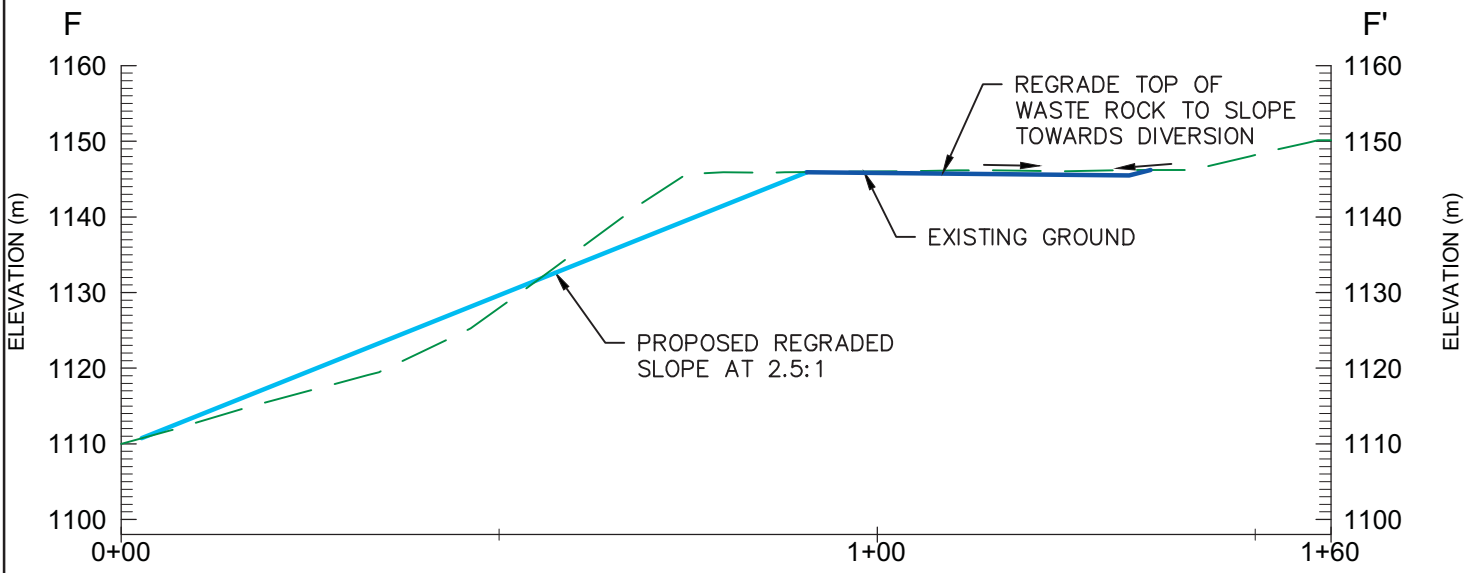
DRAWING FILENAME: i:\Projects\102000 - Keno-Hexco\Keno Coal\Grad\102000_Galkeno 300.dwg LAYOUT NAME: Galkeno Section A -C DATE: Mar 29, 2011 - 1:55pm CAD OPERATOR: cwelken
LIST OF XREFS: [n\Terra\dgn--border-8x11] [102000_xTOPO_SECTION 5] [n\Terra\dgn--border-11x17] [102000_EXHIBIT LEGEND]



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

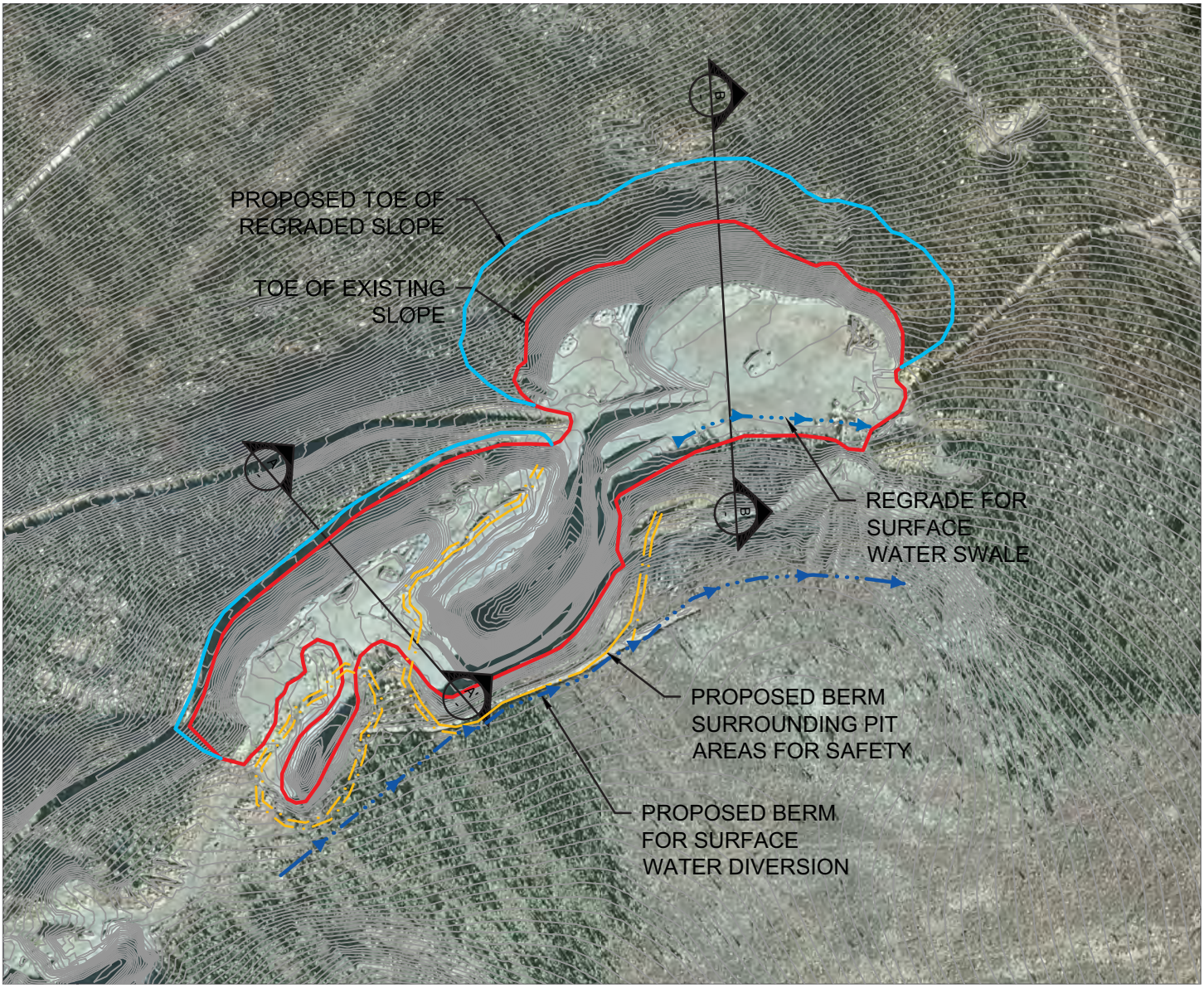
TITLE
GALKENO 300 AND SIME PITS
SECTIONS D, E & F

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

DRAWING Figure 5.22 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\Terra\Logo--border-8x11] [102000_xTOPO_SECTION 8] [n\Terra\Logo--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

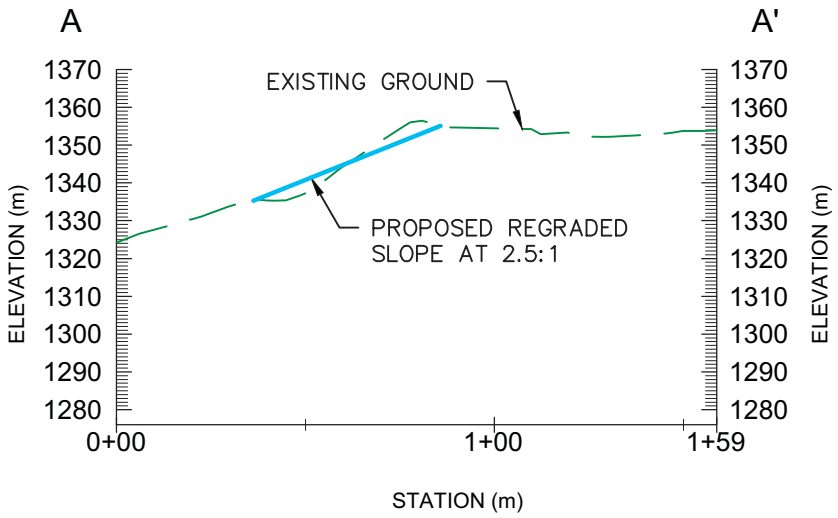
TITLE
HECTOR PIT PLAN

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

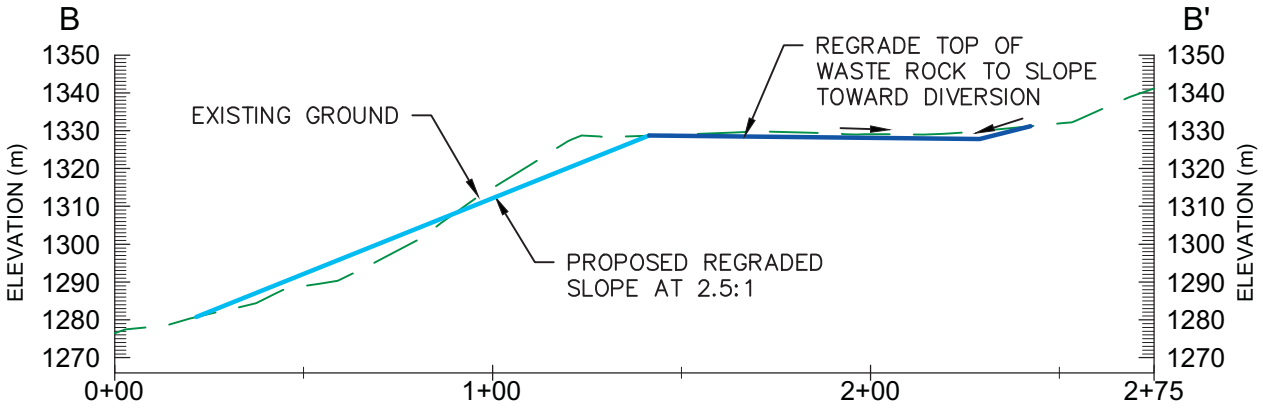
DRAWING Figure 5.23 REVISION

FILE NAME 102000_Hector Pit

DRAWING FILENAME: i:\Projects\102000 - Keno-Hector\Keno Coal\Grad\102000_Hector Pit.dwg LAYOUT NAME: Hector Pit Plan and Section DATE: Mar 30, 2011 - 8:35am CAD OPERATOR: cwelken
LIST OF XREFS: [n:\terra\cdgis-data\ex-data\ex-Bnd1] [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 = 20 m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

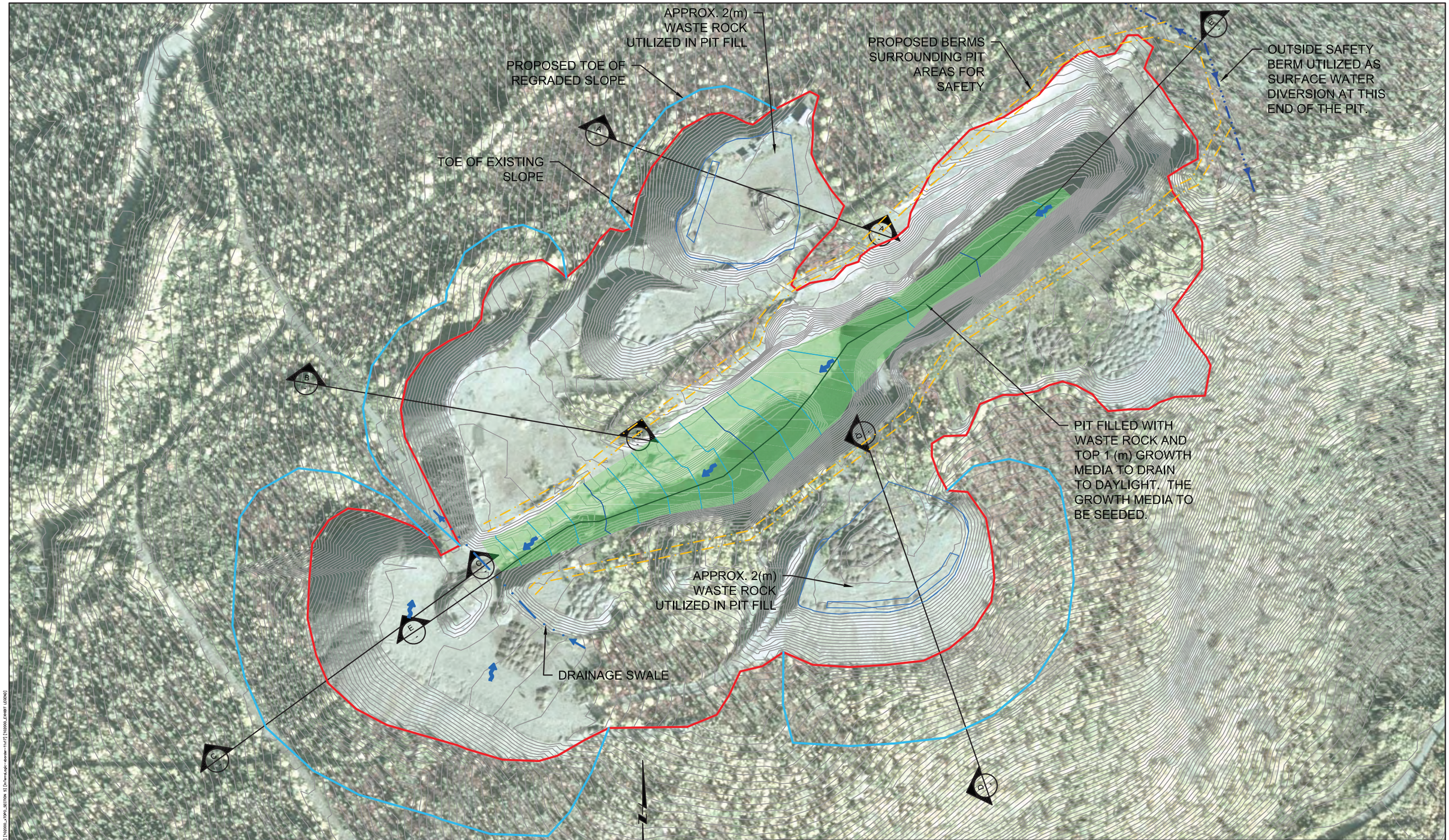
TITLE
HECTOR PIT
SECTIONS A & B

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

DRAWING Figure 5.24 REVISION

FILE NAME 102000_Hector Pit

DRAWING FILENAME: I:\Projects\102000 - Keno-Hance\Vans 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:\terra\cgbc-border-8x11] [102000_xTOPO_SECTION 9] [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

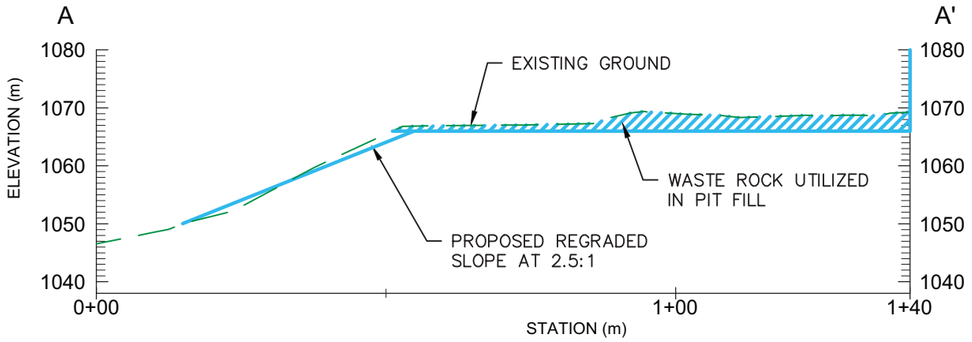
TITLE
ONEK PIT
PLAN

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

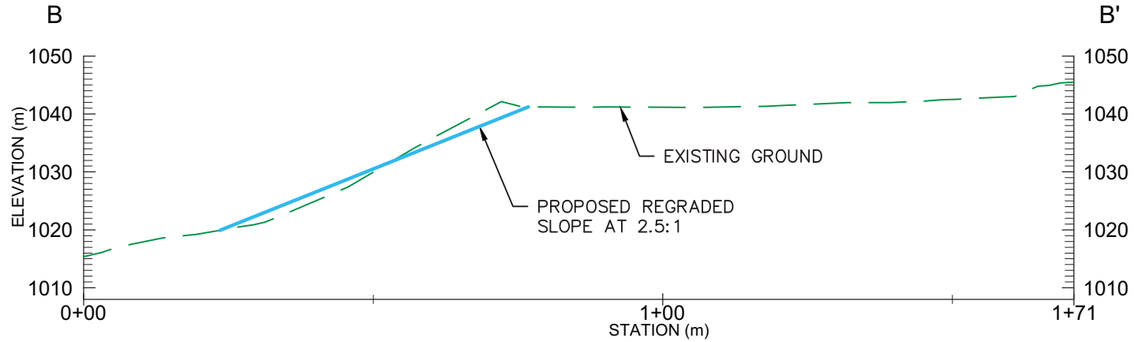
DRAWING Figure 5.25 REVISION

FILE NAME 102000_Onek

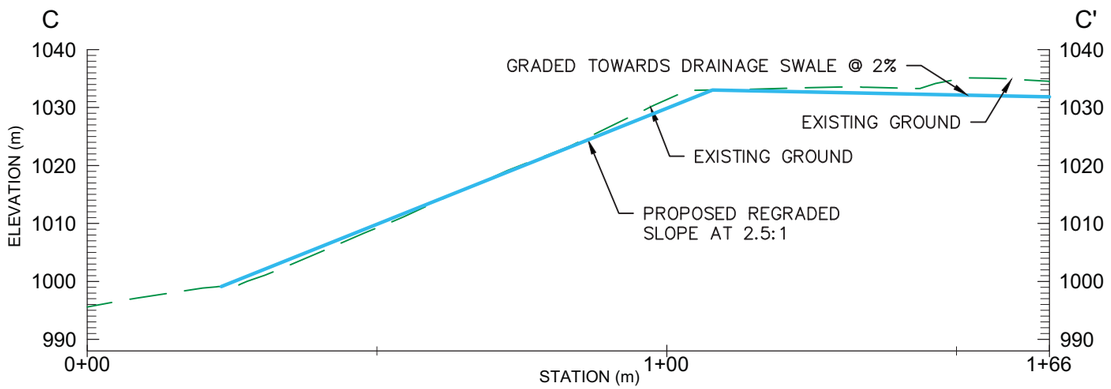
DRAWING FILENAME: I:\Projects\102000 - Keno-Hess\Keno Corp\Onek\102000_Onek.dwg LAYOUT NAME: Onek Plan DATE: Mar 06, 2011 - 7:43pm CAD OPERATOR: dgreen
LIST OF XREFS: [102000_TYP01_SECTION A] [102000_TYP01_SECTION B] [Schmidt&Dyer-Border-11x17] [102000_SHEET LEGEND]



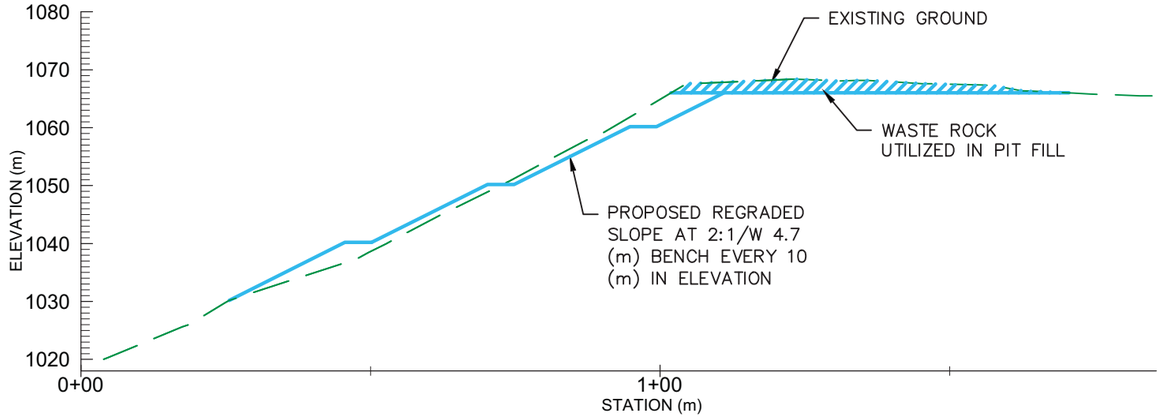
SECTION A-A'



SECTION B-B'



SECTION C-C'



SECTION D-D'

DESIGNED BY	C.GREEN	3-14-2011
DRAWN BY	C. GREEN	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:

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

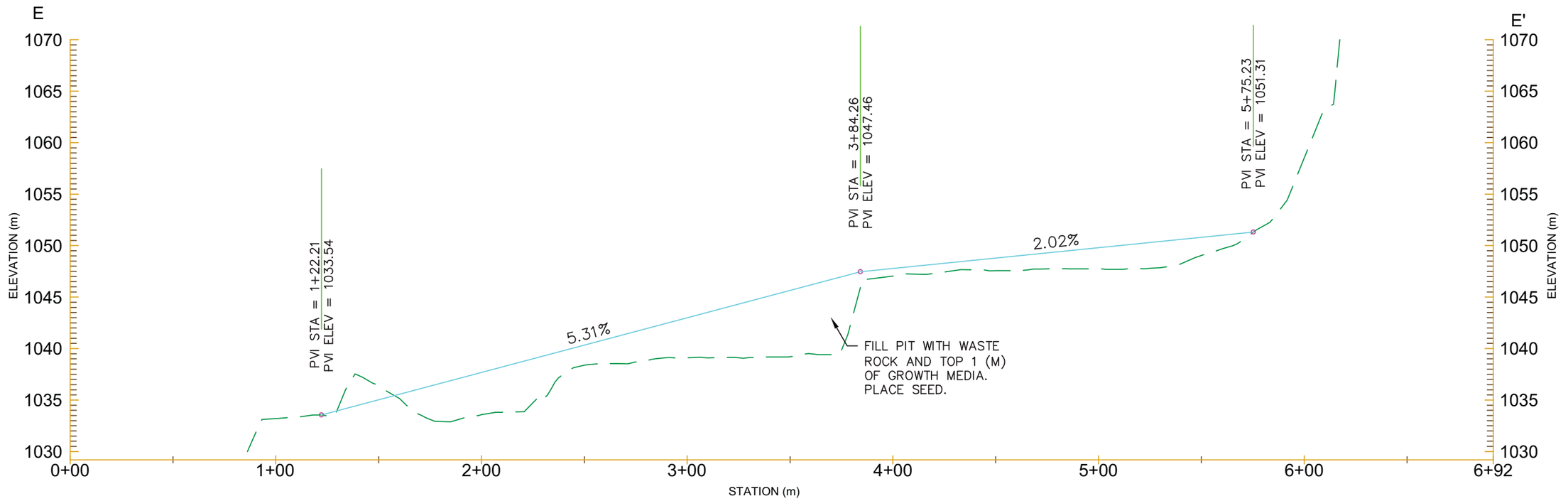
TITLE
ONEK PIT
SECTION A, B, C & D

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

DRAWING Figure 5-26 REVISION

FILE NAME 102000_Onek

DRAWING FILENAME: I:\Projects\102000 - Keno-Xeno\Keno Gis\Draft\102000_Onek.dwg LAYOUT NAME: Onek Sections DATE: Mar 26, 2011 - 7:14pm CAD OPERATOR: cgreen
LIST OF XREFS: [102000_LYOUT_SECTION B] [102000_LYOUT_SECTION B] [Interedge--Border--11x17] [102000_EXHIBIT LEGEND]



SECTION E-E'

DESIGNED BY	C.GREEN	3-14-2011
DRAWN BY	C. GREEN	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:

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

TITLE
ONEK PIT
SECTION E

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

DRAWING Figure 5.27 REVISION

FILE NAME 102000_Onek

DRAWING FILENAME: C:\Projects\102000 - Keno-Hess\Vans Cad\Cad\102000_Onek.dwg LAYOUT NAME: Onek Section E (2) DATE: Mar 30, 2011 - 7:14pm CAD OPERATOR: cgreen
LOC OF PROTS [102000_UTM_SECTOR 8][102000_UTM_SECTOR 8][Interbridge-double-11x17][102000_Sheet Layout]



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 5.28 REVISION

FILE NAME 102000_Miller

DRAWING FILENAME: L:\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]



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 = 20m

PROJECT LOCATION
KENO,YUKON, CANADA

PROJECT
KENO

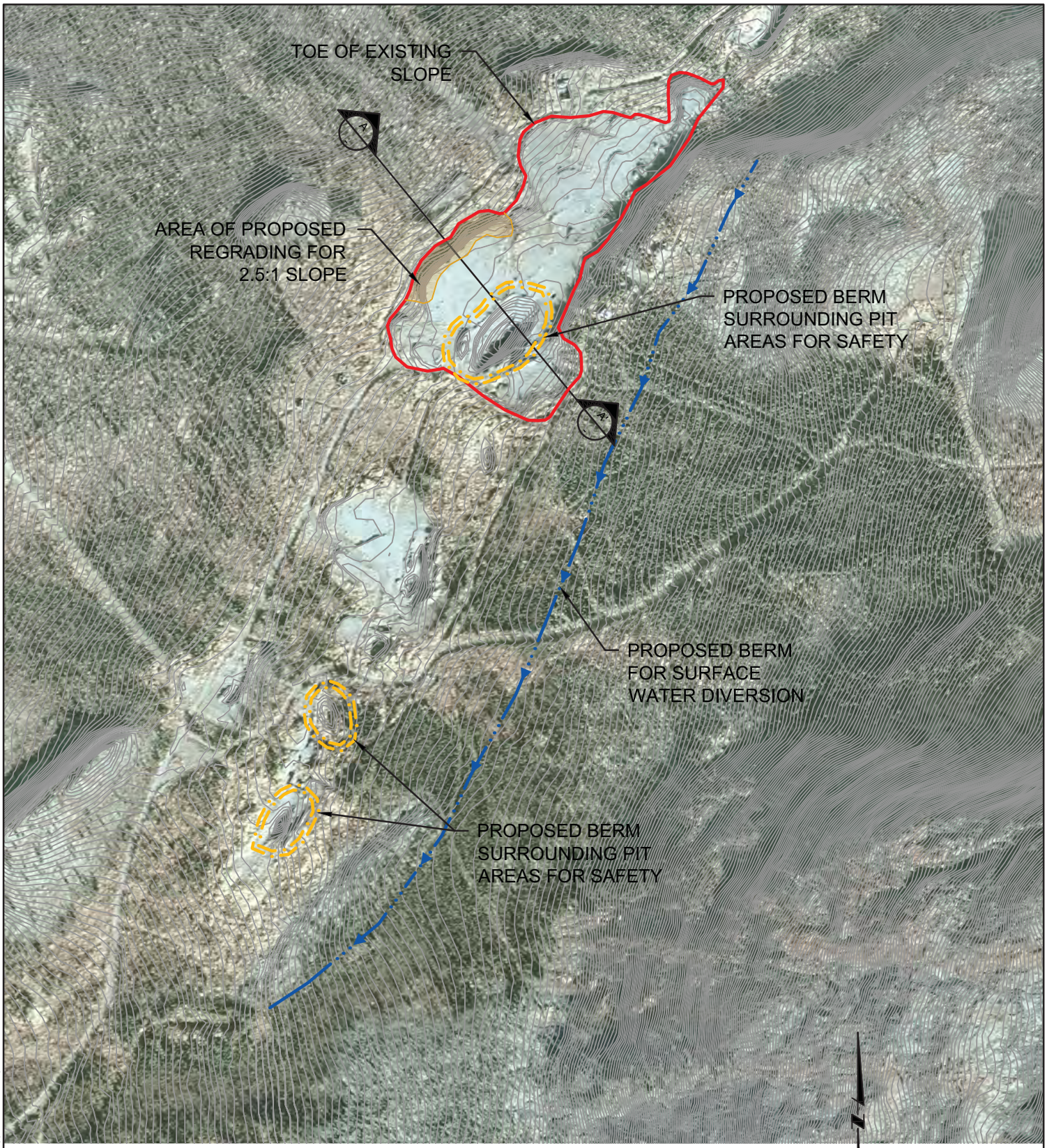
TITLE
SHAMROCK PIT
PLAN

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

DRAWING Figure 5.29 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.

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

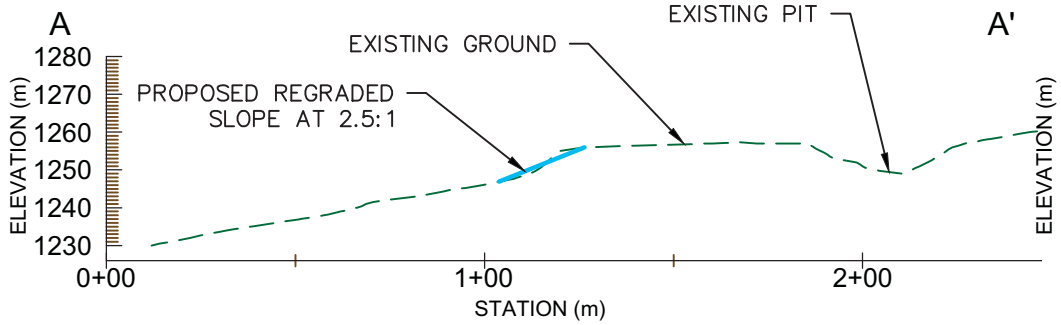
TITLE
SADIE LADUE AND WERNECKE PITS PLAN

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

DRAWING Figure 5.30 REVISION

FILE NAME 102000_Sadie Ladue

DRAWING FILENAME: I:\Projects\102000 - Keno-Nexco\Keno Coal\Graph\102000_Sadie Ladue.dwg LAYOUT NAME: Sadie Ladue_PLAN DATE: Mar 30, 2011 - 4:48pm CAD OPERATOR: cwelken
LIST OF XREFS: [InTerraLogo-border-Bw1] [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 5.31 REVISION

FILE NAME 102000_Sadie Ladue

DRAWING FILENAME: L:\Projects\102000 - Keno-Nenco\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: [b:\Terra\Logo-border-8x11] [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.

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

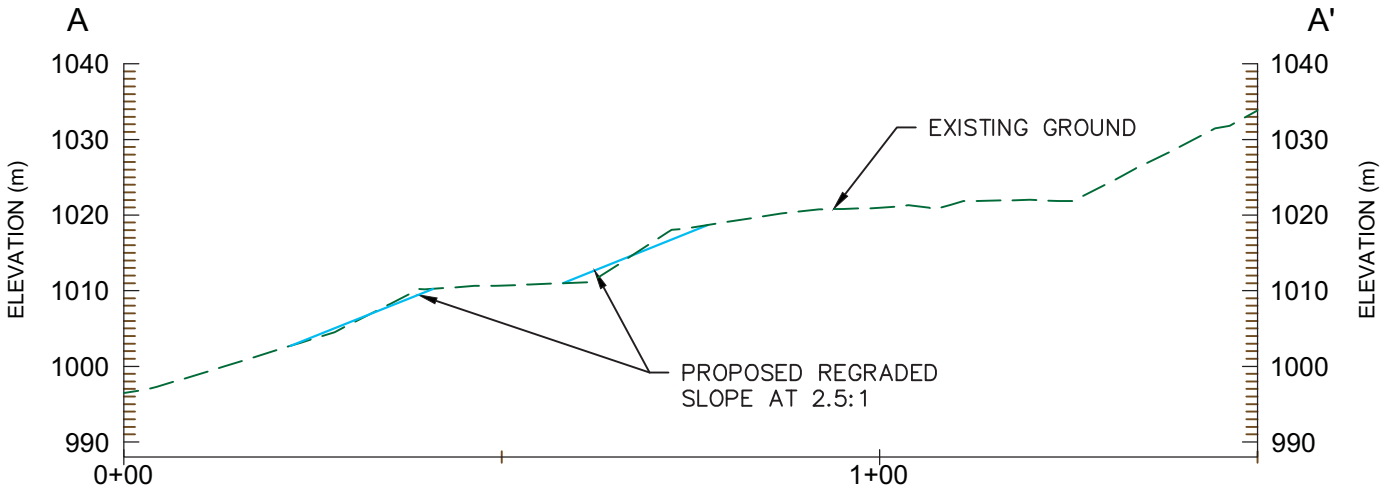
TITLE
DIXIE ADIT
PLAN

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

DRAWING Figure 5.32 REVISION

FILE NAME 102000_Dixie

DRAWING FILENAME: C:\Users\cwelken\appdata\local\temp\AcePublish_4972\102000_Dixie.dwg LAYOUT NAME: DIXIE_PLAN DATE: Mar 30, 2011 - 9:05am CAD OPERATOR: cwelken
LIST OF XREFS: [n:\land\dgbc-dundee-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 5.33 REVISION

FILE NAME 102000_Dixie

DRAWING FILENAME: C:\Users\cwelken\appdata\local\temp\AcPublish_4972\102000_Dixie.dwg LAYOUT NAME: DIXIE_SECTION A DATE: Mar 30, 2011 - 8:05am CAD OPERATOR: cwelken
LIST OF XREFS: [n:\terra\dgn--dundee--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 5.34 REVISION

FILE NAME 102000_Husky_Elsa

DRAWING FILENAME: i:\Projects\102000 - Keno-Nexco\Keno Coal\Coal\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_xTOPO_SECTION B] [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
HUSKY SHAFT PLAN

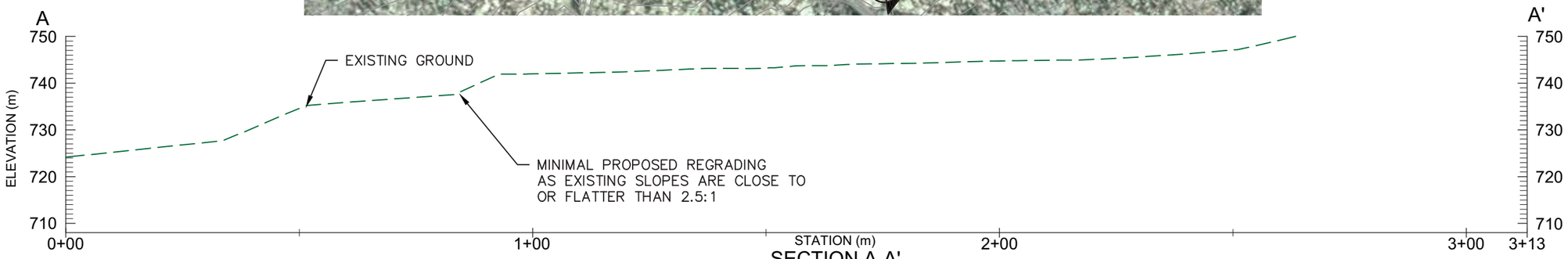
INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING Figure 5.35 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_2700N_SECTION B] [102000_GIS 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

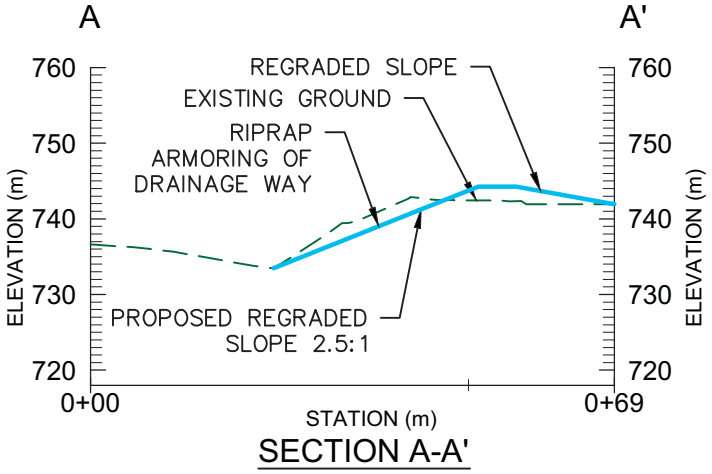
TERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING Figure 5.36 REVISION

FILE NAME 102000_Husky SW

DRAWING FILENAME: L:\Projects\102000 - Keno-Hess\Xrefs\Cad\Civil\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]

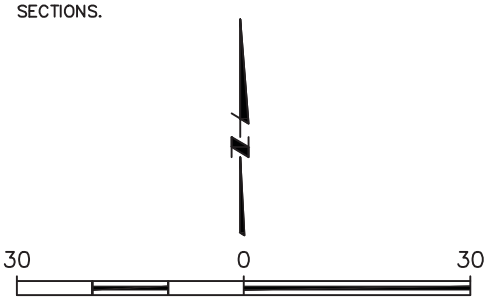




SECTION A-A'

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

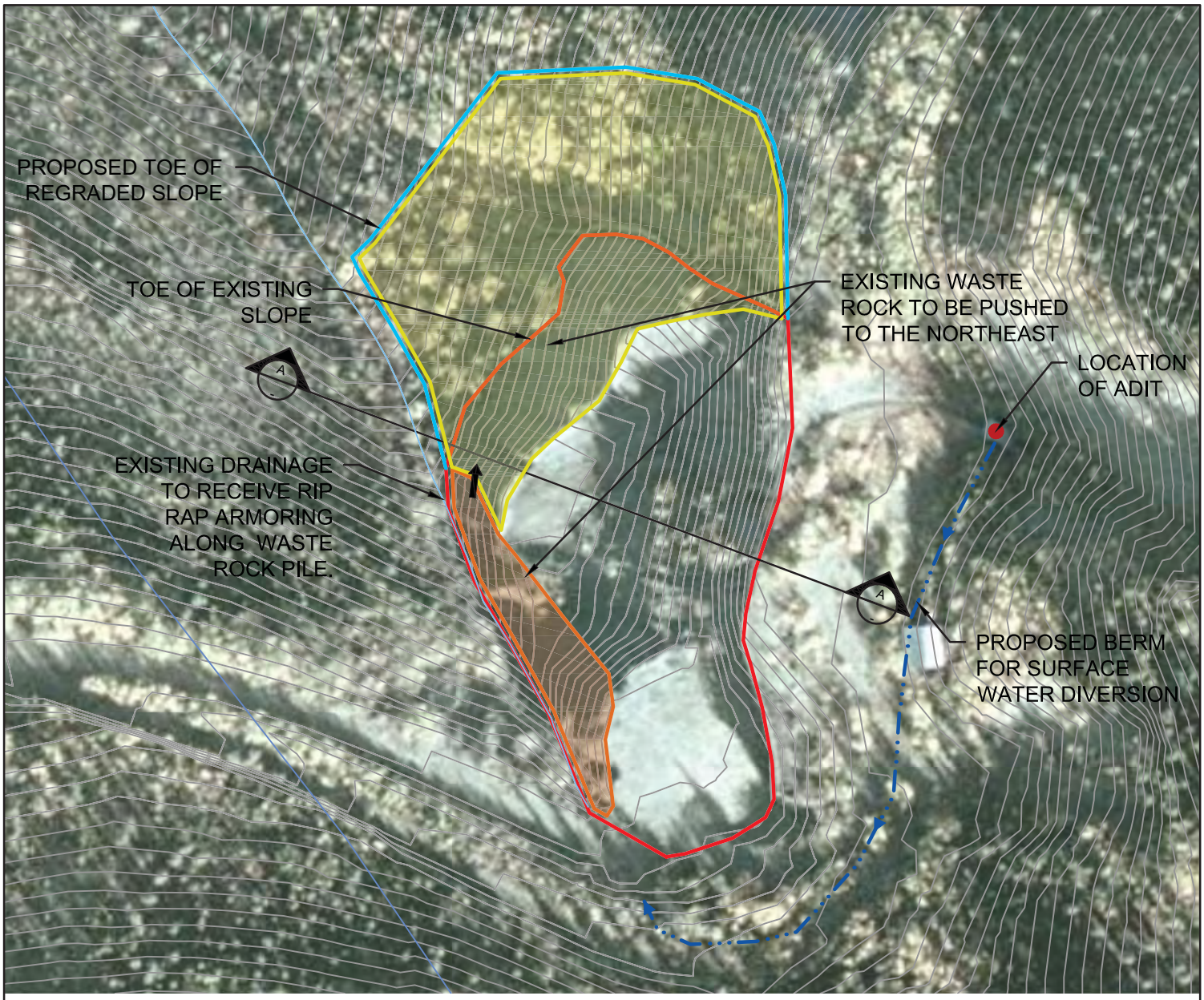
TITLE: SILVER KING 100 ADIT PLAN & SECTION A

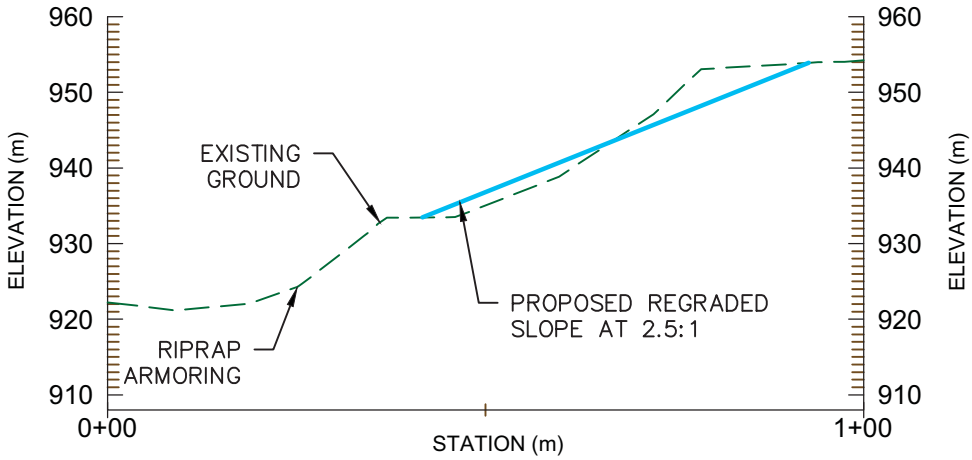
INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING: Figure 5.37 | REVISION:

FILE NAME: 102000_Silver King 100

DRAWING FILENAME: L:\Projects\102000 - Keno-Nexus\Keno Coal\Grad\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] [xTerms\xplc-xborder-8x11] [102000_EXHIBIT LEGEND] [102000_xGIS DATA]

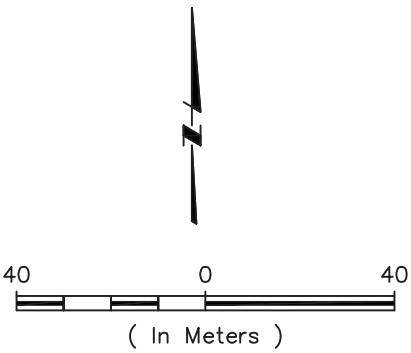




SECTION A-A'

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.



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

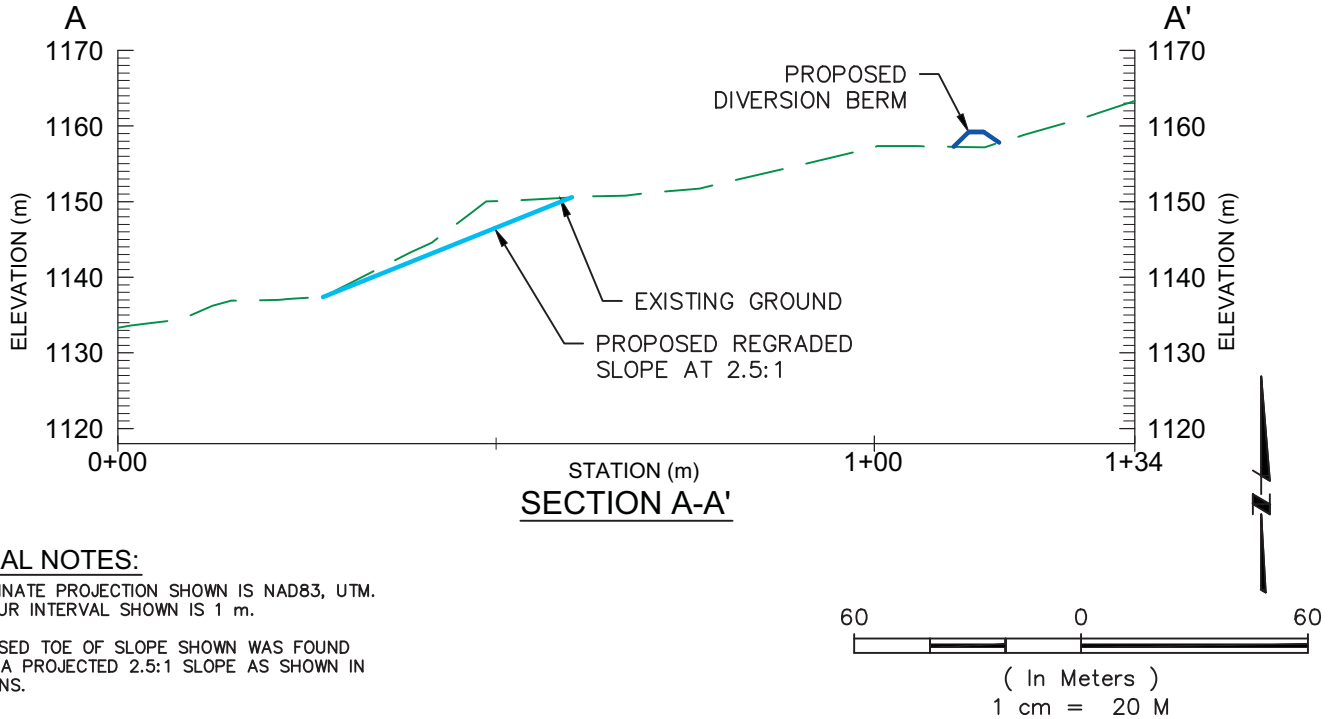
INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING Figure 5.38 REVISION

FILE NAME 102000_No Cash 500

DRAWING FILENAME: i:\Projects\102000 - Keno-Hess\Vkeno Cad\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-data\Border-8x11] [102000_EXHIBIT LEGEND] [102000_GIS 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.

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 5.39 REVISION

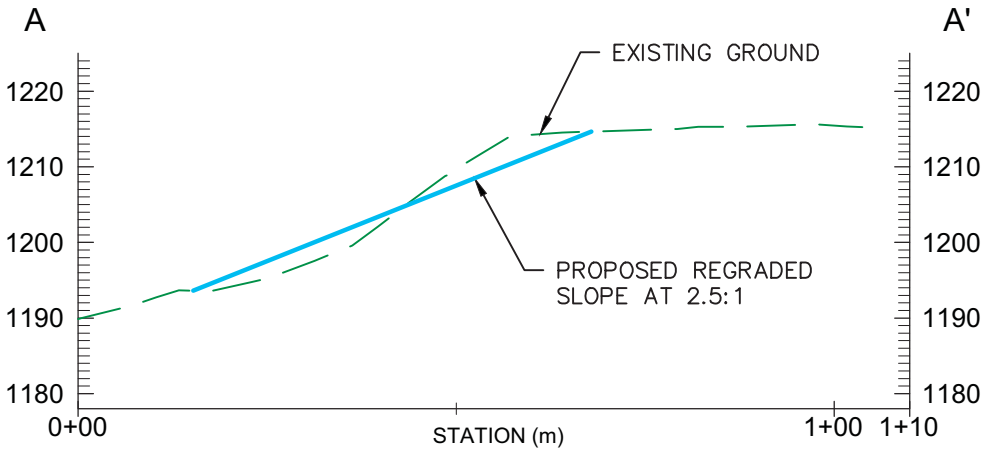
FILE NAME 102000_Ruby

DRAWING FILENAME: L:\Projects\102000 - Keno-Nexco\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 5] [102000_EXHIBIT LEGEND]

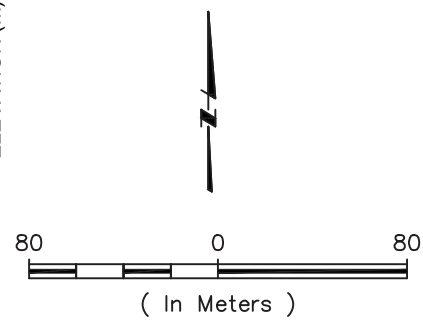


GENERAL NOTES:

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.



SECTION A-A'



(In Meters)
1 cm = 20 M

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

DRAWING Figure 5.40 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]



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

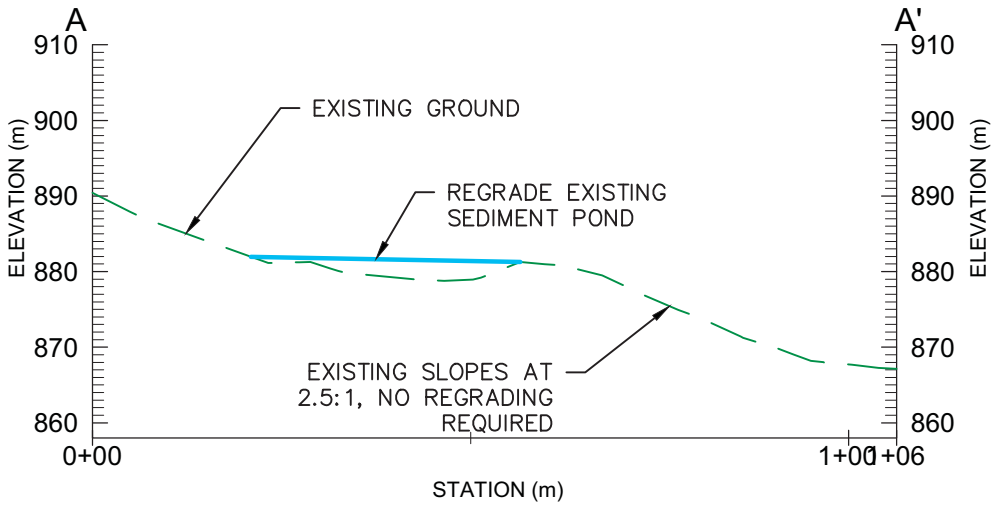
TITLE
GALKENO 900 ADIT PLAN

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

DRAWING Figure 5.41 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

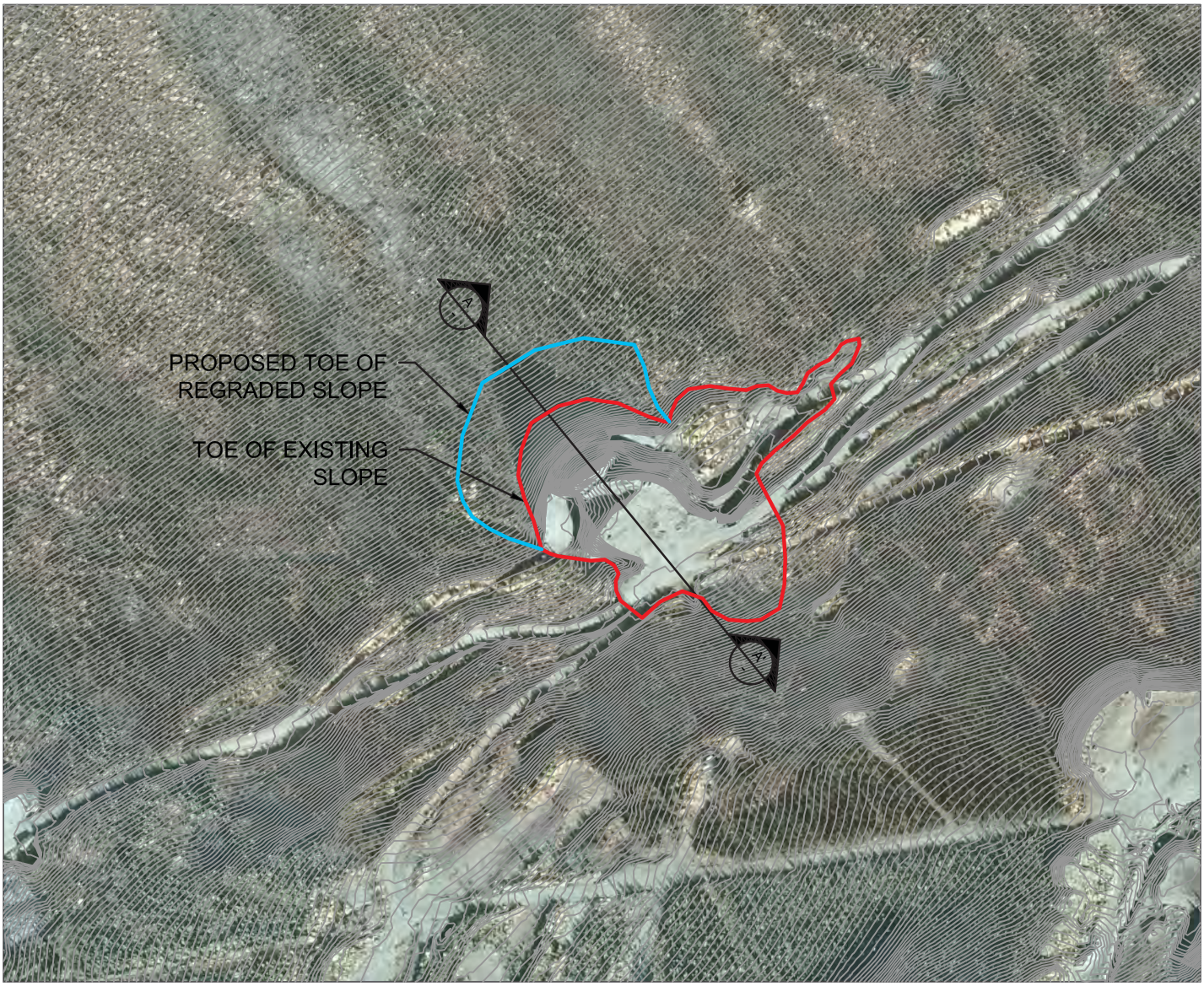
TITLE
GALKENO 900 ADIT
SECTION A

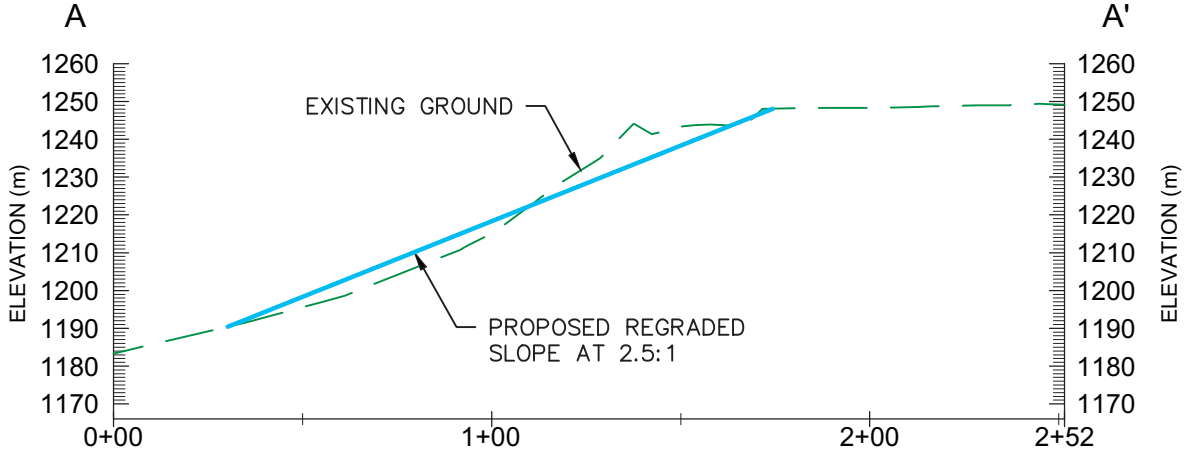
INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING Figure 5.42 REVISION

FILE NAME 102000_Galkeno 900

DRAWING FILENAME: C:\Users\cwelken\appdata\local\temp\AcPublish_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] [n:\terra\dgn~\border~11x17] [102000_EXHIBIT LEGEND] [n:\terra\dgn~\border~8x11]





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

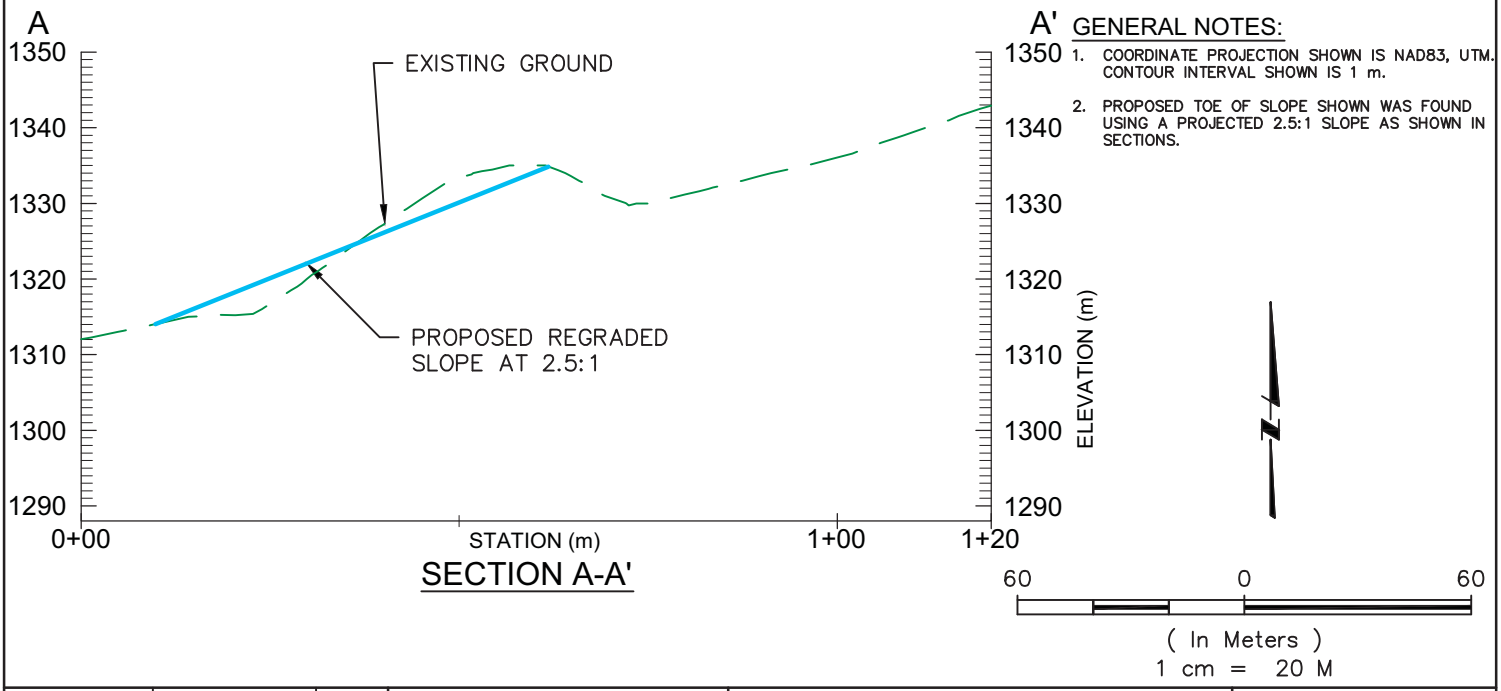
INTERRA
4715 Innovation Drive, Suite 110
Fort Collins, Co 80525
970.225.8222

DRAWING Figure 5.43 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.

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 5.44 | 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\cgbc-border-8x11] [102000_xTOPO_SECTION A] [102000_EXHIBIT LEGEND]



GENERAL NOTES:

1. COORDINATE PROJECTION SHOWN IS NAD83, UTM. CONTOUR INTERVAL SHOWN IS 1 m.
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60 0 60

(In Meters)
1 cm = 20 M

DESIGNED BY	F. MARINELLI	3-14-2011
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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

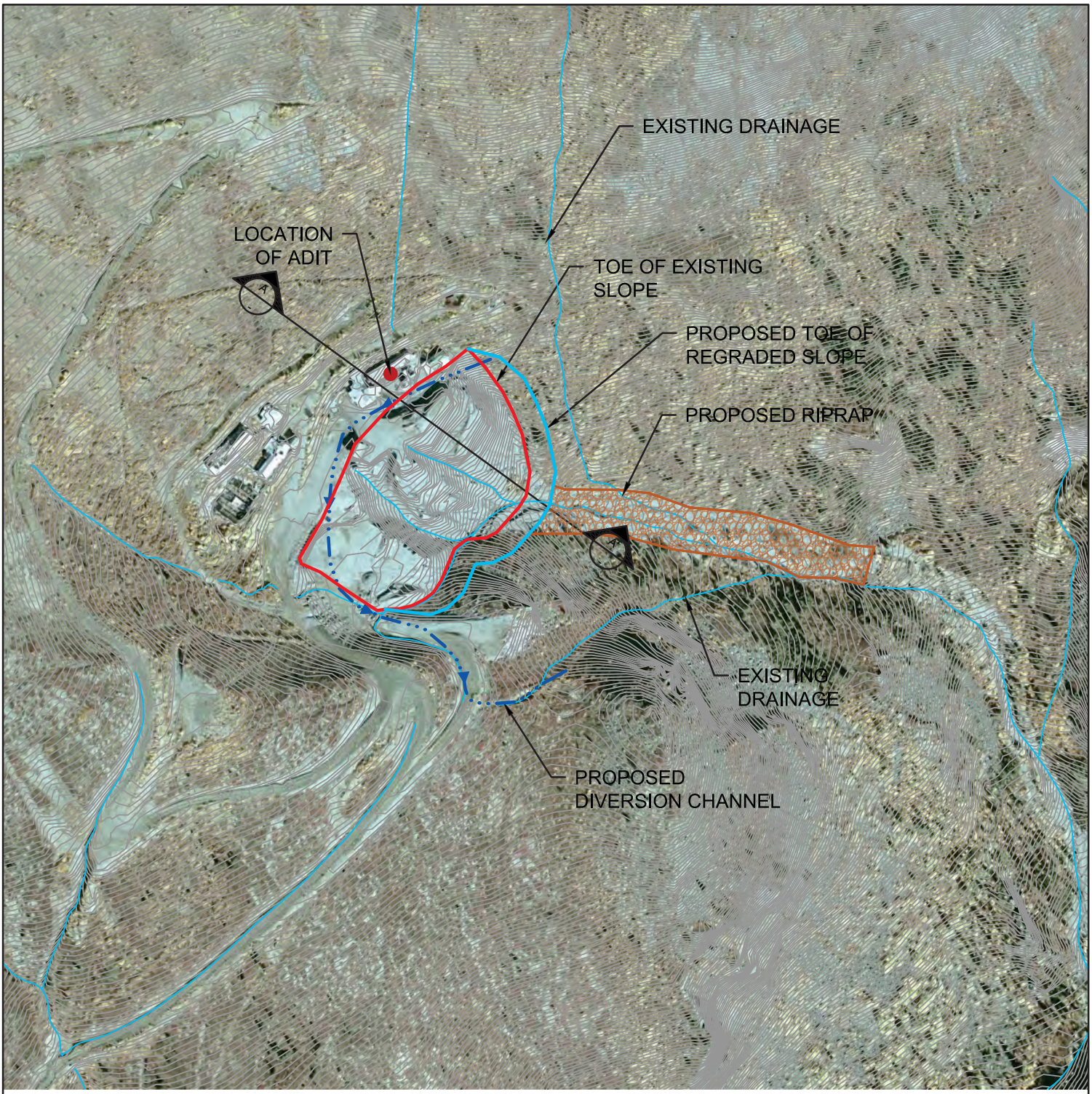
TITLE
ONEK 400 ADIT PLAN

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

DRAWING Figure 5.45 REVISION

FILE NAME 102000_Onek 400

DRAWING FILENAME: C:\Users\cwelken\appdata\local\temp\VolPlaSet_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] [InTerraLogo-standard-11x17] [102000_EXHIBIT LEGEND] [InTerraLogo-standard-8x11]



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

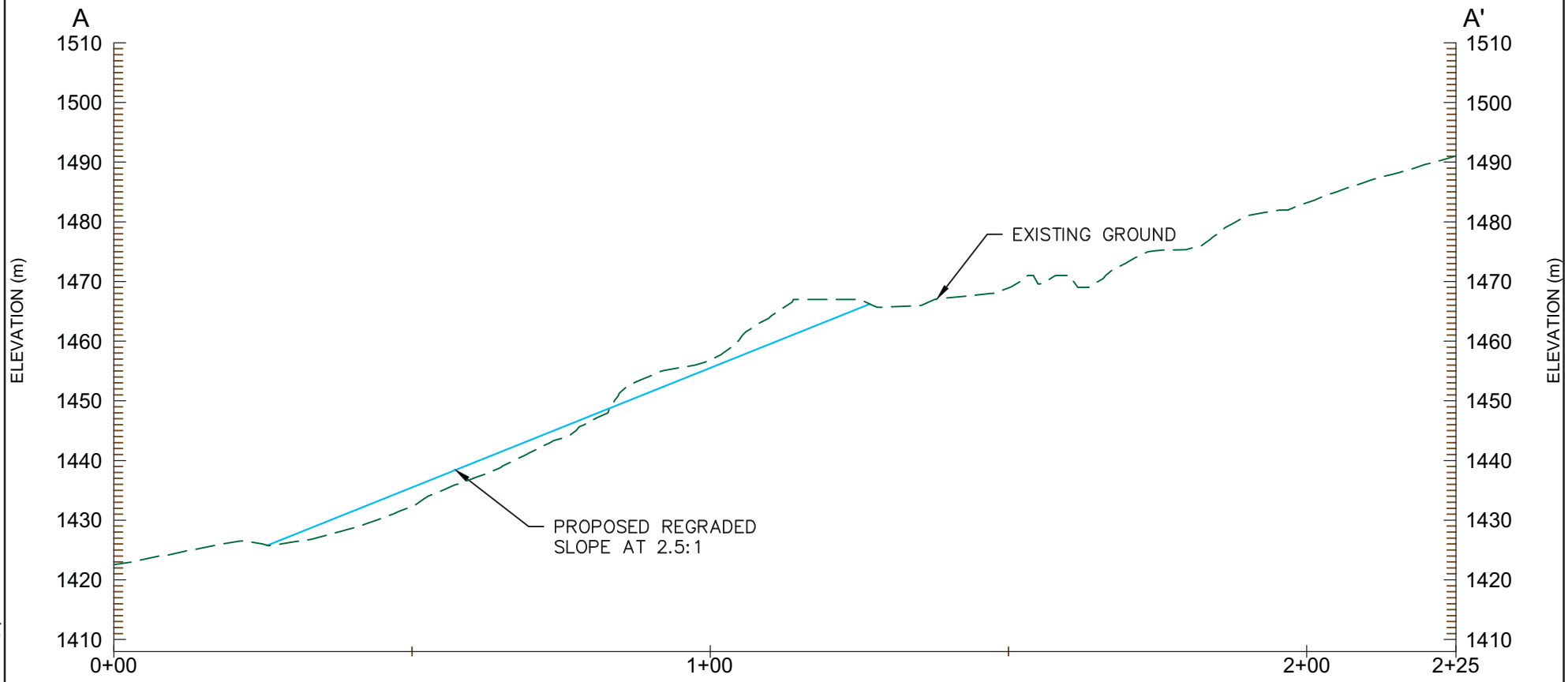
TITLE
KENO 700 ADIT PLAN

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

DRAWING Figure 5.46 REVISION

FILE NAME 102000_Keno 700 Adit

DRAWING FILENAME: i:\Projects\102000 - Keno-Hess\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:\terradigs--border-8x11] [102000_GIS DATA] [102000_EXHIBIT LEGEND] [n:\terradigs--border--8x11_v1]



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
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DRAWING Figure 5.47

REVISION

FILE NAME 102000_Keno 700 Adit

DRAWING FILENAME: s:\Projects\102000 - Keno-Alexco\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-aborder-8x11] [102000_GIS DATA] [102000_EXHIBIT LEGEND] [n:TerraLogic-aborder-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.

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 5.48 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: [n:\terradyn-dunder-Bat\] [102000_GIS DATA] [102000_TOPO_SECTION 5] [102000_EXHIBIT LEGEND]

5.5 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.

5.5.1 Shaft Inventory

A total of 32 shafts have been identified at Keno Hill which will require permanent closure; however, existing information for some of the mine sites is limited and it is possible that additional shafts will be discovered during implementation of other reclamation activities that also will require sealing. A summary of these shafts is provided in Table 5-6.

5.5.2 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 illustration.

5.5.2.1 Concept A – Dry Seal

A dry seal would be comprised 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 5-49 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 limited or 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.

5.5.2.2 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 5-50 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.

5.5.2.3 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 5-51 illustrates a conceptual design of an inverted pyramid cap.

5.5.3 Future Shaft Design and Investigation Work

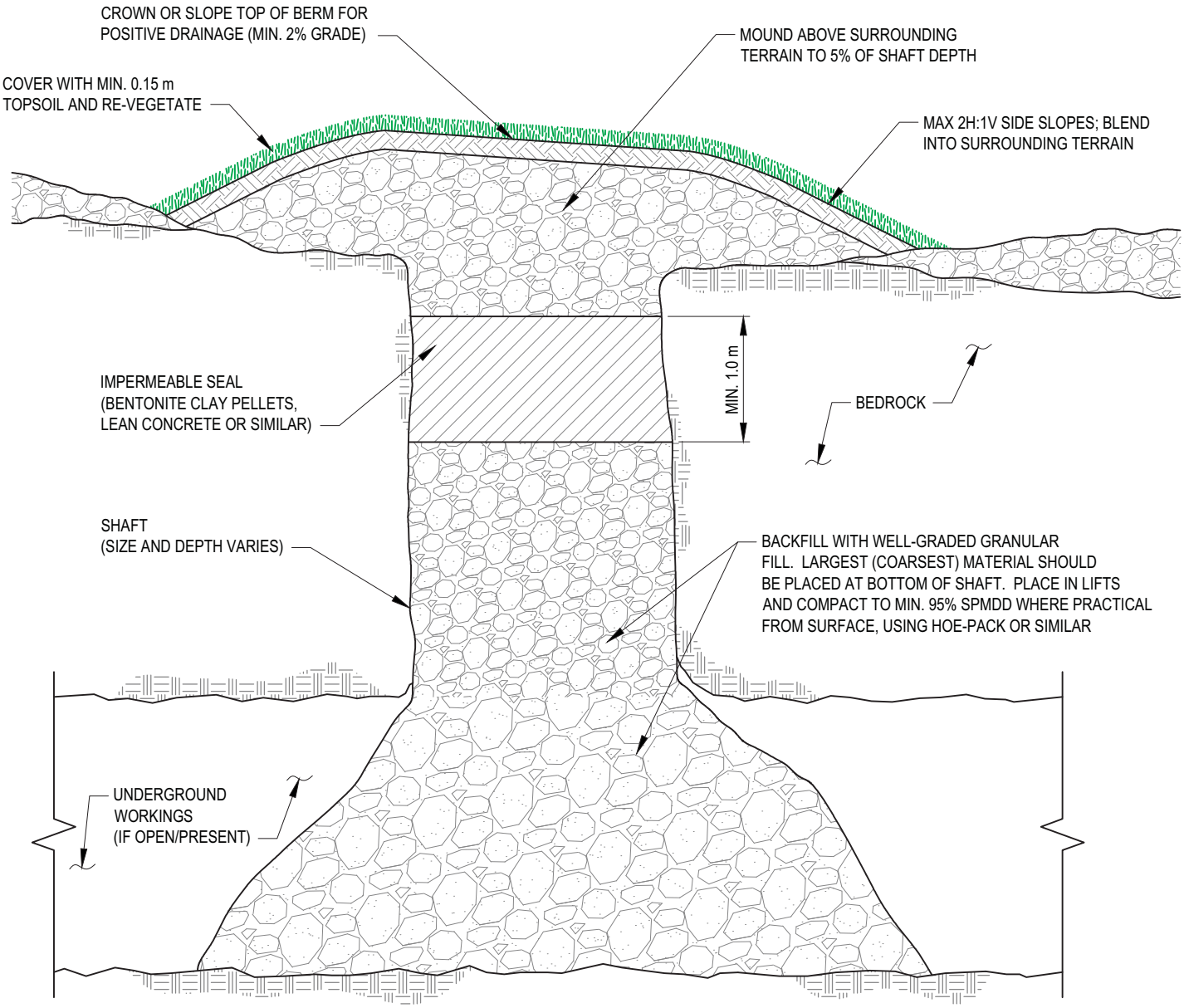
Refinement of the design and cost information during the preferred options cost refinement process will include verifying the preferred shaft closure options, finalizing shaft closure designs, and refining the construction cost estimates. This work will include a site reconnaissance to assess shaft conditions, water inflows/outflows, soil and bedrock exposures, required depth of stripping, shaft dimensions, and identifying potential borrow sources, and determining site access constraints.

Table 5-6 Summary of Shaft Closure Issues

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		
Flat Creek Watershed											
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*	
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*				*fill and cap as required*	*eliminates access and safety 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*
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*
Husky Raise	Husky #2	*not investigated; shaft house locked at last visit, and during SRK 2006 and PWGSC 2000 visits*								*fill and cap as required*	*eliminates access and safety issues*
Husky Shaft	Husky #2	*not investigated; shaft house locked at last visit, and during SRK 2006 and PWGSC 2000 visits*								*fill and cap as required*	*eliminates access and safety issues*
No Cash Bog											
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*
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*
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*
Betty shafts	Betty							standing water at bottom of both shafts	potential regressive thawing of permafrost	*fill*	*eliminates access and safety 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*
Christal Creek											
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.*
Christal Shaft #1	Christal	*At the base of a steep north facing slope about 75 m north of the camp site*	*1.5m x 1.5m x ?*	*Timbered shaft support; shaft is collapsed; water accumulated to within 1 m of surface*	*Site is on the western slope of Keno Hill; site slopes from the uphill trenches down to Shafts 1,2 and 3 with a change in elevation of ~200 m; terrain consists of dense forests and fields of moss covered boulders; schist, phyllite and quartzite are the major rock types*	*Access to the site by foot on a trail ~2.5 km out of Keno City with a campsite located at the end of the trail; shaft can be accessed by foot from the campsite*				*fill and cap as required*	
Christal Shaft #2	Christal	*Shaft is under a collapsed shed at the base of a steep facing slope ~75 m north of the camp site*	*Unknown*	*Timbered shaft support; shaft is likely collapsed; water accumulated to within 1 m of surface*	*Site is on the western slope of Keno Hill; site slopes from the uphill trenches down to Shafts 1,2 and 3 with a change in elevation of ~200 m; terrain consists of dense forests and fields of moss covered boulders; schist, phyllite and quartzite are the major rock types*	*Access to the site by foot on a trail ~2.5 km out of Keno City with a campsite located at the end of the trail; shaft can be accessed by foot from the campsite*				*fill and cap as required*	
Christal Shaft #3	Christal	*Not located during PWGSC site investigation, SRK site investigation or ACG 2009 site investigation*									

Table 5-6 Summary of Shaft Closure Issues

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		
Coesus No. 1 Shafts	Croesus No. 1	*Shaft #1 was likely located in the base of Trench #1 and appears to have been filled by trenching; shaft #2 has collapsed and is now less than 1 m deep*	*Unknown*	*Unknown; shaft is likely filled*	*Located on a moderately steep slope (~26°); thickly vegetated; 1.5m of colluvial materials on the surface below 1230m; above 1230m glacial gravels cover bedrock; minor earth flows evident;* ***permafrost*** *is likely present; no surface water; host rock consists of schist and phyllite in contact with a large greenstone lens*	*2WD access to a location 160 m from the site; from photos it appears hiking may be required to the shafts*			reported to be filled; not located in August 2009 site visit	*do nothing*	
Rico Shaft	Rico	*A small gully beside the adit leads uphill to this shaft; log cribbing and windless are above the entrance to the shaft; a metal lid covers half of the shaft opening*	*1.5m x 1.5m x 6m (may be deeper)*	*Well supported by logs; condition is fair; logs are beginning to rot but remain stable*	*Site is on a moderately steep east facing slope; possibly underlain by* ***permafrost*** *; thick vegetation and the ground is covered with a blanket of moss and decaying leaves; no surface water encountered; quartzite host rock (adit was located but so overgrown no rock out cropping)*	*Site has 4WD access on an old dirt road; portal and adit very overgrown therefore difficult to locate; shaft is 30m upslope of the adit portal.*	shaft is difficult to access from the road but marked and open			*fill and cap as required*	*eliminates access and safety issues*
Shamrock J18 Raise	Keno No. 9	*The J18 Vein was discovered and mined from the Keno Mine underground workings; a raise to surface was established to provide access for supplies/miners/equipment*	*Unknown Dimensions*	*The ground around the raise and the building covering it are collapsing; an area of ~7 to 10 m has collapsed; unstable*	*Located above treeline; area underlain by* ***permafrost*** *up to 120 m deep; soils are poorly developed and absent over the area; quartzite host rock*	*Road access to the shaft; the raise area has been fenced off*	shaft is open			*fill and cap as required*	*eliminates access issues*
Shamrock Shaft	Shamrock						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*
Prospect Shaft	Shamrock (Original)	*Small waste dump (+/- 5 tonnes); construction pre-1939*	*1.5m x 1.5m x ?; approximately 3 m depth to ice*	*Log timers, fair condition; appears to be stable*	*Site consists of a series of test pits, shafts and adits; drainage goes down a steep talus slope through a single ravine; located in an alpine ecosystem above the treeline with little vegetation; host rock is massive quartzite with graphitic schist and phyllite.*	*Access by 2WD or 4WD on a gravel road; shaft is surrounded by a steep, blocky talus slope which limits access*				*fill and cap as required*	*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*
Lightning Creek											
Unknown Shaft near 5-2 Adit	?							shaft contains shallow water		*fill shaft and cap if required*	
Apex Shaft	Apex	*Located in the bottom of trench 3 approximately 58 m from the waste rock dump at the south end of the trench; another shaft was reported at the site but only this one was located*	*2m x 1.5m x ~5m*	*Poor condition; caved in 5 m below surface*	*Located on a flattened ridge; above treeline; major rock type is thin to medium bedded quartz*	*Road access; 4WD likely require to reach shaft location*	open for 2m		timber shaft supports are rotten	*fill and cap if required*	
Porcupine Shaft	?									*rock cap and fill*	
Keno Ladue River											
Sadie Ladue Shaft (No. 1 Shaft)	Sadie Ladue - Wernecke	*Shaft head framework has been completely removed; partially open to 5m depth with partial backfilling; opening sealed with wood planks*	*Shaft collar dimensions of 1.2m x 1.4m x ~5m; partially filled with rock*	*No square set timber supports in the collar of the shaft; two timbers protrude out of the collar and the opening is decked over with reasonably sound planking; loose rock could be a safety risk and is partially covering the opening*	*Soils consist of decomposed weathered bedrock and glacial till;* ***discontinuous permafrost*** *(possibly up to 80m depth); some seeps and ponded surface water; carbonaceous phyllite underlying meta-volcanic quartz-sericite-chlorite schists host rock (elevated metal values in the host rock)*	*Accessible by 2WD*			shaft is filled at bottom of pit	*backfill with pit waste material*	*eliminates access and safety issues*
Lucky Queen Shaft #1	Lucky Queen	*Shaft #1 was rehabilitated in the 1970s and is still open. A wooden building has been built to cover the inclined shaft*	*4m x 3m x 5m*	*Large wooden timber structure support; sound and safe conditions; manway and ladders are open and easily accessed*	*Located on a gentle slope; vegetated with grass and trees; sparse soil cover of residual soils over bedrock and till;* ***permafrost*** *is likely present (up to 120 m deep); host rocks include quartzite, sedimentary and felsic meta-volcanic rocks*	*Access via a rough 2WD truck road*	easily accessible	does not produce water		*concrete cap*	
Lucky Queen Shaft #2	Lucky Queen	*Located between trench 2 and trench 3, 40m southwest of shaft #1*	*Not able to determine*	*Wooden log timbers; shaft was caved by recent surface trenching work*	*Located on a gentle slope; vegetated with grass and trees; sparse soil cover of residual soils over bedrock and till;* ***permafrost*** *is likely present (up to 120 m deep); host rocks include quartzite, sedimentary and felsic meta-volcanic rocks*	*Access via a rough 2WD truck road*	collapsed and inaccessible; open for roughly a metre	shaft is producing water		*rock cap and fill*	
Shamrock J18 Raise	Keno No. 9	*The J18 Vein was discovered and mined from the Keno Mine underground workings; a raise to surface was established to provide access for supplies/miners/equipment*	*Unknown Dimensions*	*The ground around the raise and the building covering it are collapsing; an area of ~7 to 10 m has collapsed; unstable*	*Located above treeline; area underlain by* ***permafrost*** *up to 120 m deep; soils are poorly developed and absent over the area; quartzite host rock*	*Road access to the shaft; the raise area has been fenced off*	shaft is open			*fill and cap as required*	*eliminates access issues*
No. 9 Vein Shaft	Keno No. 9									*no access, do nothing*	
Lower Lake Shaft	?						high intrigue risk; accessible to public		hanging wall of shaft collapsed; may deteriorate to produce an open hole	*remove timber and debris; fill and cap as required*	
Upper Lake Shaft	?						open to surface	water observed in shaft	minor subsidence	*remove timber and debris; fill and cap as required*	
Silver Basin Hand Shafts (Shaft #1)	Silver Basin	*The shaft has collapsed ~1 m below the surface; shaft cannot be accessed*	*1m x 1m x 3m*	*Log cribbing supports*	*Above treeline; likely underlain by continuous* ***permafrost*** *; quartzite host rock*	*4WD access*				*fill*	



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

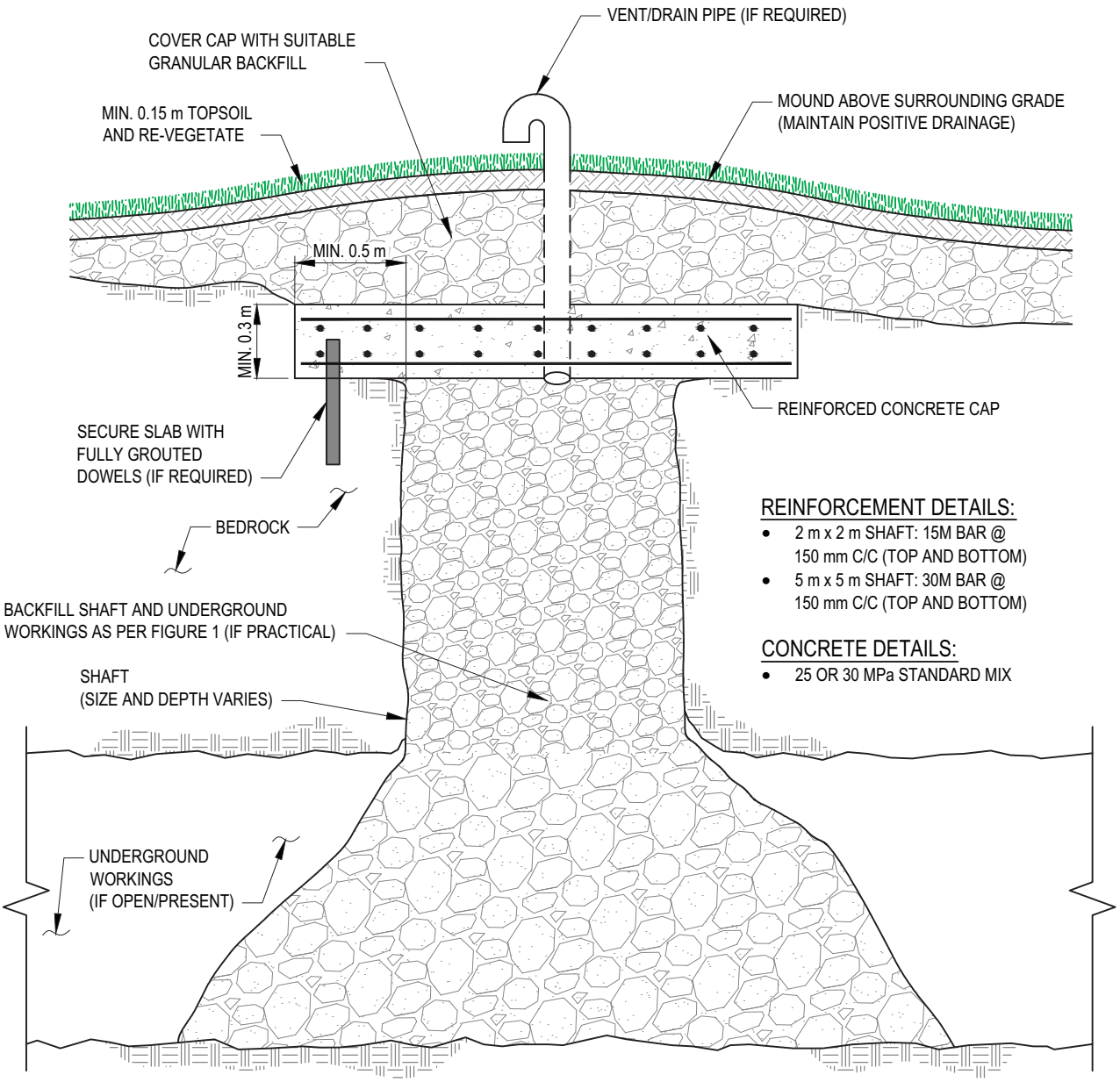
CONCEPT A
DRY SEAL

PROJECT NO.	DWN	CKD	REV
V151010□3	SF	JP	0

OFFICE	DATE
VANC	A□r□□, 2011

Figure 5.49

Q:\Vancouver\Drafting\Engineering\V151\V151010043\V151010043_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

eba A TETRA TECH COMPANY

KENO HILL SHAFT CLOSURES
KENO HILL, YT

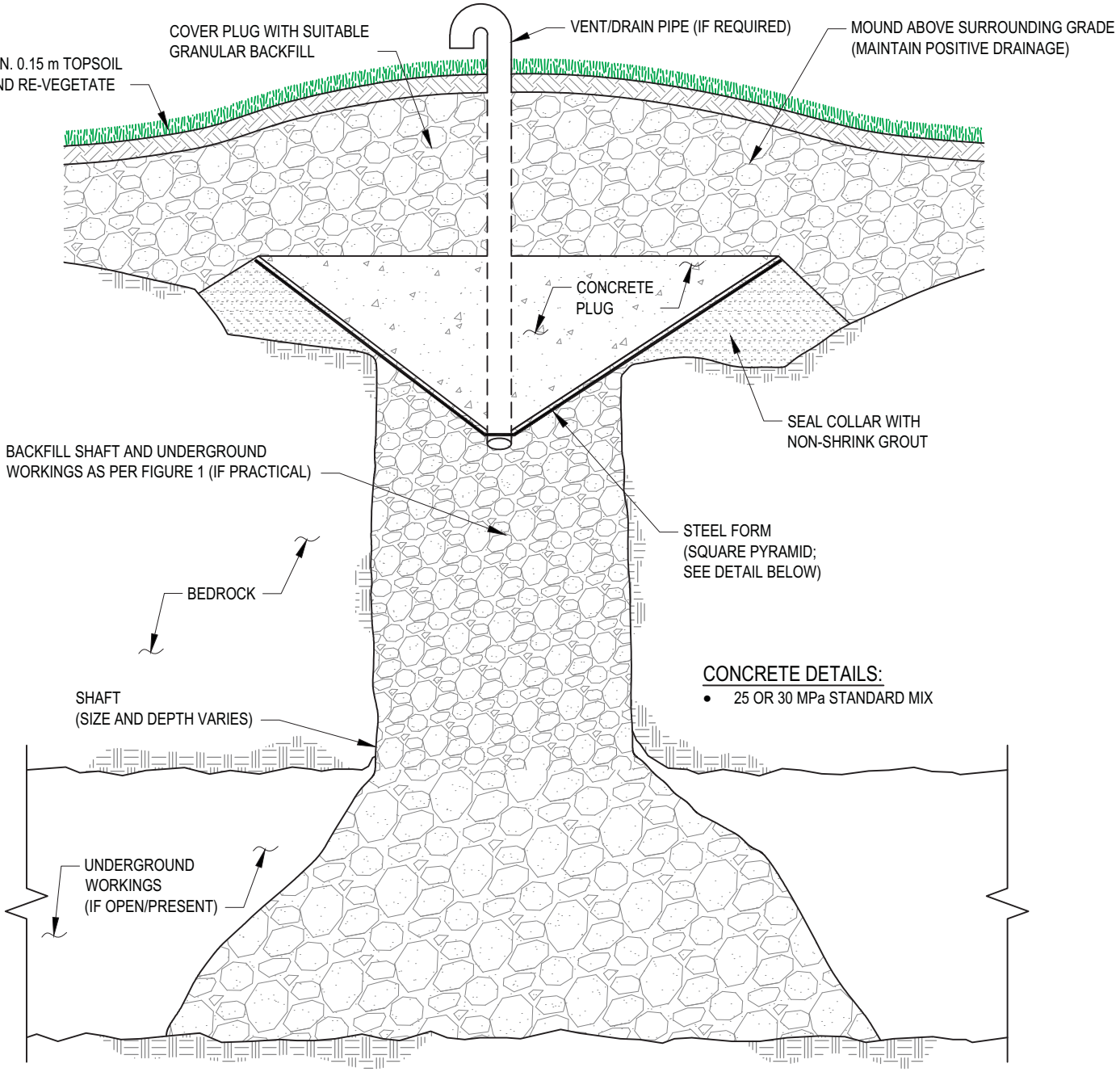
CONCEPT B
CONCRETE CAP

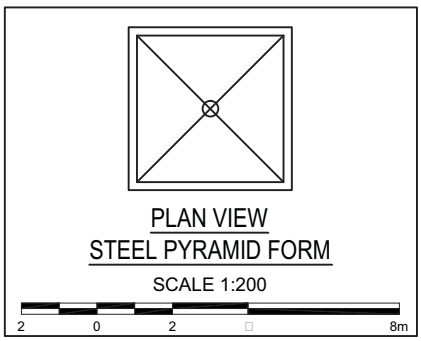
PROJECT NO.	DWN	CKD	REV
V151010□3	SF	JP	0

OFFICE	DATE
VANC	A□r□□, 2011

Figure 5.50

Q:\Vancouver\Drafting\Engineering\V151\V151010\43\V151010043_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

eba A TETRA TECH COMPANY

KENO HILL SHAFT CLOSURES
KENO HILL, YT

CONCEPT B
INVERTED PYRAMID CONCRETE CAP

PROJECT NO.	DWN	CKD	REV
V151010□3	SF	JP	0

OFFICE	DATE
VANC	A□r□□, 2011

Figure 5-51

Q:\Vancouver\Drafting\Engineering\V151\V151010\43\V151010043_FIG 1-3_R0.dwg [FIGURE 3] April 04, 2011 - 3:33:20 pm (BY: FOURNIER, SAMUEL)

5.6 MINE ADIT CLOSURE

SRK (2008c) 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 of the rock around the adit and physical instability of the slopes, 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 5.3 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 are included after the adit closure options are listed. SRK (2008c) includes figures for each of these options.

5.6.1 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 site-specific investigations would be required before proceeding to final design. Adit plugs can be candidate closure options where objectives such as 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, but instead be used to divert water into a drainage structure. As discussed in Section 5.3.4 it is not anticipated to install an adit plug that causes significant buildup of water as a closure option due to negative feedback of that approach during the initial risk assessment meetings in 2009.

5.6.2 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 due to not having to address water management issues; 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.

5.6.3 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.

5.6.4 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 conforms to the surrounding landforms around the portal.

5.6.5 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 physical access 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.

5.6.6 Recommended Adit Closure Approach

SRK (2008c) 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 mine manager after an inspection of all the portals was performed in 2009.

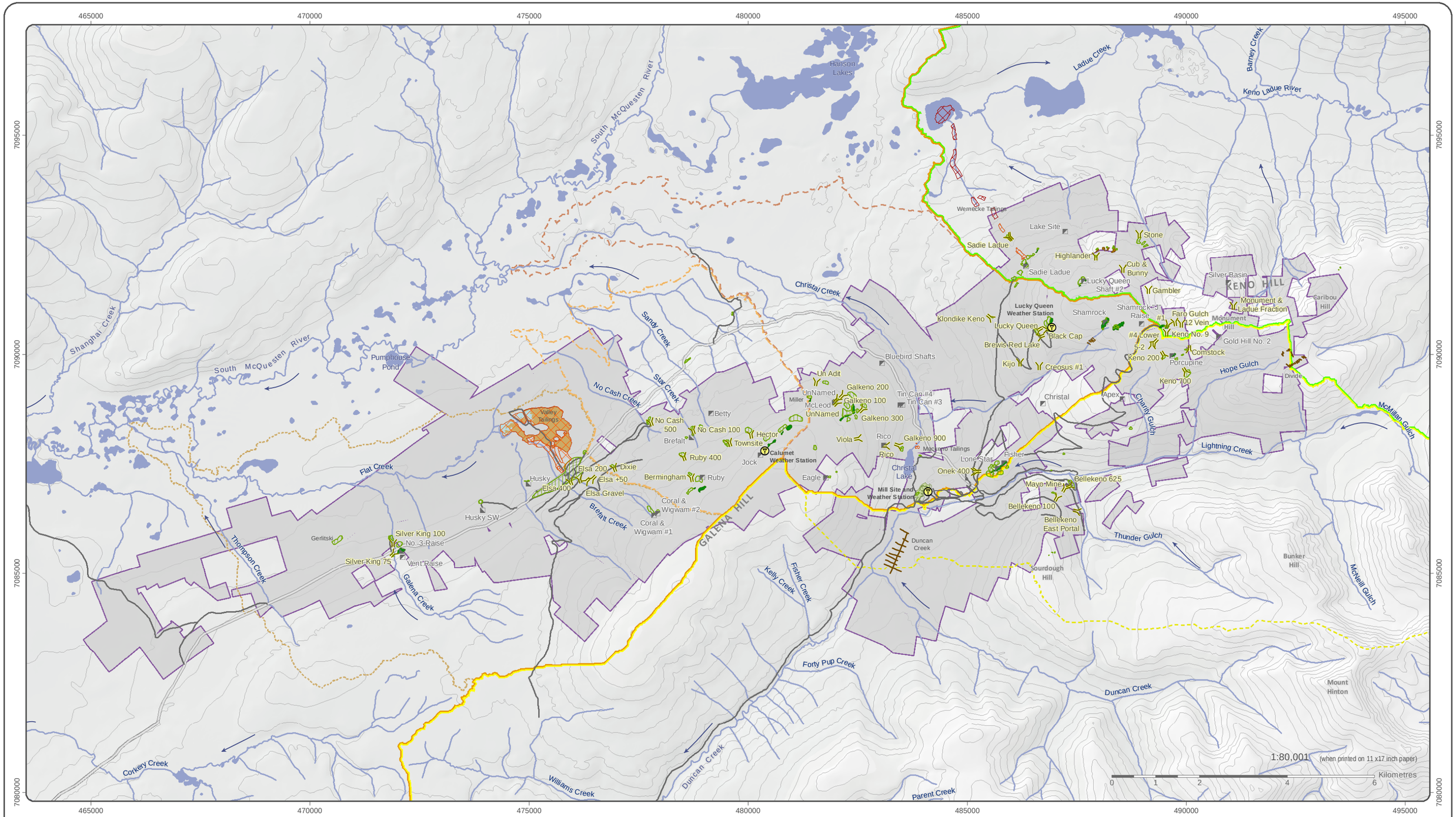
6 ORGANIZATION OF KHSD SITES AND CLOSURE OPTIONS BY WATERSHED

6.1 SUMMARY TABLES AND FIGURES

An extensive review of relevant materials has been conducted from previous investigations into environmental conditions and mining related issues in the KHSD. This, along with site visits and inspections carried out during the last 6 years, has led to the identification of the major closure issues for each component (e.g. adit, shaft, waste rock etc.) at each site on the property. This section presents a summary of the various issues that the closure plan options will address at each site, broken down by component. The set of vetted options that are presented were determined from discussions with the Closure Planning Team, and have been refined to only include options which can resolve those issues while achieving closure objectives. The objectives driving closure planning at Keno Hill (described in Section 4.1) fall under the following broad categories: public and worker health and safety, contamination of the environment (including water, air and land), community and traditional land uses, socio-economic benefit impacts, liability and risks associated with the site, liability and risks associated with implementation of the ESM reclamation plan, and to minimize costs in accomplishing the implementation of the ESM reclamation plan.

The mine sites presented in this section (Table 6-1) are categorized in two ways. The most significant and complicated individual mine components in the Keno District are presented first, and in order of their watershed association. All other mine sites are then presented, organized by watershed. The rationale for this presentation stems from the closure philosophy discussed in Section 4, namely, a watershed ecosystem-based management approach. The aim of this presentation approach is to familiarize closure planning participants and regulators with the groups of sites that will be assessed in concert with one another.

The watersheds are as follows: Christal Creek, Flat Creek (both of which drain into the South McQuesten River), the Keno Ladue River (which flows into the Stewart River), Lightning Creek (which drains into Duncan Creek and ultimately the Mayo River), and the No Cash Bog (which reports to ground, with the groundwater ultimately reporting to the South McQuesten River watershed).



Canvec compiled by Natural Resources Canada at a scale of 1:10,000 - 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.
Watersheds were derived, where possible, with ESRI Spatial Analyst with hydrography and contours derived from 2006 aerial imagery obtained from Aero Geometrics, Calgary Alberta. Extensions of the watersheds were created with Canvec data and ESRI Spatial Analyst.
Quartz claim boundaires and ownership are current as of Mar 26th 2012. Data obtained from Yukon Mining Recorder.

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

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- Adit
- Shaft
- Weather Station
- Highway
- Secondary Road
- ERDC Quartz Claims
- Off-Claim Tailings
- On-Claim Tailings
- Waste Rock Dump
- Open Pit
- Trenching

Catchments
- Keno Ladue River
- Mayo River
- South McQuesten River

Subcatchments
- Christal Creek
- No Cash Bog
- Flat Creek
- Lightning Creek

ERDC

ACCESS

ELSA RECLAMATION AND DEVELOPMENT COMPANY
CLOSURE OPTIONS REPORT

FIGURE 6-1

CLOSURE SITES DELINATED BY CATCHEMENT

FEBRUARY 2013

D:\Project\AllProjects\ALEX-05-01\gis\mxd\UKHM\Closure Plans and Reports\Closure_Options_Report_2013\MineSites_Drainage_20130226.mxd
(Last edited by: jlindeman; 26/02/2013/15:21 PM)

Table 6-1 Closure Sites

Designation	Watershed/Site	Location
	Flat Creek	
Complex	Husky SW Shaft	Galena Hill
Complex	Silver King 100 Level Adit	Galena Hill
Complex	Valley Tailings Facility	Galena Hill
	Coral and Wigwam Site	Galena Hill
	Elsa Site	Galena Hill
	Gerlitski Site	Galena Hill
	Husky Site	Galena Hill
	No Cash Bog	
Complex	Bermingham Adit	Galena Hill
Complex	Ruby Adit	Galena Hill
Complex	Hector 400 Level Adit WRSA	Galena Hill
Complex	No Cash 500 Level Adit	Galena Hill
	Betty Site	Galena Hill
	Dixie Site	Galena Hill
	No Cash 100 Site	Galena Hill
	Townsite Site	Galena Hill
	Christal Creek	
Complex	Galkeno 300 Level Adit	Galena Hill
Complex	Galkeno 900 Level Adit	Galena Hill
Complex	Mackeno Tailings	Galena Hill
Complex	Onek 400 Level Adit	Keno Hill
	Bluebird Site	Galena Hill
	Christal (Dorothy) Site	Keno Hill
	Croesus No. 1 Site	Keno Hill
	Dragon (UN) and Miller Site	Galena Hill
	Eagle Site	Galena Hill
	Galkeno Site	Galena Hill
	Hector-Calumet Site	Galena Hill
	Kijo Site	Keno Hill
	Klondike Keno Site	Keno Hill
	Lucky Queen and Blackcap Adit Sites	Keno Hill
	Onek Waste Rock Area	Keno Hill
	Rico Site	Galena Hill
	Shamrock Site	Keno Hill
	Tin Can Site	Galena Hill
	Lightning Creek	
Complex	Keno 700 Level Adit	Keno Hill
	5-2 Site	Keno Hill
	Apex Site	Keno Hill
	Divide Site	Keno Hill
	Duncan Creek Site	Sourdough Hill
	Gold Hill No. 2 Site	Keno Hill
	Keno 200 Site	Keno Hill
	Keno Ladue River	
Complex	Sadie Ladue 600 Adit	Keno Hill
Complex	Wernecke Tailings Site	Keno Hill
	Cub and Bunny Site	Keno Hill
	Fox Site	Keno Hill
	Highlander Site	Keno Hill
	Keno No. 9 System Site	Keno Hill
	Lake Site	Keno Hill
	Lucky Queen Shaft Site	Keno Hill
	Monument and Ladue Fraction Site	Keno Hill
	Silver Basin Site	Keno Hill
	Stone Site	Keno Hill

6.1.1 Closure Sites – Flat Creek Watershed

The Flat Creek valley is located downstream of the Elsa town site and tailings dams in a low-lying valley dominated by wetlands and mature forest. Flat Creek collects drainage from the Elsa Tailings and the Husky, Silver King and Elsa mines, as well as a significant catchment area on the northern side of Galena Hill. The Elsa tailings are located in the Flat Creek valley bottom below the Elsa mill and town site. The major accumulation of the Elsa tailings is upstream from the main stem of Flat Creek in a swampy area that ultimately drains into the main branch of Flat Creek. Porcupine Creek passes through the tailings area via the Porcupine Creek Diversion.

The aquatic resources and water chemistry in Flat Creek have historically been dominantly influenced by tailings deposition and tailing supernatant and, to a lesser degree, adit discharge. There is documented evidence that tailings solids were released to Flat Creek drainage as a result of several dam failures of the No. 1 dam in the 1960s (PWGSC 2000). It is understood that the aquatic habitat and resources in Flat Creek deteriorated as a result of the initial tailings deposition and later tailings loss and redeposition. These events caused the tailings solids to alter the natural stream bed composition and metals concentrations. The impacts of the tailings impoundment and dispersed tailings to Flat Creek have been the subject of a number of studies related to Keno Hill District closure (SRK 2009a; Interralogic 2012a). Moreover, treated effluent from the Valley Tailings is currently discharged to Flat Creek on a seasonal basis.

The following UKHM sites fall within the Flat Creek watershed, and are either known or suspected as contributing metals mass load to the drainage:

- Husky SW Site
- Silver King Site
- Valley Tailings Site
- Elsa Mine Site (it is understood that Husky SW site is likely the low spot that is the primary discharge site for Husky SW, Husky, and Elsa Mines; based on underground mine maps and geologic mapping it is believed that all of these mines are connected via underground workings and faults)
- Coral and Wigwam Site
- Gerlitski Site
- Husky Site

6.1.2 Closure Sites – No Cash Bog

The No Cash Bog is situated below the northwest slope of Galena Hill and comprises the wetlands northeast of the Valley Tailings Facility. This bog captures drainage from No Cash, Sandy and Star Creeks, as well as any other surface or subsurface flow off the northwest slope of Galena Hill. From

creek surface headwaters on Galena Hill to dispersion in the bog, the distance is roughly 3km. Various mine workings on Galena Hill in this catchment area produce water, including No Cash 500, Bermingham and Ruby adits. The most significant producer of metals load among the three is currently No Cash 500. Galena Hill also produces a number of seeps that may have contact with mineralized areas underground. It is pertinent to note that during active mining of the Galena Hill mines in this area, dewatering water was noted to have been discharged down these drainages or to land surface on the hillside, which ultimately also ended up in this bog area.

A field program was carried out between 2010 and 2012 on No Cash Creek and the No Cash bog to assess the potential for natural attenuation processes to occur which might aide in treatment of water and protection of the receiving environment. Investigation by Kwong (1997) showed that more than 90% of metals leaving the hillside were removed to become solid phases in the soils and sediments of the creeks and bogs. The potential usefulness of these reactions to provide natural/passive water treatment for these mine waters in closure was raised by closure planning participants. To further investigate this potential, a number of additional stations were established within the watershed in 2009, and subsequently expanded as necessary to carry out this study. Preliminary results for this program were analysed and summarized by Interralogic during 2010 with the closure planning group. Results from this preliminary study were presented and from the ensuing discussion follow-up studies were conducted in 2011 and 2012. A summary report of all works was prepared in 2013 (Interralogic 2013d), which presents a current state of knowledge of the potential for natural attenuation as a mine closure approach for UKHM sites and is included as Appendix P to this report.

The following UKHM sites fall within the No Cash Bog catchment area, and are either known or suspected as contributing metals mass load to the drainage:

- Bermingham and Ruby Sites
- Hector 400 WRSA*
- No Cash 500 Site
- Betty Site
- Dixie Site
- No Cash 100 Site
- Townsite Site

*Note: The Hector-Calumet mine area sits on the surface water divide; Hector mine areas primarily are located in the South McQuesten watershed with flow into the No Cash Bog that appears not to have any surface water discharge; Calumet mine areas primarily are located in the Christal Creek watershed which ultimately drains into the South McQuesten River watershed.

6.1.3 Closure Sites – Christal Creek Watershed

The Christal Creek valley is located downstream of Christal Lake. Water chemistry and aquatic resources in the creek have been influenced by previous mine and milling operations including tailings deposition and adit discharge.

Water quality monitoring in this watershed begins at Christal Creek before its confluence with Hinton Creek and ends at the mouth of Christal Creek before entering the South McQuesten River. There are no significant tributaries to Christal Creek upstream of Hinton Creek; however, it is unknown to what degree mine-related discharges may have historically had an influence on the drainage above the most upstream station. At the current time, the Galkeno 300 treatment site is discharged along a ditch that joins the headwaters of Hinton Creek that runs off the southwest side of Galena Hill. It is safe to interpret that water quality at the Christal Creek headwaters reflects some degree of mine-related contamination as a result of its proximity to mining areas, as well as elevated background metals levels from naturally-mineralized rock seeps.

Between the upper monitoring stations and the mouth of Christal Creek, there are a number of significant mine-related inputs to the drainage system. The discharge from workings draining off the northeast flank of Galena Hill impact the Christal Creek system, including treated discharges from both the Galkeno 300 and 900 level adits. A number of other contaminant sources drain directly to Christal Lake and the Christal Creek catchment, including the Onek Adit which goes to ground upgradient of the Christal Creek/Christal Lake area; the UN Adit which intermittently flows; and the Mackeno mill site and tailings. Tailings from the MacKeno mill were deposited on land at the edge of Christal Lake and into Christal Lake and Christal Creek during the 1950s. These tailings have been partially inundated and there is evidence of ongoing tailings migration via erosion into Christal Creek.

During 2010, the Bellekeno Mill was constructed and commissioned within the Christal Creek watershed. Impacts resulting from the mill and mining activities theoretically could enter the Christal Creek watershed; however, no water has been discharged from the Bellekeno Mill to date. Because the Bellekeno Mill is operated in a zero discharge configuration, and any seepage from the Bellekeno tailings is collected and recycled into the mill water pond, it is expected that future metal loading impacts from the Bellekeno Mill present very low or insignificant loading potential to the Christal Creek watershed.

In recent years (late 1990s until 2007) the main source of contamination into the Christal Creek watershed in terms of the primary known contaminants (cadmium and zinc), was the Silver Trail Culvert. This site conveyed water from the Galkeno 300 area (both before and after a treatment facility was constructed and intermittently operated in the early 2000s) and was the source of glaciation at the Silver Trail Highway. In fall 2007, after ERDC had taken over care and maintenance activities, the site treatment facilities were upgraded so that treatment has become continuous and has met licence criteria since that time. Since 2007 all discharge from the Galkeno 300 treatment facility has been routed to Hinton Creek headwaters in the Christal Creek catchment above Christal Lake. During the time that KV-29 was active, KV-30 (Christal Creek 825 m downstream of Silver Trail Highway) was

initiated to monitor contributions by the treatment discharge to Christal Creek. Similarly, KV-16 was initiated to monitor Christal Creek prior to influences from the Galkeno 300 treatment discharge. It appears that for most of the time the greater portion of the contamination in Christal Creek below KV-30 came from the Silver Trail Culvert, i.e., Galkeno 300 effluent that was only partially treated. However, there were times during which the contamination at KV-16 exceeded the contamination at KV-30, which could be the result of tailings-based contributions from Mackeno tailings, or untreated discharge from the Onek mine.

The following UKHM sites fall within the Christal Creek watershed, and are either known or suspected to contribute metals mass load to the drainage:

- Galkeno 300 Site
- Galkeno 900 Site
- Galkeno Site
- Hector Calumet Site (see note above in Section 6.1.2)
- Mackeno Mill/Tailings Site
- Onek Site
- Bluebird Site
- Christal (Dorothy)
- Croesus No. 1
- Dragon (UN) and Miller Sites
- Eagle
- Kijo
- Klondike Keno Site
- Lucky Queen and Black Cap Adits
- Rico
- Shamrock Site
- Tin Can

It is also noteworthy that some mine sites in the Christal drainage never were part of the UKHM claim package; this closure plan only addresses UKHM historical sites. The mines/claims that could potentially affect the Christal drainage include the Paddy and Formo sites.

6.1.4 Closure Sites – Lightning Creek Watershed

Lightning Creek is located within a narrow valley with a steep gradient flowing from the north side of Mount Hinton and Sourdough Hill and the south side of Keno Hill into Duncan Creek, which ultimately drains into the Mayo River. Hope and Thunder Gulches flow into Lightning Creek within the bounds of the Keno Hill property. Lightning Creek and its tributaries have been and continue to be the site of extensive placer mining upstream of Keno City. Alexco Resource's Bellekeno mine development is located at the confluence of Thunder Gulch and Lightning Creek, and has been in operation beginning in 2010 and continuing to the present time. The Lightning Creek drainage has also been affected by localized quartz mining activities including mine adit drainage from the historic Bellekeno 625 and Keno 700 adits, which report to the Lightning Creek drainage.

Lightning Creek is not connected to the South McQuesten River. There are eight regularly monitored sites within the Lightning Creek watershed from the background baseline station near the creek headwaters to the station at the Lightning Creek Bridge near Keno City.

Hope Gulch enters Lightning Creek just above station KV-38. The primary source of contamination to Hope Gulch is the Keno 700 adit, which drains over the Keno 700 waste rock dump and directly into Hope Gulch. This is the largest known, measurable load of metals to Lightning Creek, at times accounting for the vast majority of the metals load measured in Lightning Creek.

The following UKHM sites fall within the Lightning Creek watershed, and are either known or suspected as contributing metals mass load to the drainage:

- Keno 700 Site
- Keno 200 Site
- 5-2 Site
- Apex Site
- Divide Site
- Duncan Creek Site
- Gold Hill No. 2 Site

6.1.5 Closure Sites – Keno Ladue River

The Keno Ladue River collects drainage flowing from the north side of Keno Hill and then flows eastward into the Stewart River basin. This drainage includes, significantly, both runoff from the Sadie Ladue workings and contact water from the Wernecke tailings that fill the Sadie Ladue drainage on Keno Hill.

There are also a number of more minor sites that are located on the UKHM claims within the Keno Ladue watershed. They are as follows:

- Sadie Ladue 600 Adit Site
- Sadie Ladue/Wernecke Mill Sites
- Cub and Bunny Site
- Divide
- Fox
- Highlander Site
- Keno No. 9 System
- Lake Site
- Lucky Queen Shaft
- Monument & Ladue Fraction Site
- Silver Basin Site
- Stone

6.2 CLOSURE ISSUES AND OPTIONS SUMMARY BY WATERSHED

As described before, to present closure options for all site components would be an exhaustive exercise that would have diminishing potential effects on the environment beyond the most significant sites. Discussions with the closure planning participants in 2010 and 2011 resulted in selection of "complex" sites that require multiple options to be evaluated to optimize the closure activities' effects on the environment, with other "simple" sites where standard mitigative reclamation approaches will be undertaken.

Table 6-2 to 6-6 summarize the possible closure options identified for the most complex mine components at the Keno Hill Property. Based on mass balance load modelling, on an untreated basis these sites represent over 99% of the metals load potential to surface water in the KHSD (see Interralogic 2013a, 2013b, 2013c). Section 7 presents the detailed analysis of the loads for each site on a relative basis by watershed. These "complex" sites are (by watershed):

Flat Creek:

- Husky SW shaft
- Silver King 100 level adit
- Elsa Valley Tailings

No Cash Bog:

- Bermingham adit
- Ruby adit
- Hector adit WRSA
- No Cash 500 level adit

Christal Creek:

- Galkeno 300 level adit
- Galkeno 900 level adit
- Mackeno tailings
- Onek 400 level adit

Lightning Creek:

- Keno 700 level adit

Keno Ladue River:

- Sadie Ladue adit
- Wernecke tailings

Tables 6-2 to 6-6 summarize the possible closure options identified for the complex mine components, presented by watershed, at the Keno Hill Property. Tables 6-7 through 6-42 present a summary of closure issues and options for each site grouped by watershed. Associated with each closure option site table is a summary figure (Figures 6-2 to 6-51) that illustrates the site using an aerial photograph (2006), and the location of each closure option for all sites. A handful of minor sites do not have associated summary figures, as the manifestation of mining is not visible either from the images, or on the ground.

Table 6-2 Summary of Flat Creek Complex 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	Design Questions	Alternatives	Major Cost Elements	Alternatives Considered but not Advanced
Flat Creek Watershed														
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) feasibility of monitoring natural attenuation 2) unknown discharge flow rates from shaft into subsurface 3) residence time and chemistry in mine pool 4) long term stability of loading rates from mine 5) what is effect of waste rock interactions with water discharging from shaft 6) potential influence of ice plug on drainage from the shaft at this location	**(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	Enhanced Treatment by Iron Addition. Iron in uncontrolled setting can re-release sorbed contaminants. Requires periodic maintenance to refresh media.
								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	**Passive Chemical Reactor (eg. Zero Valent Iron)** High cost of media and passivation in high sulphide water.
												(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)	
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) feasibility of monitoring natural attenuation 2) feasibilty of subsurface injection for attenuation distribution 3) residence time in mine pool, connectedness in workings between pit and veins 1 and 2 with veins 3-5 that are connected with adit discharge 4) long-term stability of Silver King 100 drainage, physical and chemical 5) long-term impacts of potential plant uptake of metals (natural attenuation) 6) adit rehabilitation design 7) potential load reductions through surface source control	**(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)	Enhanced Treatment by Iron Addition Iron in uncontrolled setting can re-release sorbed contaminants. Requires periodic maintenance to refresh media.
								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)	**Reclamation-only** Reclamation only would not improve adit discharge quality to allow for direct discharge to receiving environment
												(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)	**Wetland Treatment (stand-alone)** Wetlands have been tested in the District but shown not to be effective year-round. Wetland treatement design component are incorporated into MNA and bioreactor alternatives.
												(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)	

Table 6-2 Summary of Flat Creek Complex Sites

Component Description	Component Type	Closure Activitiy No. (map reference)	Closure Issue Categories					Min Flow	Average Flow	Max Flow	Design Questions	Alternatives	Major Cost Elements	Alternatives Considered but not Advanced
			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				
Flat Creek Watershed														
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) evaluate geochemical loading from tailings in major areas (Flat Creek valley bottom, behind dams, near diversions, from hillside outside of dam catchment) 2) surface water hydrology 3) distribution in of tailings that require cover (degree of consolidation required) 4) method of handling tailings 5) requirement for cover to vegetate or to reduce loading 6) are dams necessary permanent features 7) can existing wetland feature be left as is or is additional cover required 8) can existing peat layers underneath dispersed tailings be used for cover 9) refining groundwater aquifer characteristics	**(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	**Re-processing** Not considered as part of Closure Plan but may be considered by AHKM for future development of the District. Questions around cost offsets. Subsidiary Agreement may prevent re-processing without triggering a Production Unit.
												(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	Rehandle back into local underground workings high cost of rehandling, multiple disposal locations possibly required,
												(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	

Table 6-3 Summary of No Cash Bog Complex Sites

Component Description	Component Type	Closure Activitiy No. (map reference)	Closure Issue Categories					Min Flow	Average Flow	Max Flow	Design Questions	Alternatives	Major Cost Elements	Alternatives Considered but not Advanced
			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				
No Cash Bog														
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) feasibility of monitoring natural attenuation in No Cash Bog 2) possible residence time in mine pit pond and pool 3) monitoring of adit flow continuous for one year 4) long term stability of loading rates from mine 5) how to best evaluate options given No Cash discharges drive drainage quality of receiving environment 6) potential load reductions through surface source control	**(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)	Enhanced Treatment by Iron Addition. Sufficient iron in drainage to not warrant additional iron.
								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)	**Wetland Treatment (stand-alone)** Wetlands have been tested in the District but shown to not be effective year-round. Wetland treatement deisgn component are incorporated into MNA and bioreactor alternatives.
												(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)	**Passive Chemical Reactor (eg. Zero Valent Iron)** High cost of media and passivation in high sulphide water.
												(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	
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) feasibility of monitoring natural attenuation in No Cash Bog 2) possible residence time in mine pool 3) monitoring of adit flow continuous for one year 4) long term stability of loading rates from mine 5) how to best evaluate options given No Cash discharges drive drainage quality of receiving environment 6) potential load reductions through surface source control	**(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)	Enhanced Treatment by Iron Addition. Iron in uncontrolled setting can re-release sorbed contaminants. Requires periodic maintenance to refresh media.
								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)	**Wetland Treatment (stand-alone)** Wetlands have been tested in the District but shown to not be effective year-round. Wetland treatement deisgn component are incorporated into MNA and bioreactor alternatives.
												(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)	**Passive Chemical Reactor (eg. Zero Valent Iron)** High cost of media and passivation in high sulphide water.
												(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	
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) cause of vegetation stress downgradient of dump (current chemical vs historical physical/chemical) 2) refined estimation of geochemical load from the dump (i.e., extent of requirement for cover) 3) mineral grades in dump 4) source control measures to divert water from dump	**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	**Re-processing** Not considered as part of Closure Plan but may be considered by AHKM for future development of the District.
												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		

Table 6-3 Summary of No Cash Bog Complex Sites

Component Description	Component Type	Closure Activitiy No. (map reference)	Closure Issue Categories					Min Flow	Average Flow	Max Flow	Design Questions	Alternatives	Major Cost Elements	Alternatives Considered but not Advanced
			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				
No Cash Bog														
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 McQuesten 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)	Enhanced Treatment by Iron Addition. Iron in uncontrolled setting can re-release sorbed contaminants. Requires periodic maintenance to refresh media.
								2.5	**5.5**	**8.0**	1) feasibility of monitoring natural attenuation in No Cash Bog 2) possible residence time in mine pool created by low pressure adit plug 3) geotechnical feasibility of bioreactor at No Cash 500 adit 4) long-term stability of No Cash 500 drainage, physical and chemical 5) potential load reductions through surface source control 6) linkages to closure options for Bermingham and Ruby Complex sites	**(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)	**Wetland Treatment (stand-alone)** Wetlands have been tested in the District but shown to be effective year-round. Wetland treatement deisgn component are incorporated into MNA and bioreactor alternatives.
												(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)	**Passive Chemical Reactor (eg. Zero Valent Iron)** High cost of media and passivation in high sulphide water.
												(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	

Table 6-4 Summary of Christal Creek Complex Sites

Component Description	Component Type	Closure Activitiy No. (map reference)	Closure Issue Categories					Min Flow	Average Flow	Max Flow	Design Questions	Alternatives	Major Cost Elements	Alternatives Considered but not Advanced
			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				
Christal Creek Watershed														
Galkeno 300 Level Adit	*adit*		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) feasibility of piping G300 discharge, scaling, pipeline maintenance, routes on surface or subsurface 2) geotechnical feasibility of locating larger plant facility either at G300 or Silver Trail highway sites (assumed feasible sites in Elsa) 3) feasibility of reagents other than lime 4) is zinc or manganese recovery economically viable 5) feasibility of mine pool storage and possible impacts of varying pool elevation in Hector Calumet 6) long term stability of Galkeno 300 adit, physical and chemical 7) alternative treatment plant designs and configuration 8) alternative treatment designs and configurations (minepool pre-treatment) 9) long term sludge behaviour and management	**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	**Wetland Treatment (stand-alone)** Wetlands have been tested in the District but shown to not be effective year-round. Wetland treatement deisgn component are incorporated into MNA and bioreactor alternatives.
												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	**Bioreactor Treatment**
												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	
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) feasibility of piping Galkeno 900 discharge, scaling, pipeline maintenance, routes on surface or subsurface to Silver Trail highway 2) geotechnical feasibility of locating larger bioreactor along existing road or other locations 3) long-term stability of Galkeno 900 adit drainage, physical and chemical	**(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)	**Passive Chemical Reactor (eg. Zero Valent Iron)** High cost of media and passivation in high sulphide water.
								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	**Wetland Treatment (stand-alone)** Wetlands have been tested in the District but shown to not be effective year-round. Wetland treatement deisgn component are incorporated into and bioreactor alternatives.
												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	
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) evaluate geochemical loading from tailings 2) surface water hydrology 3) distribution in lake and stream channels	**(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	**Re-processing** Not considered as part of Closure Plan but may be considered by AHKM for future development of the District. Would require new mill as not conducive to re-processing through Bellekeno Mill
												(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	**Reclamation-only** Reclamation only would not address ongiong impacts on water Quality in Christal Creek
												(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	

Table 6-4 Summary of Christal Creek Complex 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	Design Questions	Alternatives	Major Cost Elements	Alternatives Considered but not Advanced
Christal Creek Watershed														
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) feasibility of piping Onek 400 discharge, scaling, pipeline maintenance, routes on surface or subsurface to Silver Trail highway 2) bioreactor pretreatment design recognizing higher load than prior test at G900 3) long-term stability of Onek 400 drainage, physical and chemical 4) source control to reduce loadings from adit to the downstream receiving environment	**(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)	**Passive Chemical Reactor (eg. Zero Valent Iron)** High cost of media and passivation in high sulphide water.
								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	**Mine Pool Treatment** Considered but not evaluated due to cost and advanced of mine pool creation by pressurized adit plug to allow for treatment
												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		

Table 6-5 Summary of Lightning Creek Complex Sites

Component Description	Component Type	Closure Activitiy No. (map reference)	Closure Issue Categories					Min Flow	Average Flow	Max Flow	Design Questions	Alternatives	Major Cost Elements	Alternatives Considered but not Advanced
			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				
Lightning Creek Watershed														
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) feasibility of piping Keno 700 discharge, scaling, pipeline maintenance, routes on surface or subsurface to Christal Creek drainage 2) bioreactor geotechnical locations feasibility 3) long-term stability of Keno 700 adit, physical and chemical 4) possible residence time in mine pool created by low pressure adit plug	**(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)	**Passive Chemical Reactor (eg. Zero Valent Iron)** High cost of media and passivation in high sulphide water.
								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)	Enhanced Treatment by Iron Addition. Iron in uncontrolled setting can re-release sorbed contaminants. Requires periodic maintenance to refresh media.
												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		

Table 6-6 Summary of Keno Ladue River Complex Sites

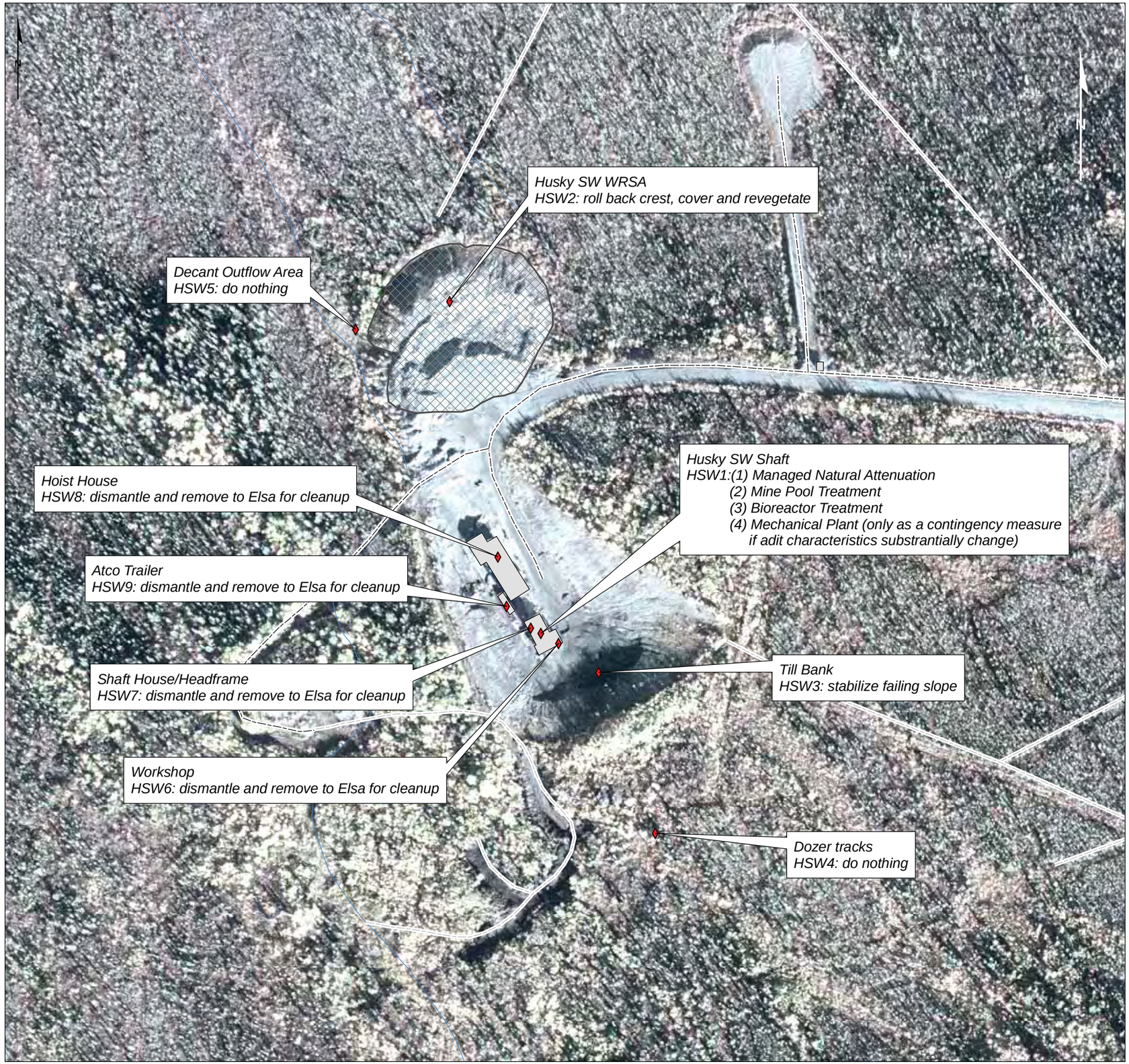
Component Description	Component Type	Closure Activitiy No. (map reference)	Closure Issue Categories					Min Flow	Average Flow	Max Flow	Design Questions	Alternatives	Major Cost Elements	Alternatives Considered but not Advanced
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical 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				
Keno Ladue River Watershed														
Sadie Ladue Adit											1) feasibility of monitoring natural attenuation in Sadie Ladue drainage 2) geotechnical suitability of locations near Sadie Ladue 600 for bioreactor 3) extent of tailings-impacts on Ladue drainage, net benefit of Sadie Ladue treatment 4) long-term stability of Sadie Ladue 600 drainage, physical and chemical 5) potential for source control effects on loading to the receiving environment	**(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)	**Mine Pool Treatment** Considered but not evaluated due to cost and advanced of mine pool creation by pressurized adit plug to allow for treatment
	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 (4.9SL/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		**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)	Enhanced Treatment by Iron Addition. Iron in uncontrolled setting can re-release sorbed contaminants. Requires periodic maintenance to refresh media.
								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)	**Passive Chemical Reactor (eg. Zero Valent Iron)** High cost of media and passivation in high sulphide water.
Wernecke Tailings (on UKHM claims)	*tailings*	*SLW4*			visible gullying						1) evaluate geochemical loading from tailings 2) surface water hydrology 3) distribution in stream channels	**(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	**Re-processing** Not considered as part of Closure Plan but may be considered by AHKM for future development of the District.
												(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	

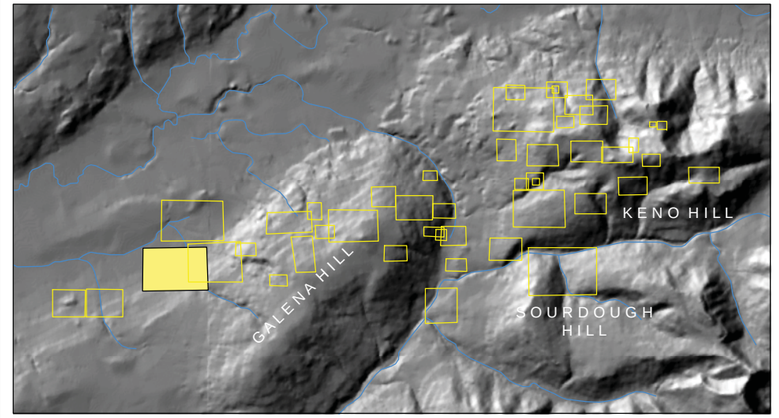
Table 6-7 Summary of Husky SW Site Closure Issues and Options

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

ERDC

ACCESS Consulting Group

Keno Hill Silver District
Closure Options Report

Figure 6.2

Husky SW

Drawn By: TL/JP

APRIL 2011

Table 6-8 Summary of Silver King Site Closure Issues and Options

Common Site Name: **Silver King**

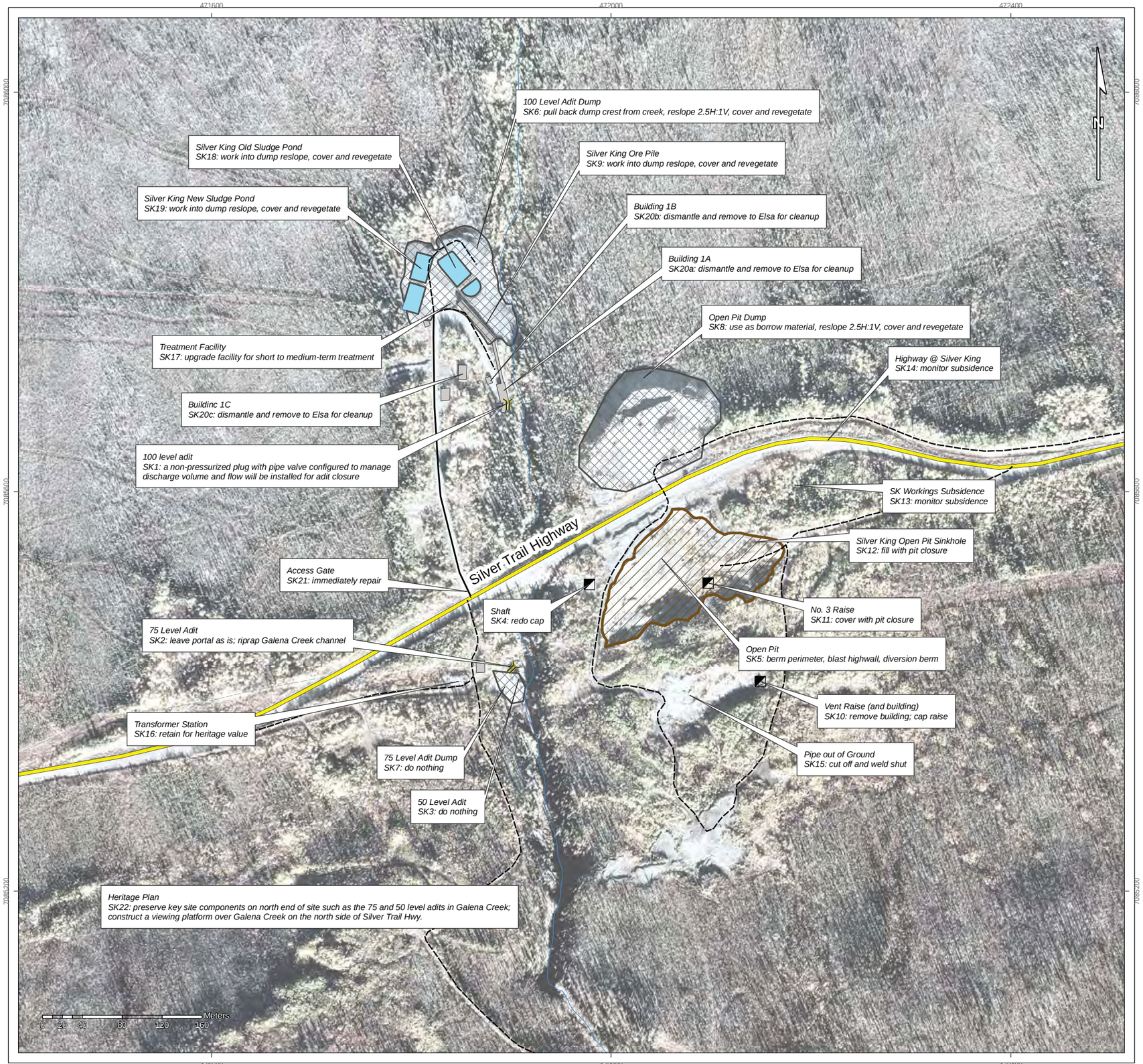
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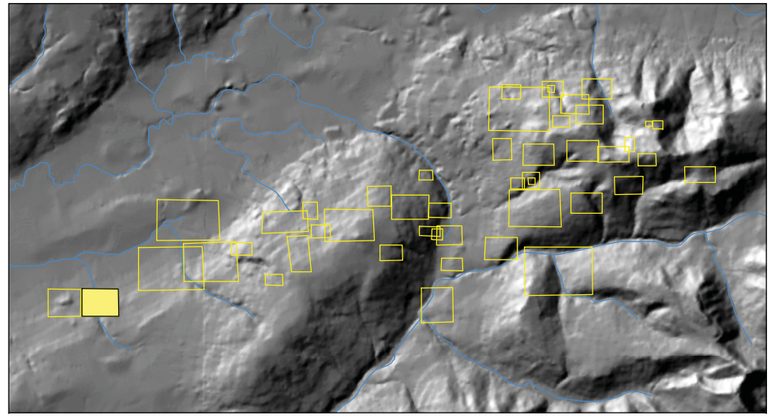
Component Description	Component Type	Closure Activity No. (map reference)	Closure Issue Categories					Proposed Component Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Silver King 100 Level Adit	*adit*	*SK1*	- 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*

Table 6-8 Summary of Silver King Site Closure Issues and Options

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
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
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*





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 6.3

Silver King

Drawn By: TL/JP

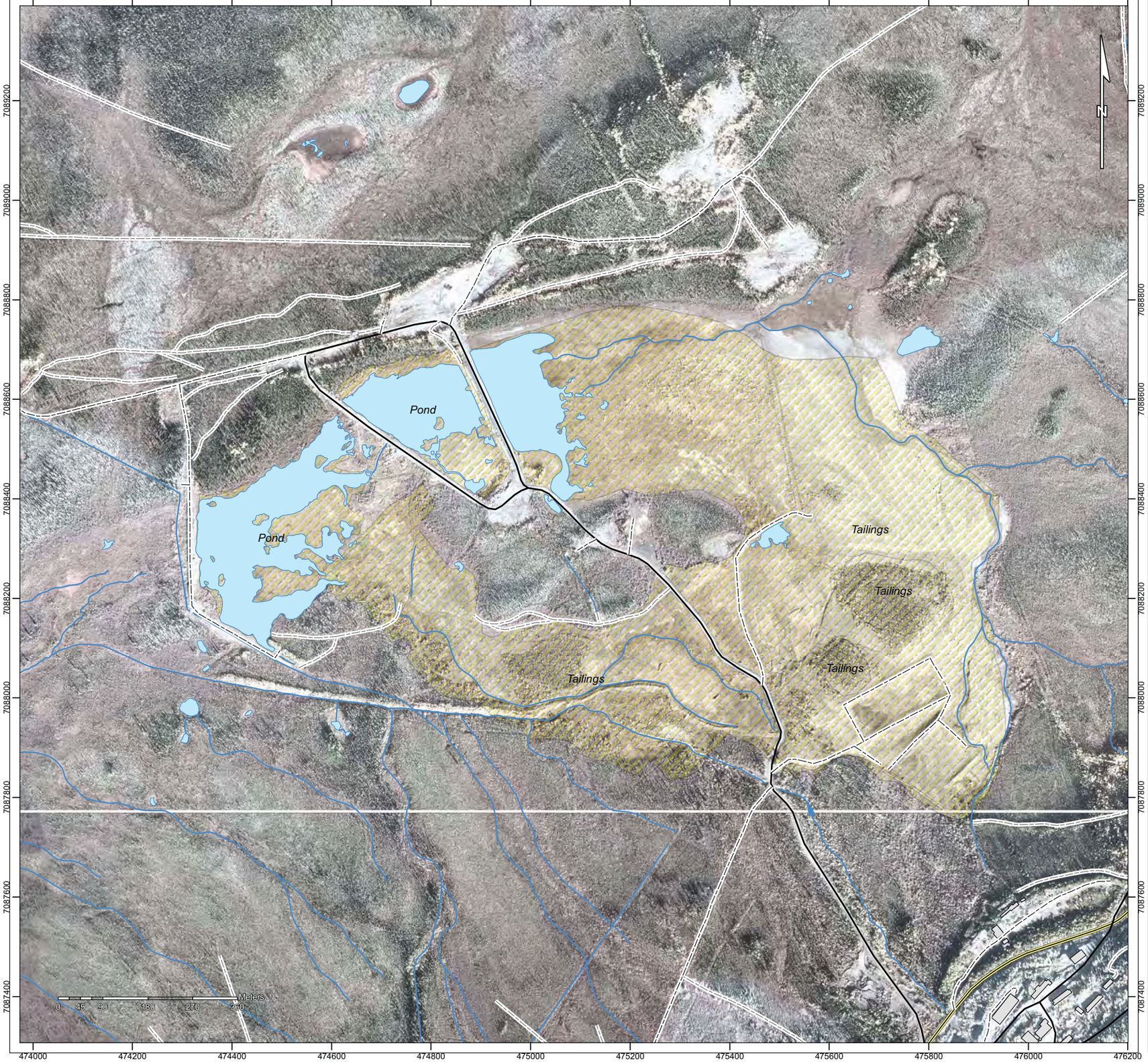
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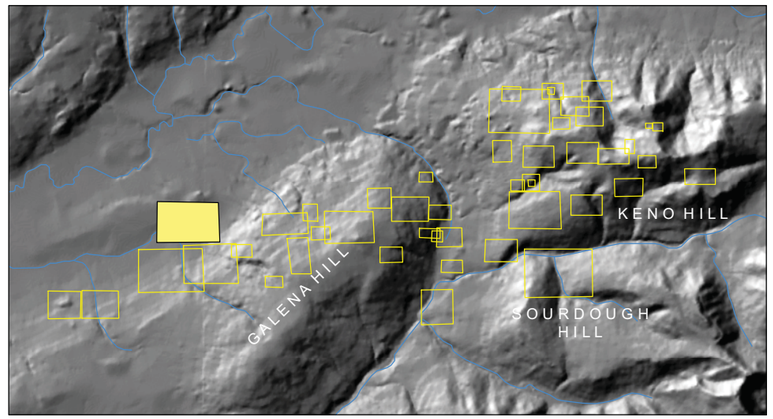
Table 6-9 Summary of Valley Tailings Facility Closure Issues and Options

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*	*VT1*	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*	





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

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Figure 6.4

Valley Tailings Facility

Drawn By: TL/JP

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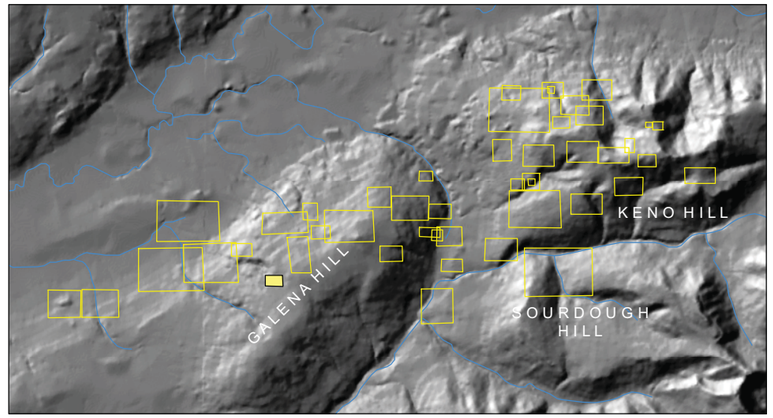
Table 6-10 Coral and Wigwam Sites Closure Issues and Options

Common Site Name: **Coral and Wigwam**

Site coordinates:	easting	northing	*coordinates are UTM zone 8N NAD83
	477902	7086335	

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 #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*





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 6.5

Coral and Wigwam

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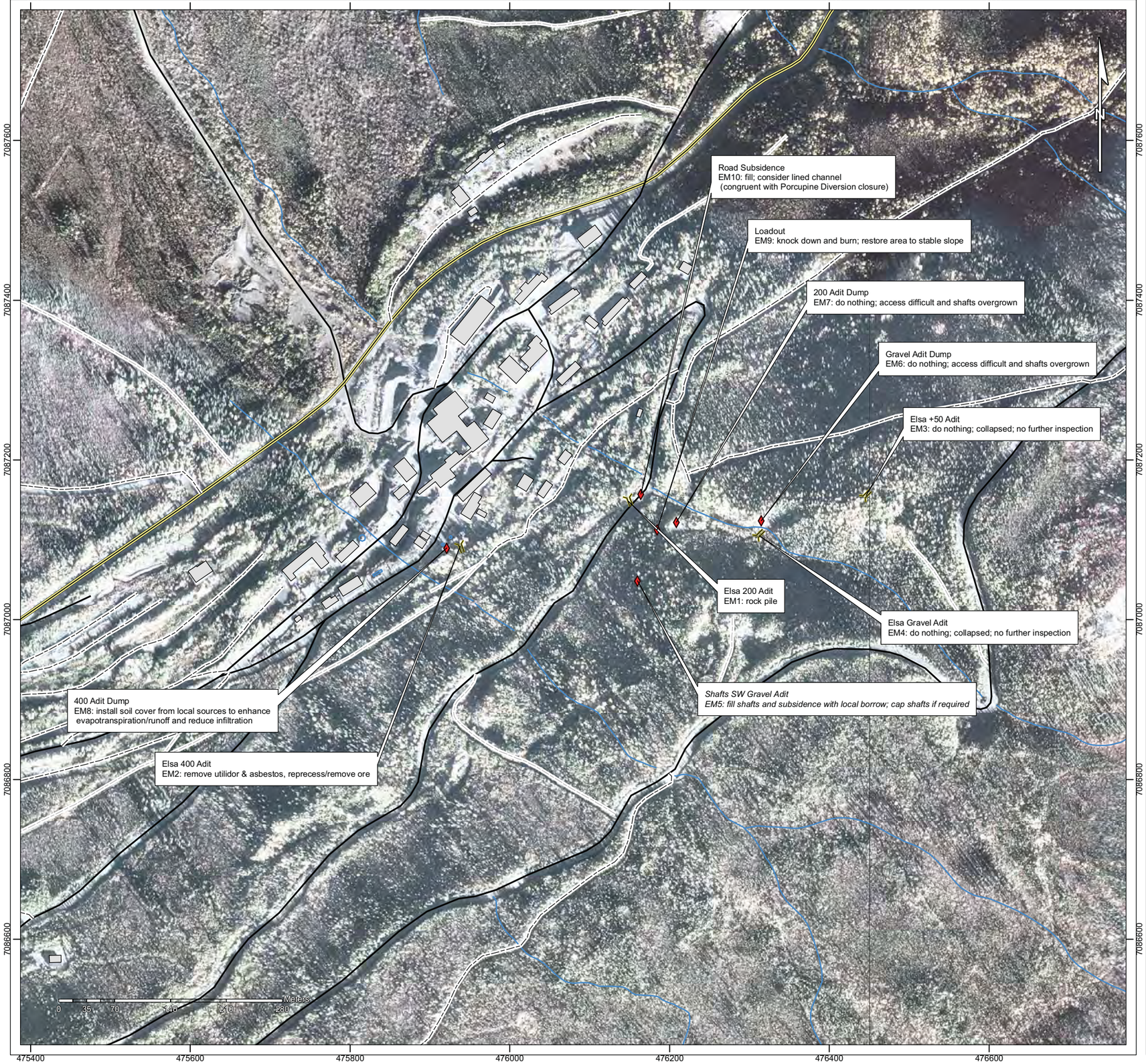
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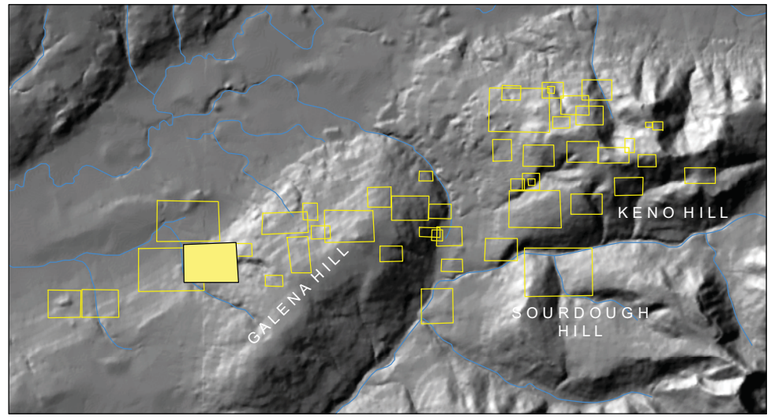
Table 6-11 Elsa Site Closure Issues and Options

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*	*E1*	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*	*E2*				confirmed collapse		*do nothing*	*adit is confirmed collapsed and inaccessible; no activity required*
200 Level Adit	*adit*	*E3*	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*	*E4*	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*	*E5*	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*	*E6*		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*	*E7*		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		*E8*		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*	*E9*	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*	*E10*	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

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Figure 6.6

Elsa

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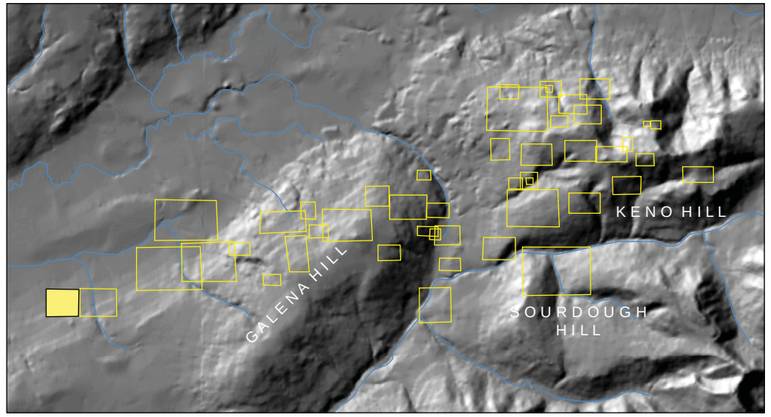
Table 6-12 Gerlitski Site Closure Issues and Options

Common Site Name: **Gerlitski**

Site coordinates:	easting	northing	*coordinates are projected to UTM zone 8 N, Nad 1983
	470681	7085697	

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		
Gerlitski									
Trenching	*trenching*								*do nothing*
Waste rock	*dump*		stressed vegetation below dump	heavy staining; stressed vegetation below dump					*cover with borrow and revegetate*





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

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Closure Options Report

Figure 6.7

Gerlitski

Drawn By: TL/JP

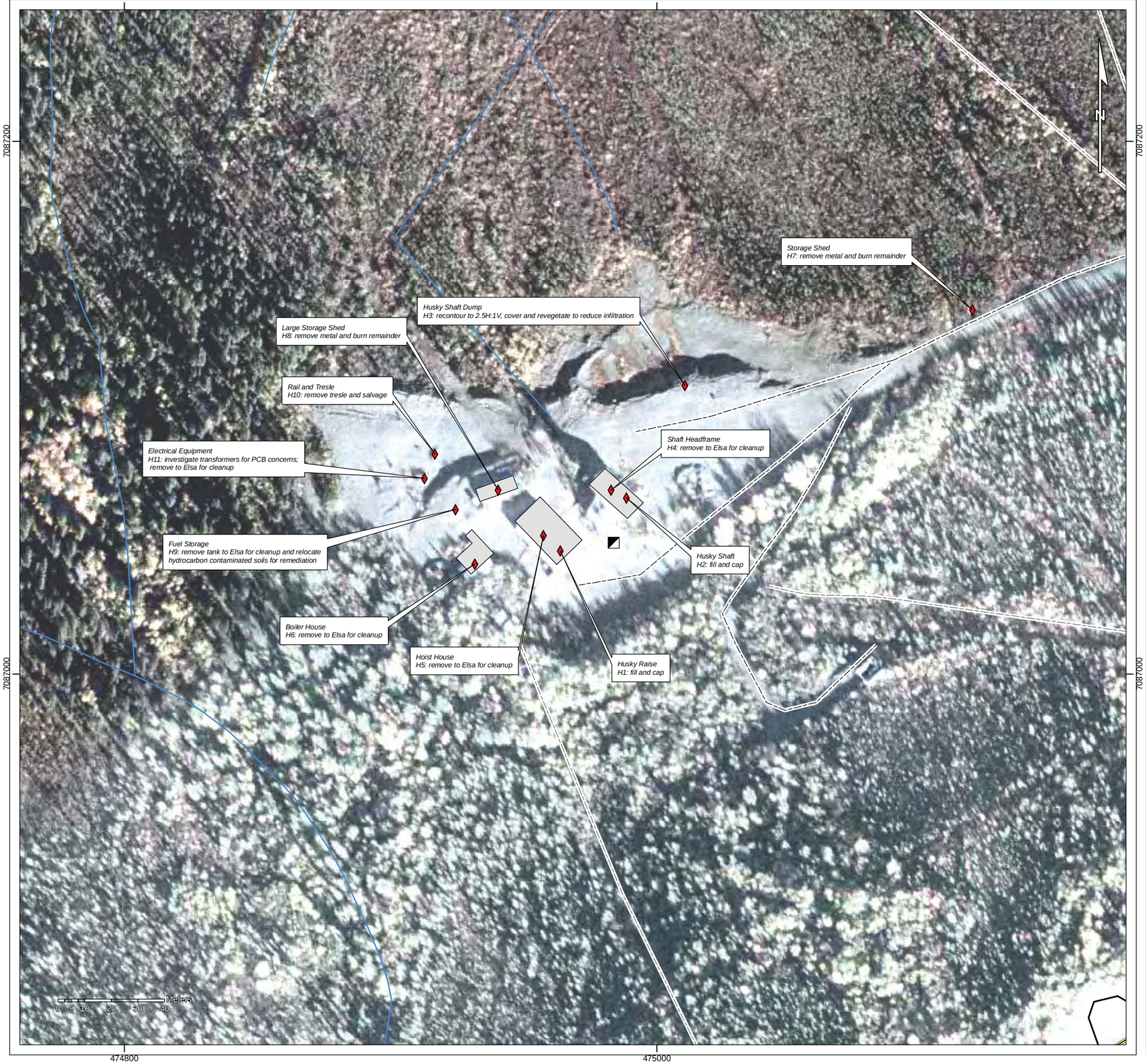
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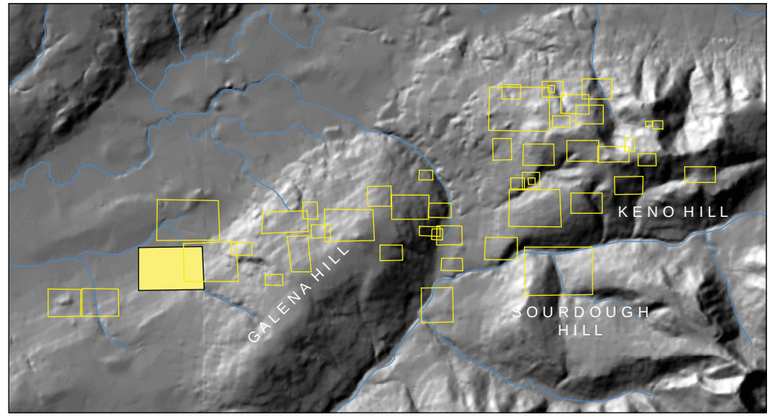
Table 6-13 Summary of Husky Site Closure Issues and Options

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 generating (SRK 2009)						
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 asbestos floor tiles)		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			





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 6.8

Husky

Drawn By: TL/JP

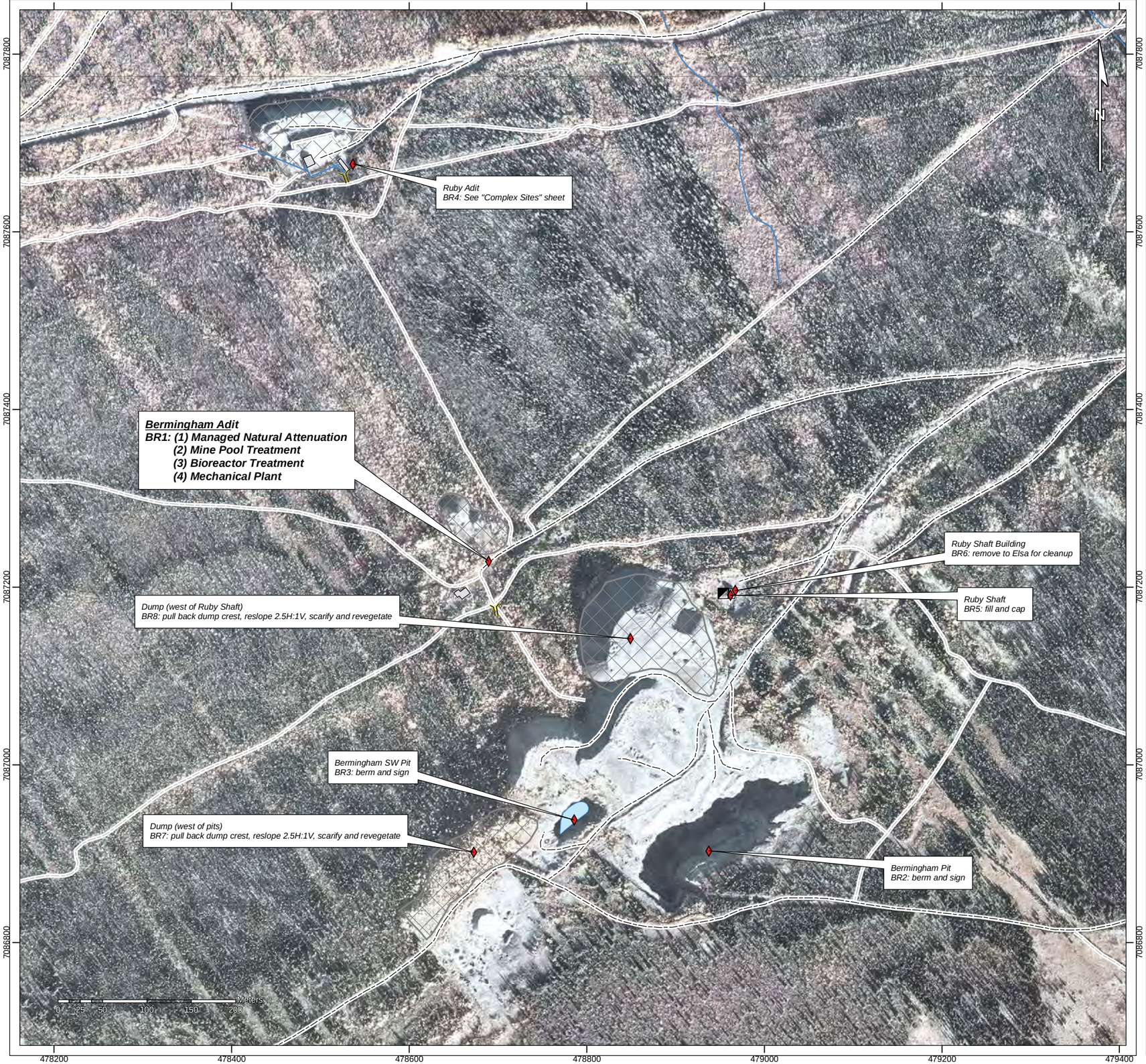
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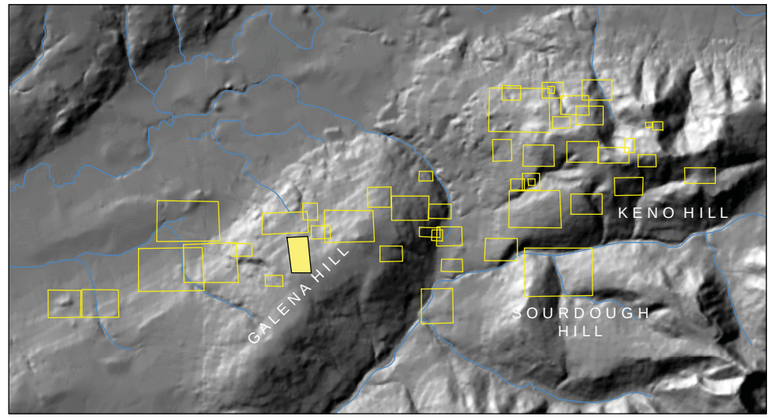
Table 6-14 Summary of Bermingham and Ruby Site Closure Issues and Options

Common Site Name: **Bermingham**

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

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*





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 6.9

Bermingham and Ruby

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Table 6-15 Summary of No Cash 500 Site Closure Issues and Options

Common Site Name: **No Cash 500**

Site coordinates:	easting	northing	
	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 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*

477600 477700 477800

7098600 7098500 7098400 7098300

N

No Cash 500 adit flowpath
NC500-2: work into dump closure

No Cash 500 adit dump
NC500-3: pull back dump crest from creek, reslope 2.5H:1V, cover and revegetate

No Cash 500 level adit
NC500-1: (1) Managed Natural Attenuation
(2) Mine Pool Treatment
(3) Bioreactor Treatment
(4) Mechanical Plant

Debris
NC500-9: remove debris to Elsa for cleanup

Loadout
NC500-4: knock down and burn

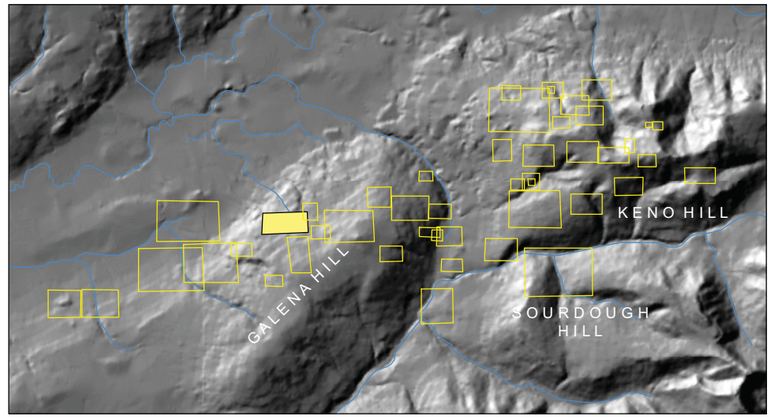
Garage
NC500-7: remove to Elsa for cleanup

Retaining wall
NC500-6: tear down and work into dump reslope and cleanup

Timber culvert
NC500-5: remove culvert and remediate channel

Stream crossing @ road
NC500-8: road upgrade and culvert construction

Meters
0 4 8 16 24 32



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 6.10

No Cash 500

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Table 6-16 Summary of Betty Site Closure Issues and Options

Common Site Name: **Betty**

Site coordinates:	easting	northing
	479024	7089089

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		
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*	
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*

479000

479200

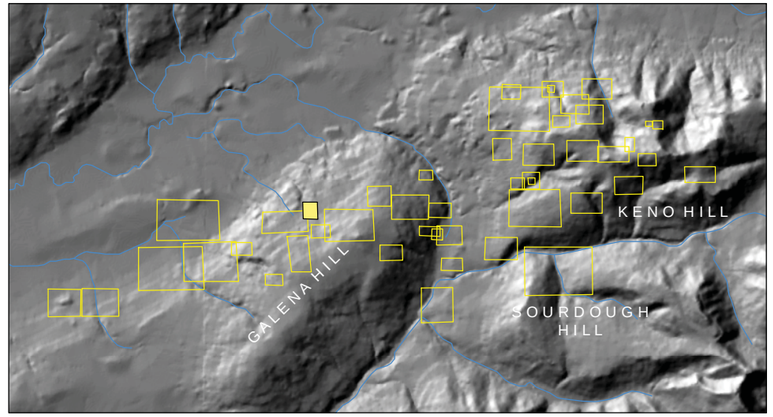
7088800

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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Figure 6.11

Betty

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Table 6-17 Summary of Dixie Site Closure Issues and Options

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

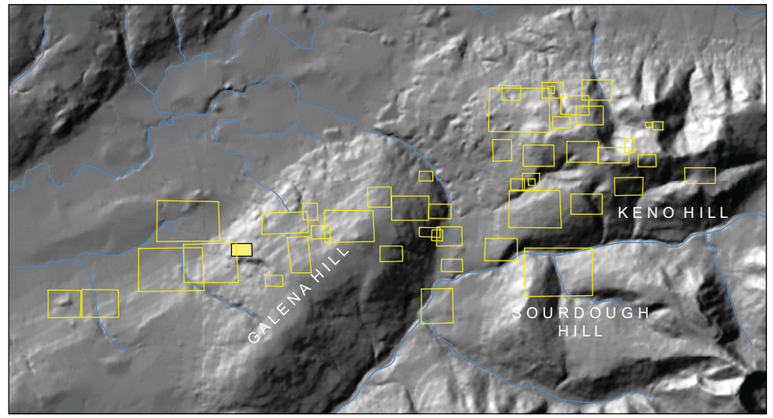
Dixie Shaft
D2: cap shaft

Dixie Adit
D1: rock pile

Vent Raises
D3: cap raises

Building
D8: remove to Elsa for cleanup

0 5 10 20 30 40 Meters



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 6.12

Dixie

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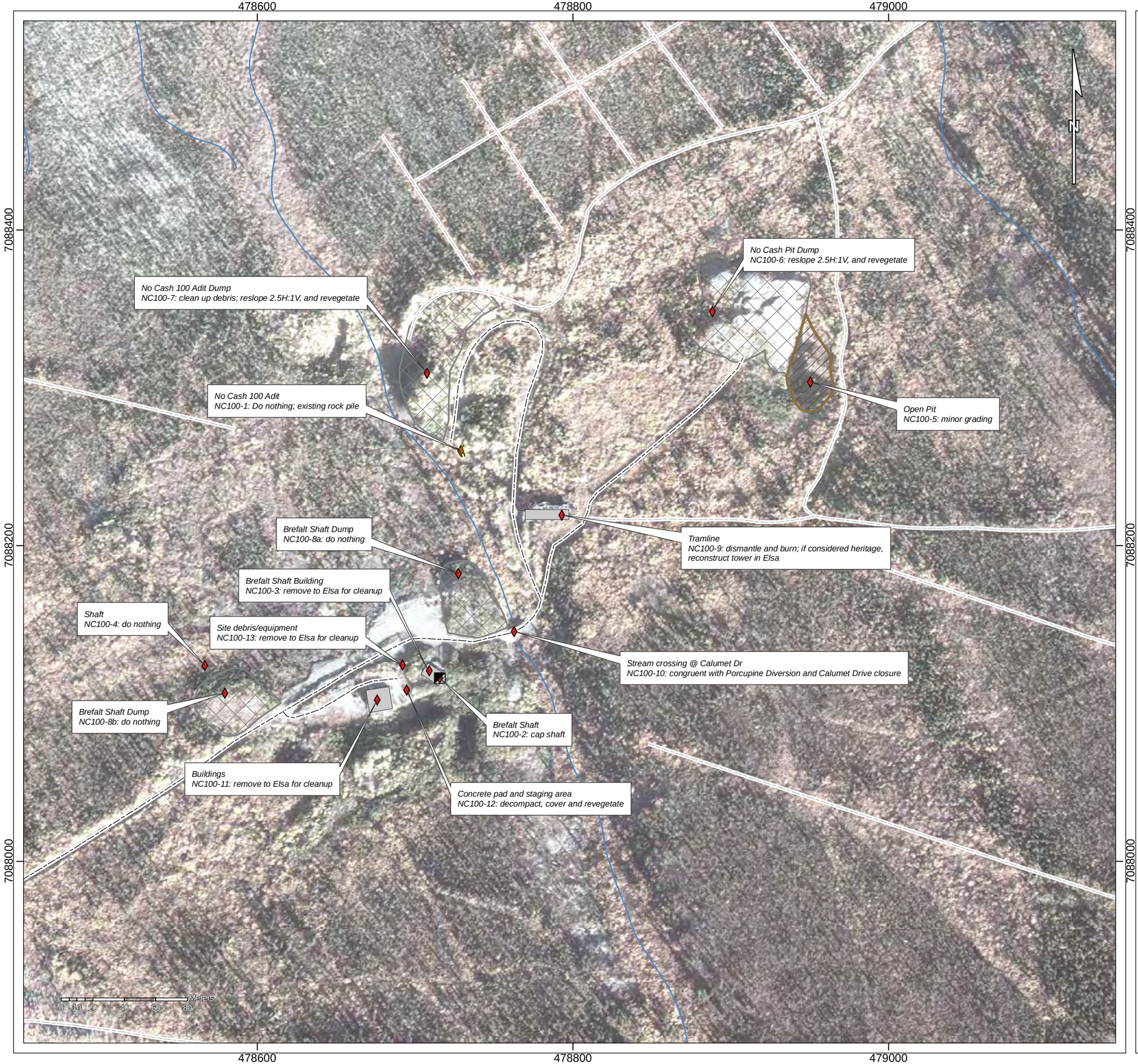
APRIL 2011

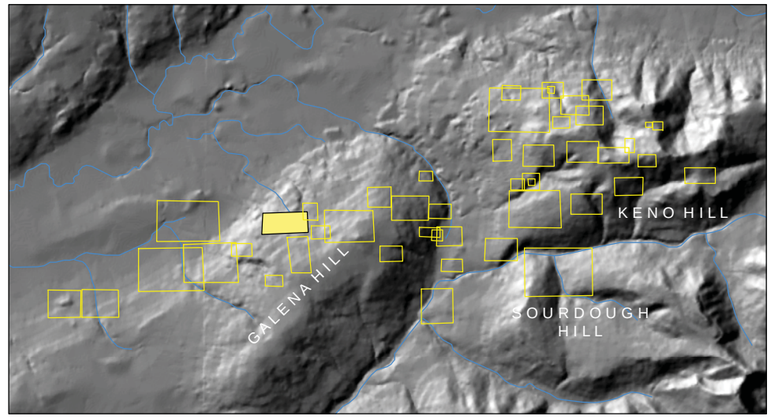
Table 6-18 Summary of No Cash 100 Site Closure Issues and Options

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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Figure 6.13

No Cash 100

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Table 6-19 Summary of Townsite Site Closure Issues and Options

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	portal structure collapsed, potential safety hazard		*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*		PAG (SRK 2009); vegetation kill zone below dump that is failing to regenerate		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	possible asbestos tiling		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

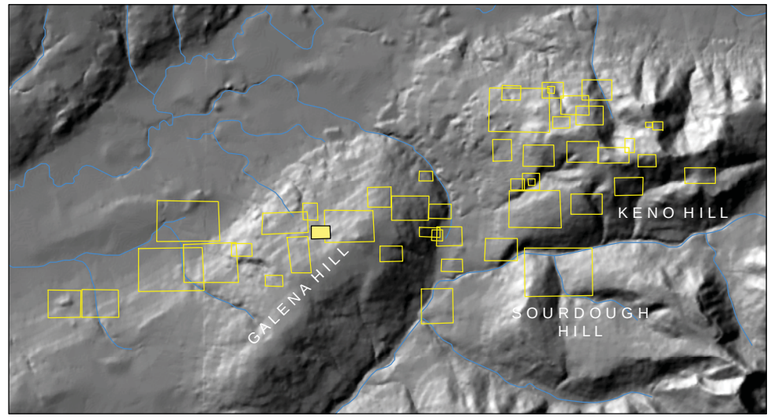
Building
TS5: demolish and remove to Elsa for cleanup

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 6.14

Townsite

Drawn By: TL/JP

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Table 6-20 Summary of Galkeno 300 Site Closure Issues and Options

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*	

482500 482600 482700 482800

7098400 7098600 7098800 7099000

Water Management
GK300-2: construct a pipeline from adit portal to Elsa along road to convey adit water to HDS facility

Galkeno 300 Old Pond
GK300-4a: move sludge to lower sime pit, work into Galkeno 300 adit dump closure

Galkeno 300 Adit Dump
GK300-3: reslope, cover with borrow material and revegetate

Buildings
GK300-6: dismantle and remove to Elsa for cleanup

Former Discharge Path
GK300-8: scarify and revegetate path

Clarifiers
GK300-5: move clarifiers to Galkeno 900 and Onek 400

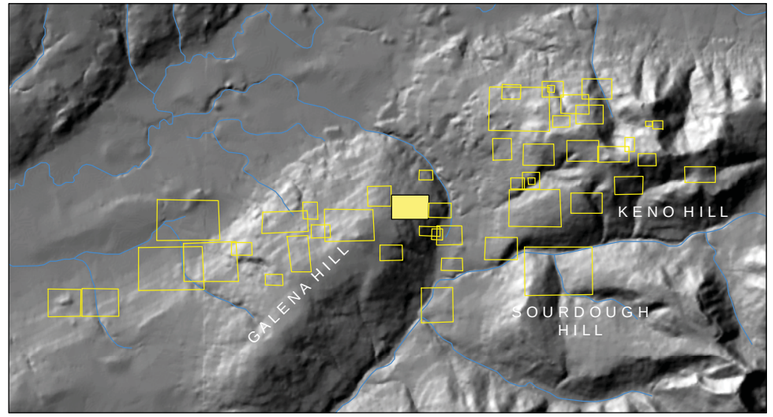
Debris
GK300-7: move debris to Elsa for cleanup

Galkeno 300 Adit
GK300-1: adit water will be piped to a centralized conentional HDS treatment facility at Elsa; adit portal will be sealed to prevent public access but allow access to site personnel

Galkeno 300 Settling Pond
GK300-4b: move sludge to lower sime pit, work into Galkeno 300 adit dump closure

N

0 5 10 20 30 40 Meters



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 6.15

Galkeno 300 Treatment Area

Drawn By: TL/JP

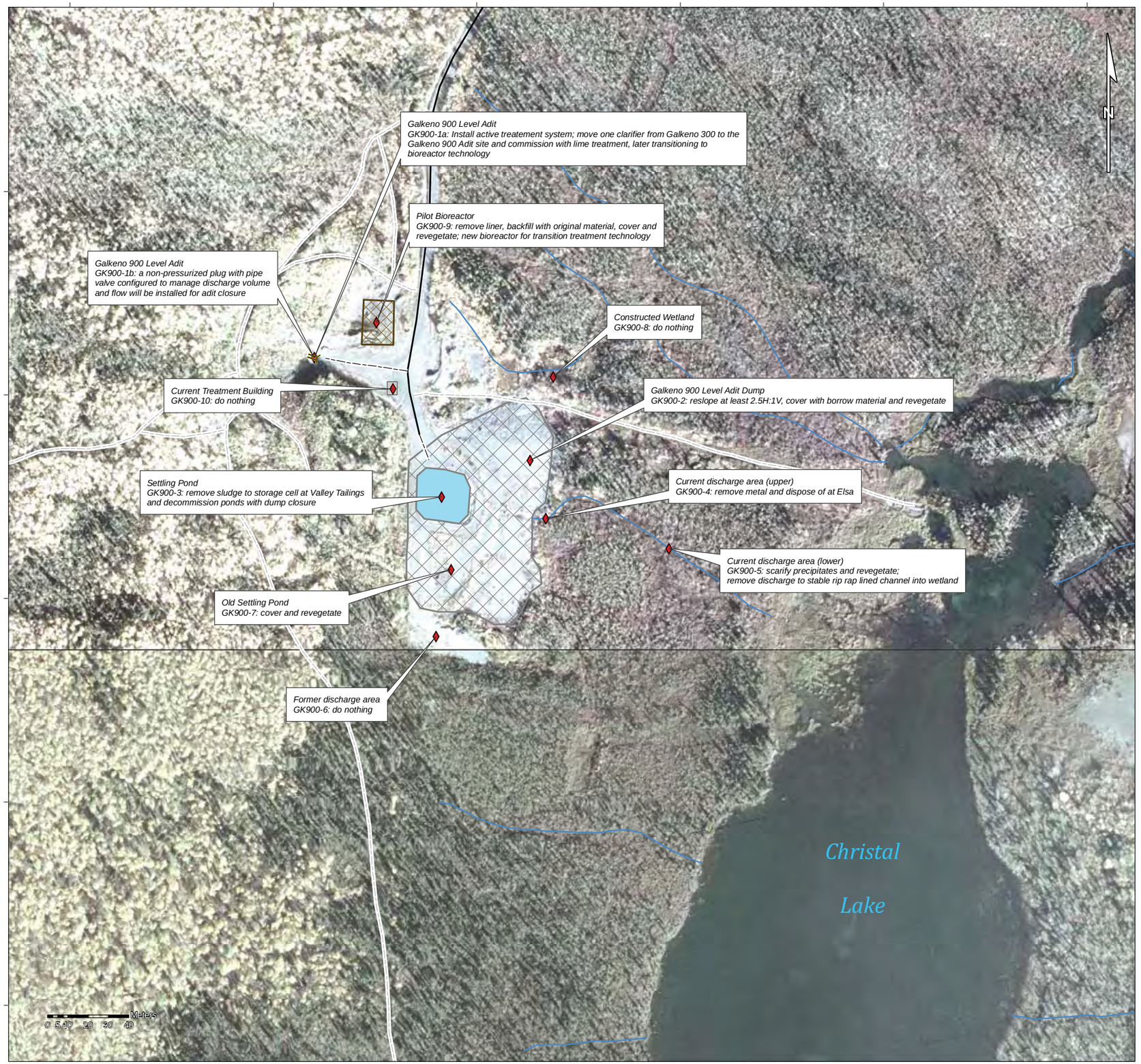
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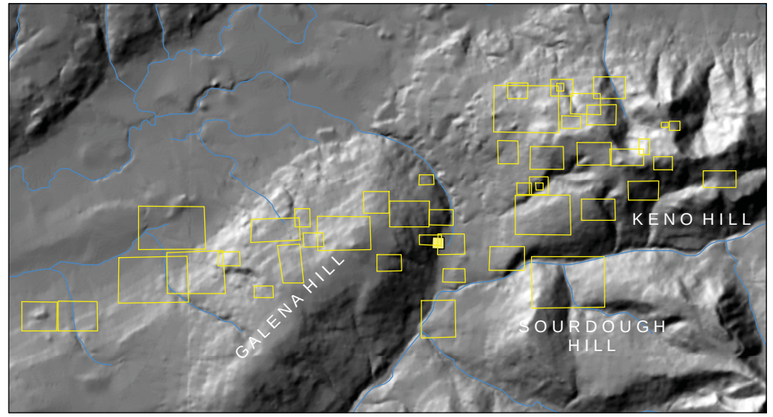
Table 6-21 Summary of Galkeno 900 Site Closure Issues and Options

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*





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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Figure 6.16

Galkeno 900 Treatment Area

Drawn By: TL/JP

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Table 6-22 Summary of Galkeno Site Closure Issues and Options

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, 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, revegetate*	*enhances physical stability; dump is not geochemical issue so cover not required*

482000

482500

7089000

7088500

N

200 Level Dump
GK14: pull back dump crest, reslope at least 2.5H:1V, cover with borrow material and revegetate

Galkeno 200 Adit
GK2: rock pile

Lower Sime Pit Dump
GK12: pull back dump crest, reslope at least 2.5H:1V, cover with borrow material and revegetate

Debris
GK15: site cleanup

Galkeno 100 Adit
GK1: rock pile

McLeod Shaft
GK7: fill and cap

Lower Sime Pit
GK6: consolidate Galkeno 300 sludge production, berm and sign

Sime #4 Pit Dump N
GK10: pull back dump crest, reslope at least 2.5H:1V, cover with borrow material and revegetate

Sime #6 Pit Dump NW
GK9: pull back dump crest, reslope at least 2.5H:1V, cover with borrow material and revegetate

Sime #6 Pit Dump NE
GK8: pull back dump crest, reslope at least 2.5H:1V, cover with borrow material and revegetate

Sinkhole @ Lower Sime Pit
GK16: fill

Upper Sime Pit
GK5: berm and sign

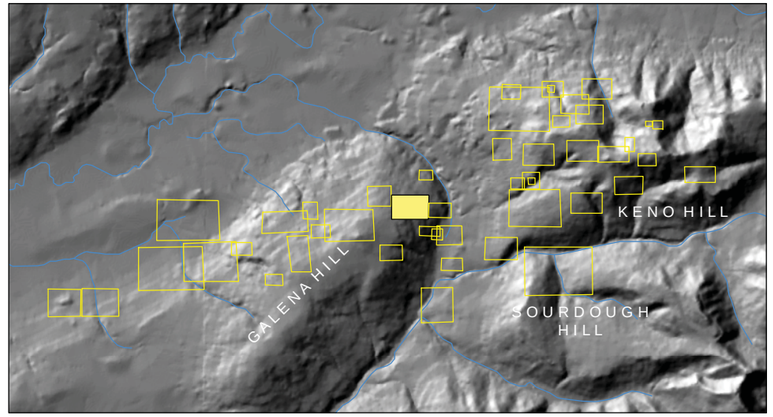
Upper Sime Pit Dump
GK13: pull back dump crest, reslope at least 2.5H:1V, cover with borrow material and revegetate

Sime #4 Pit Dump S
GK11: pull back dump crest, reslope at least 2.5H:1V, cover with borrow material and revegetate

Sime #6 Pit
GK3: berm and sign

Sime #4 Pit
GK4: berm and sign

0 25 50 100 150 200 Meters



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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Closure Options Report

Figure 6.17

Galkeno Site

Drawn By: TL/JP

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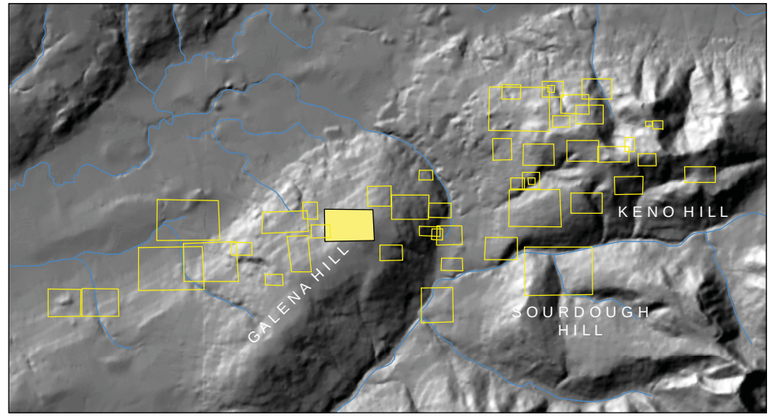
Table 6-23 Summary of Hector Calumet Site Closure Issues and Options

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			*See "Complex Sites" Sheet*	
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
7089000
7088500
7088000
7087500
N
0 25 50 100 150 200 Meters
Hector 400 Level Adit Dump
HC8: (1) Cover for Revegetation
(2) Cover for Reduced Infiltration and Source Control
(3) Reclaim With No Cover
Hector 400 Level Adit
HC1: consider for heritage
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 WRSA
HC10: pull back dump toe from road, reslope, cover with borrow material and revegetate; use some material as backfill for pits
Calumet 1-15 Pit
HC4: berm perimeter; fill pit bottom with dump borrow material
Calumet South Pit
HC5: berm perimeter
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



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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Keno Hill Silver District
Closure Options Report
Figure 6.18

Hector Calumet

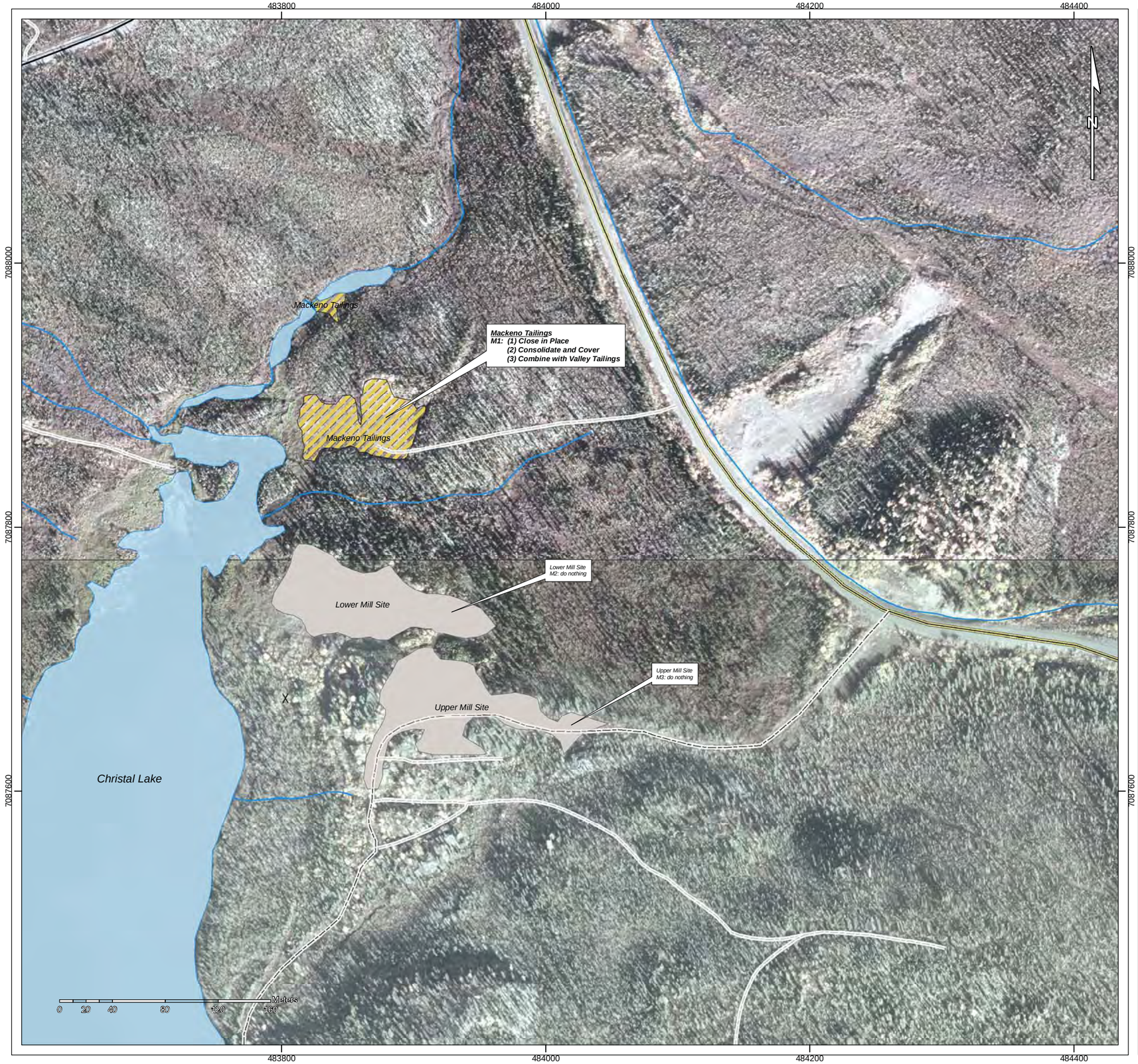
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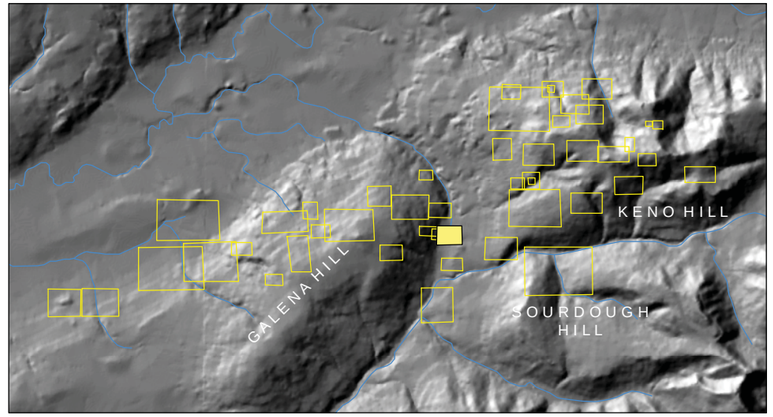
Table 6-24 Summary of Mackeno Site Closure Issues and Options

Common Site Name: **Mackeno Tailings**

Site coordinates:	easting	northing	*coordinates are UTM zone 8N NAD83
	479027	7089089	

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 6.19

Mackeno Tailings and Mill Site

Drawn By: TL/JP

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Table 6-25 Summary of Onek Site Closure Issues and Options

Common Site Name: **Onek**

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

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		
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.*
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*

Table 6-25 Summary of Onek Site Closure Issues and Options

Common Site Name: **Onek**

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

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		
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*

485000 485100 485200 485300 485400

7087500 7087400 7087300 7087200 7087100

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

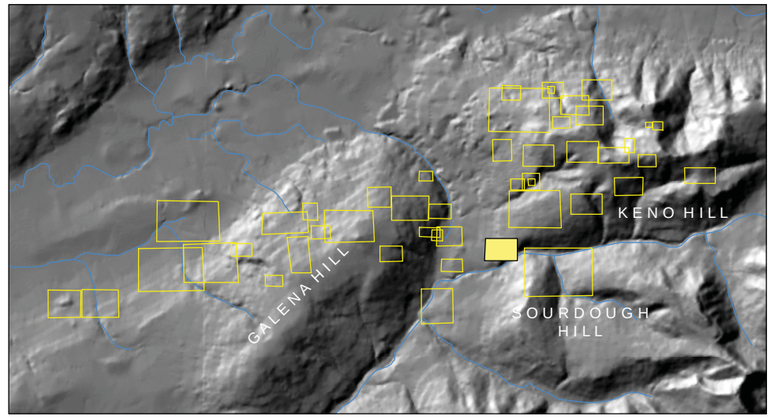
Building
O8: dismantle and remove to Elsa

Debris
O9: remove with site cleanup

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

N

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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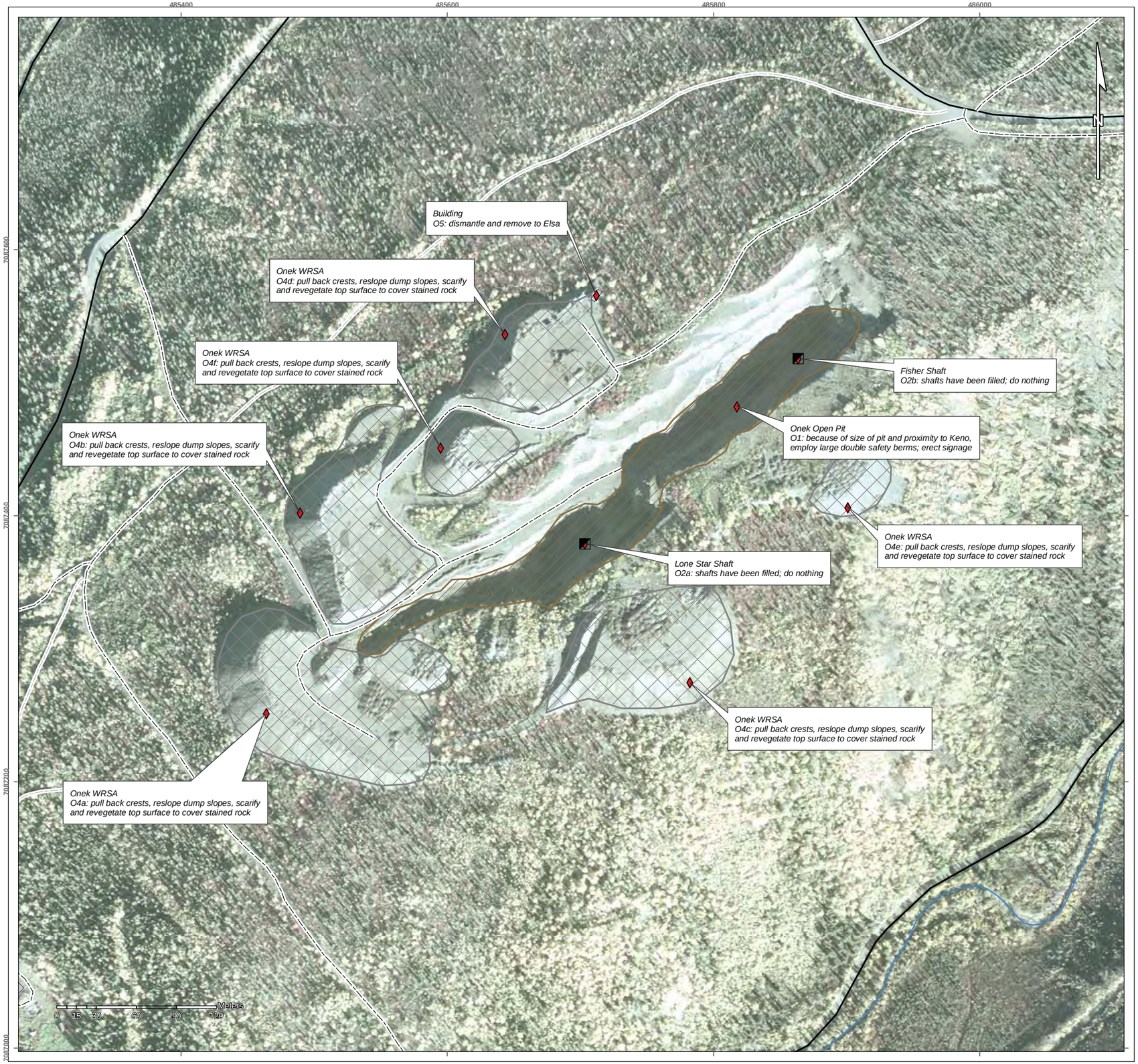
Keno Hill Silver District
Closure Options Report

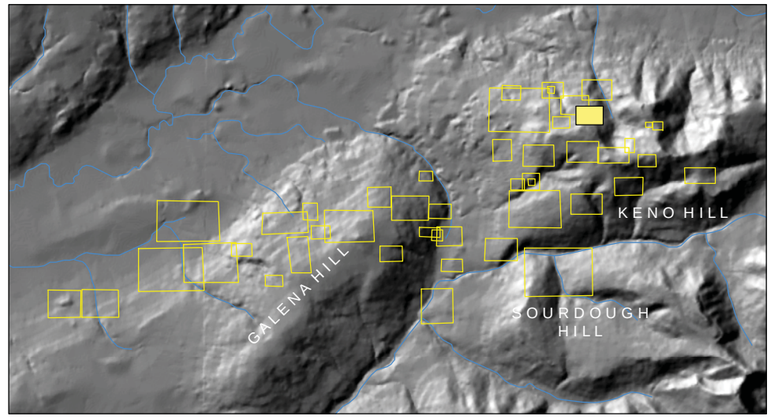
Figure 6.20

Onek 400 Adit Area

Drawn By: TL/JP

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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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Figure 6.21

Onek Waste Rock Area

Drawn By: TL/JP

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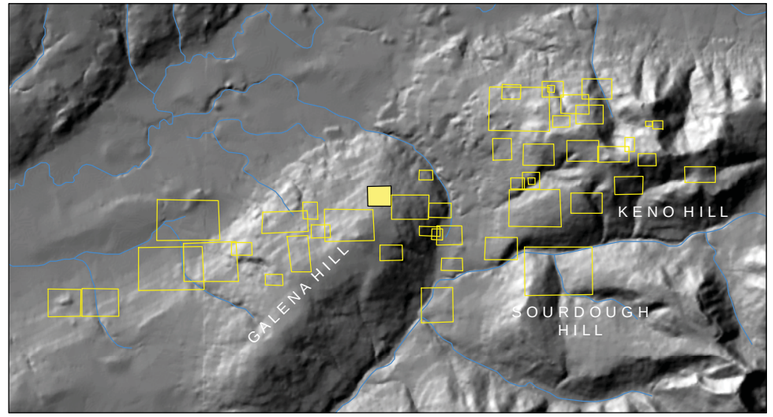
Table 6-26 Summary of Dragon (UN) and Miller Sites Closure Issues and Options

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

	easting	northing	
Site coordinates:	481500	7088800	*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		
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

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 6.22

Dragon (UN) and Miller

Drawn By: TL/JP

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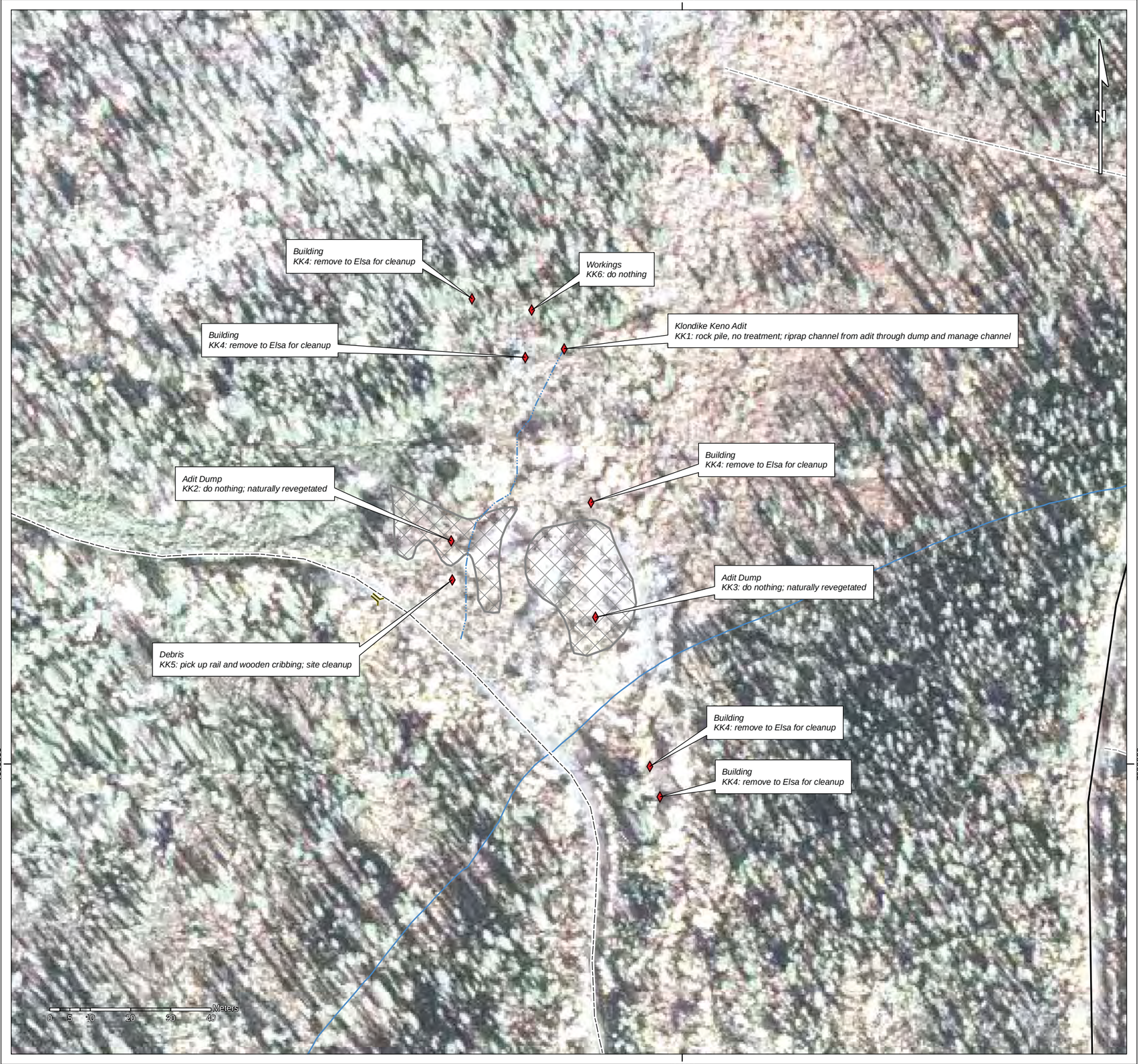
Table 6-27 Summary of Klondike Keno Site Closure Issues and Options

Common Site Name: **Klondike Keno**

Site coordinates:	easting	northing
	485597	7090841

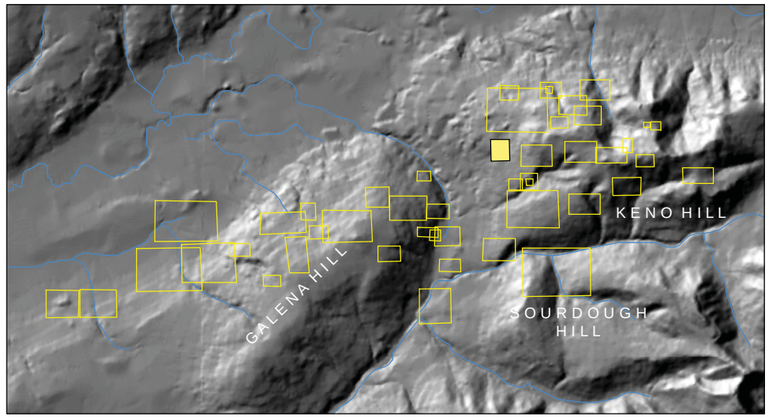
General Location Description	Component Type	Closure Activity No.	Closure Issue Categories					Proposed Measure	Closure Rationale
			Human & Wildlife Health and Safety	Chemical Control	Water Management	Physical Stability	Community Interest		
Klondike Keno Adit	*adit*	*KK1*	debris near adit portal; adit 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 6.23

Klondike Keno

Drawn By: TL/JP

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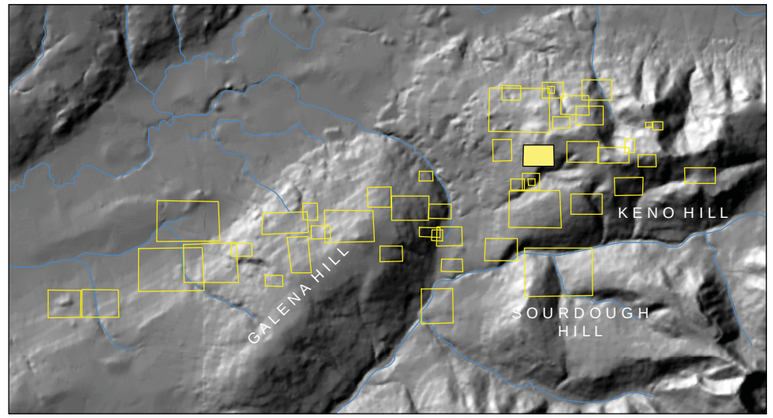
Table 6-28 Summary of Lucky Queen and Black Cap Adits Site Closure Issues and Options

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

	easting	northing
Site coordinates:	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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Closure Options Report

Figure 6.24

Lucky Queen and Black Cap Adits Area

Drawn By: TL/JP

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Table 6-29 Summary of Shamrock Site Closure Issues and Options

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*

488200 488400 488600 488800 489000

7091000 7090800 7090600 7090400 7090200

Power pole cribs
SR6: remove and burn; possibly save for heritage

Access Road
SR5: partially scarify road and maintain as trail for heritage access

Shamrock Shaft
SR1: do nothing; remediation with pit closure

Shamrock J-18 workings
SJ2: do nothing

Original Shamrock Open Pit
SR2: fill

Shamrock "K" Open Pit
SR3: fill

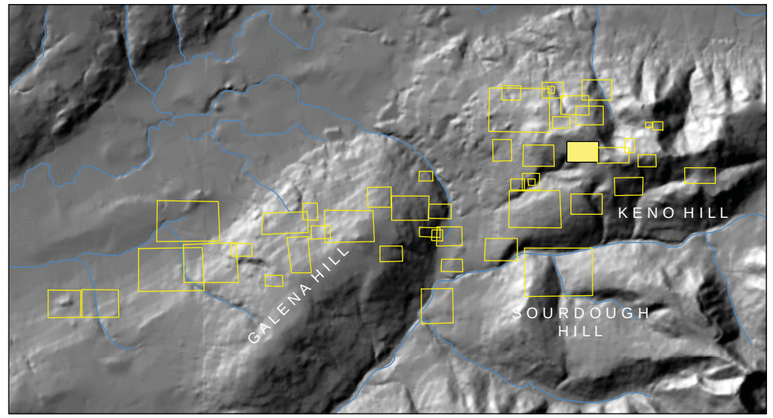
Building over raise
SJ3: dismantle and remove to Elsa for cleanup

Shamrock "J" Raise
SJ1: fill and cap as required

Shamrock WRSAs
SR4: use as borrow material for open pits

N

0 25 50 100 150 200 Meters



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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Figure 6.25

Shamrock

Drawn By: TL/JP

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Table 6-30 Summary of Other Christal Creek Watershed Sites Closure Issues and Options

Common Site Name: **Christal Creek Watershed - Other Sites**

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		
Bluebird [1]									
Site coordinates:	easting 483031	northing 7089792	*coordinates are UTM zone 8N NAD83						
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*
Christal (Dorothy)									
Shaft #1	*shaft*								
Shaft #2	*shaft*								
Cabin	*infrastructure*								
Croesus No. 1									
Shafts	*shaft*					reported to be filled; not located in August 2009 site visit			*do nothing*
Trenching	*trenching*			minor veining observed in trench					*do nothing*
Eagle									
Cannot Locate Information Files/Did not visit August 2008									
Kijo									
Trenching	*trenching*								*do nothing*
Waste material from trench	*dump*			minor staining on clasts					*do nothing*
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*	
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*

1. Was not located during ACG August 2009 site visit

483000

483200

7090600

7089800

N

Log Cabin
BB5: remove asbestos; do nothing

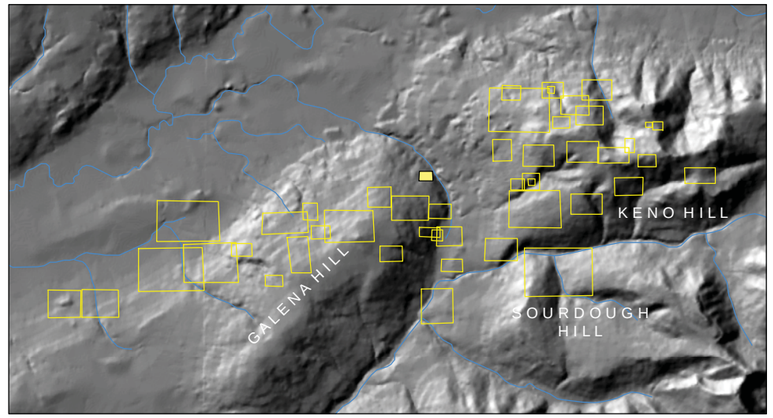
Bluebird Shaft #4
BB4: shafts are shallow and densely overgrown; do nothing

Bluebird Shaft #3
BB3: shafts are shallow and densely overgrown; do nothing

Bluebird Shaft #2
BB2: shafts are shallow and densely overgrown; do nothing

Bluebird Shaft #1
BB1: shafts are shallow and densely overgrown; do nothing

Meters
0 5 10 20 30 40



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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Keno Hill Silver District
Closure Options Report

Figure 6.26

Bluebird

Drawn By: TL/JP

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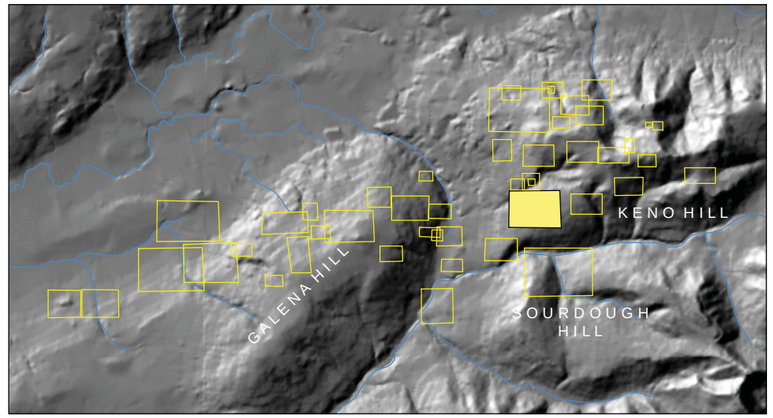
485800 486000 486200 486400 486600 486800 487000 487200 487400 487600 487800

7089600 7089400 7089200 7089000 7088800 7088600 7088400 7088200 7088000 7087800

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

N

Meters
0 40 80 160 240 320



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

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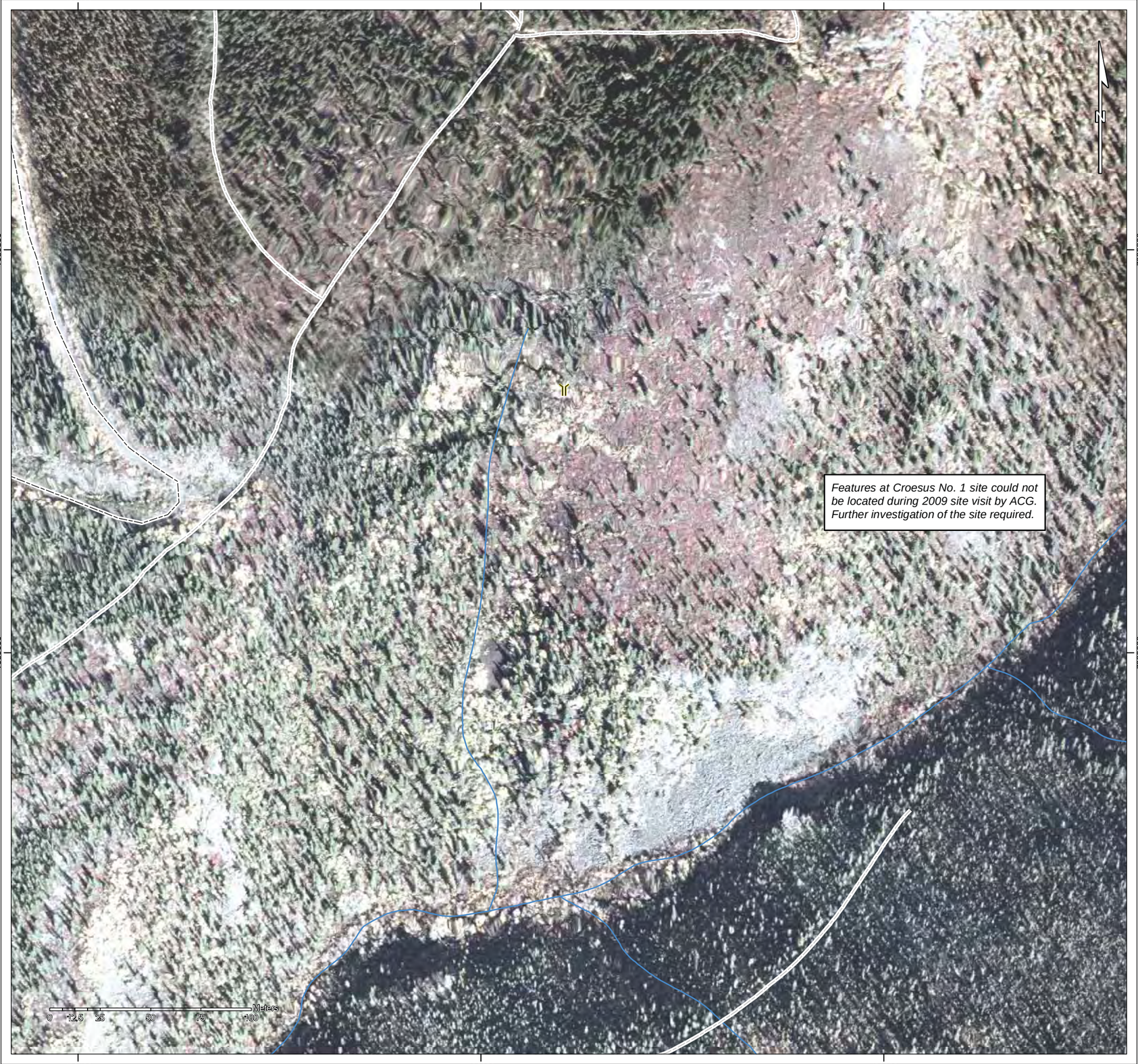
Keno Hill Silver District
Closure Options Report

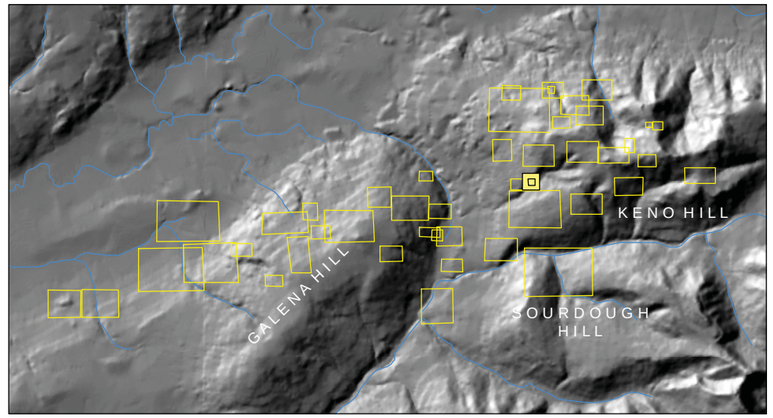
Figure 6.27

Christal (Dorothy)

Drawn By: TL/JP

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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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Figure 6.28

Croesus No. 1

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481600 481800 482000 482200

7087400 7087200 7087000

N

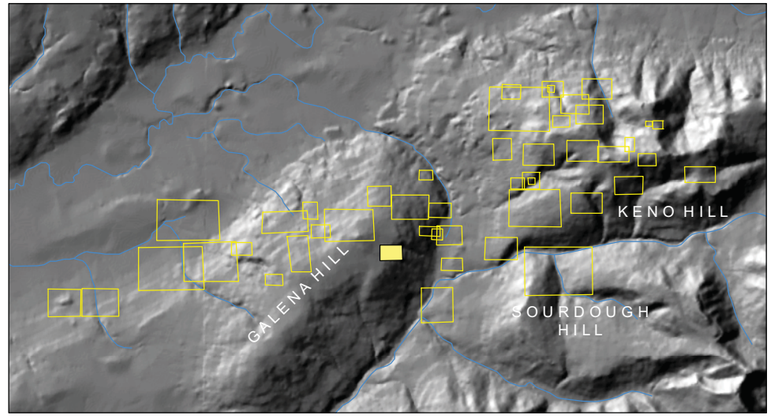
Cabin
Eagle4: remove to Elsa for cleanup

Main Trench
Eagle2: do nothing

Shaft
Eagle1: fill with trench material

Waste Rock
Eagle3: do nothing

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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Closure Options Report

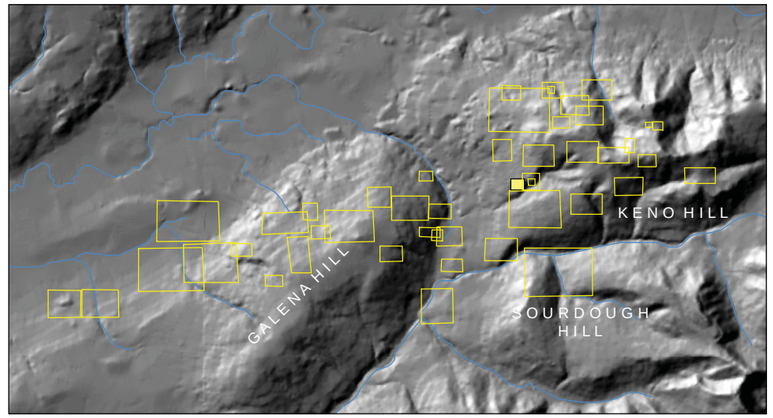
Figure 6.29

Eagle

Drawn By: TL/JP

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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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Closure Options Report

Figure 6.30

Kijo

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483200

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N

Waste Rock Pile #2
Rico4 : do nothing; completely overgrown

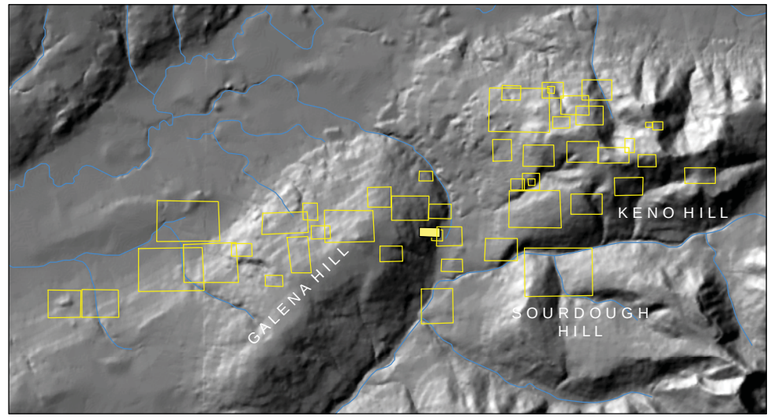
Rico Shaft
Rico2: do nothing; access is extremely difficult without disturbing the surrounding vegetation

Waste Rock Pile #1
Rico3: do nothing; completely overgrown

Rico Adit
Rico1: do nothing; adit is collapsed and densely overgrown

Log Cabin
Rico5: remove cabin debris to Elsa for cleanup

0 5 10 20 30 40 Meters



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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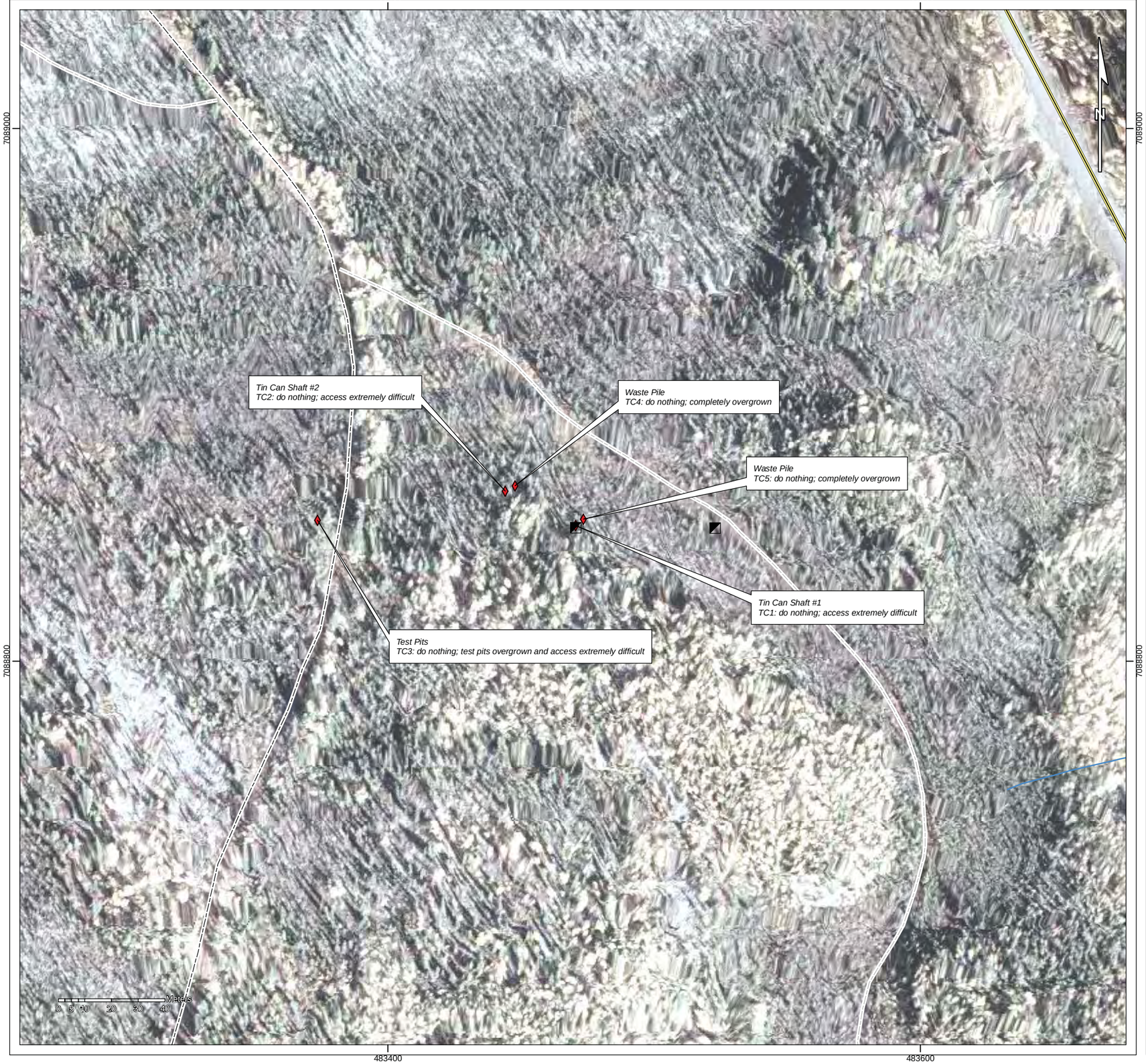
Keno Hill Silver District
Closure Options Report

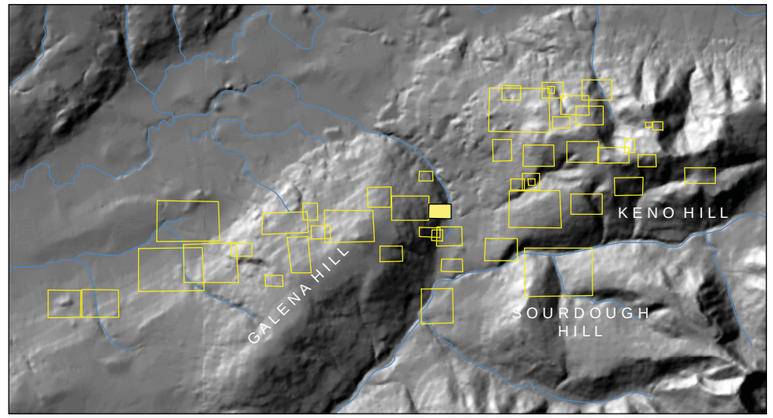
Figure 6.31

Rico

Drawn By: TL/JP

APRIL 2011





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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Closure Options Report

Figure 6.32

Tin Can

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Table 6-31 Summary of Keno 700 Site Closure Issues and Options

Common Site Name: **Keno 700**

Site coordinates:	easting	northing
	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*	

489800 489900 490000 490100 490200

7089800 7089700 7089600 7089500 7089400 7089300

N

Keno 700 Adit
K700-1: install a passive bioreactor treatment cell to reduce zinc concentrations with a mobile lime treatment facility as contingency; the adit will be rehabilitated as necessary and an adit plug with pipe valve installed to manage flows

Keno 700 Adit Dump
K700-2: 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

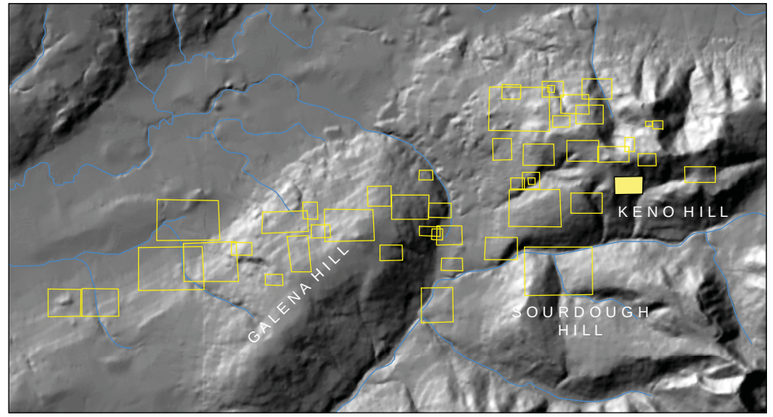
Structures
K700-6: structures were removed in 2009

Water Management
K700-3: construct an upgraded (for long term use) riprap-lined channel to divert adit drainage away from waste rock

Debris
K700-5: remove from site to Elsa for cleanup

Access Road
K700-4: maintain access for adit water treatment

0 12.5 25 50 75 100 Meters



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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Keno Hill Silver District
Closure Options Report

Figure 6.33

Keno 700

Drawn By: TL/JP APRIL 2011

Table 6-32 Summary of 5-2 Site Closure Issues and Options

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

489200

489400

7090200

7090200

N

No. 4 Lower Adit
5-2_2: do nothing

5-2 Adit
5-2_1: existing rock pile; do nothing

Unknown Shaft near 5-2
5-2_3: fill shaft and cap if required

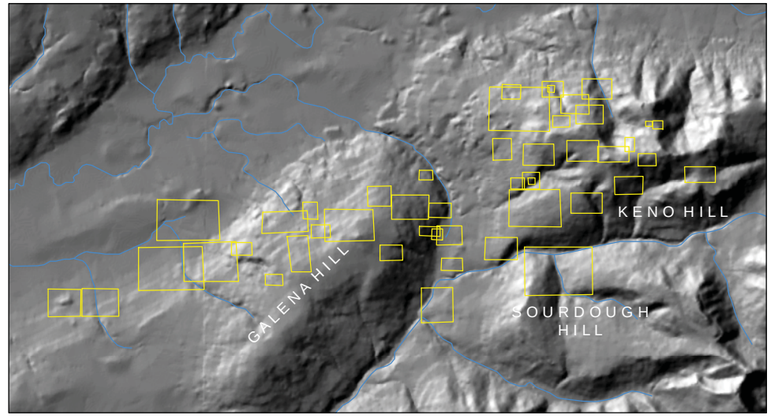
Building over Unknown Shaft
5-2_5: knock down and burn, debris to Elsa dump

Trench near 5-2 Adit
5-2_4: do nothing

0 5 10 20 30 40 Meters

489200

489400



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 6.34

5-2 Adit Area

Drawn By: TL/JP

APRIL 2011

Table 6-33 Summary of Keno 200 Site Closure Issues and Options

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

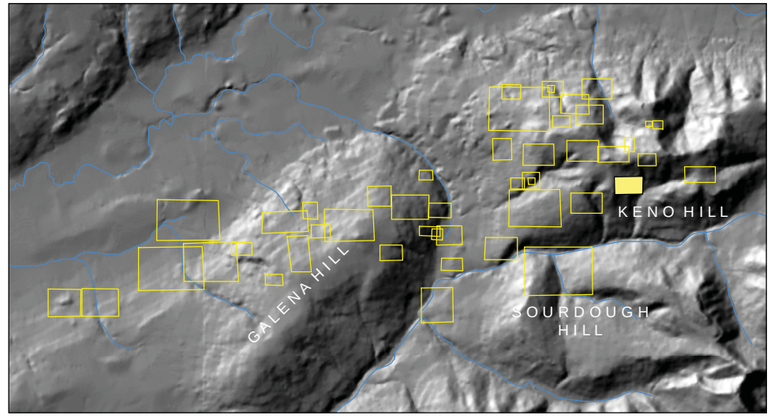
Porcupine Loadout
K200_9: remove and burn wood; reslope as required

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

Meters
0 15 30 60 90 120



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 6.35

Keno 200

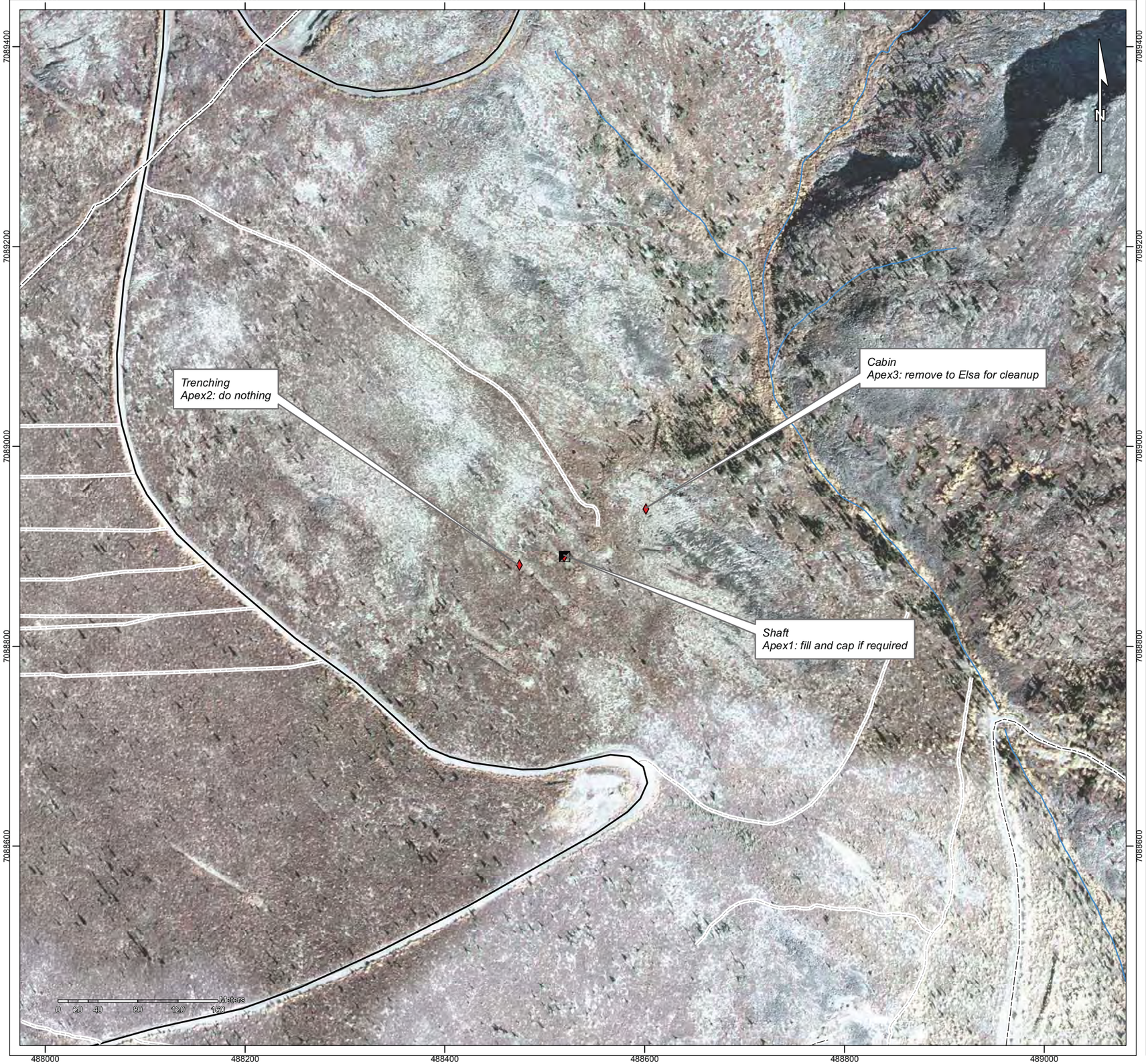
Drawn By: TL/JP

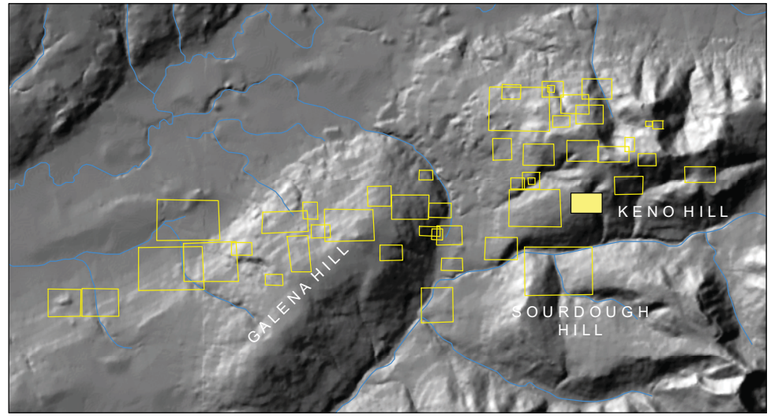
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Table 6-34 Summary of Other Lightning Creek Watershed Sites Closure Issues and Options

Common Site Name: **Lightning Creek Watershed - Other Sites**

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		
Apex										
Shaft	*shaft*		open for 2m			timber shaft supports are rotten			*fill and cap if required*	
Trenching	*trenching*									
Cabin	*infrastructure*								*remove to Elsa for cleanup*	
Divide										
Trenching	*trenching*				trenches free-drain	solifluction in most trenches			*do nothing*	
Oil Barrel	*misc.*			50% full of hydraulic oil					*remove to Elsa for cleanup*	
Building	*infrastructure*					collapsed			*remove to Elsa for cleanup*	
Duncan Creek										
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*
Gold Hill No.2										
Trenching	*trenching*	*GH1*								
Waste Rock	*dump*	*GH2*								
Site Debris	*misc.*	*GH3*								





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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Closure Options Report

Figure 6.36

Apex

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492200 492400 492600

7090200 7090000 7089800

N

Collapsed Building
DV2: do nothing

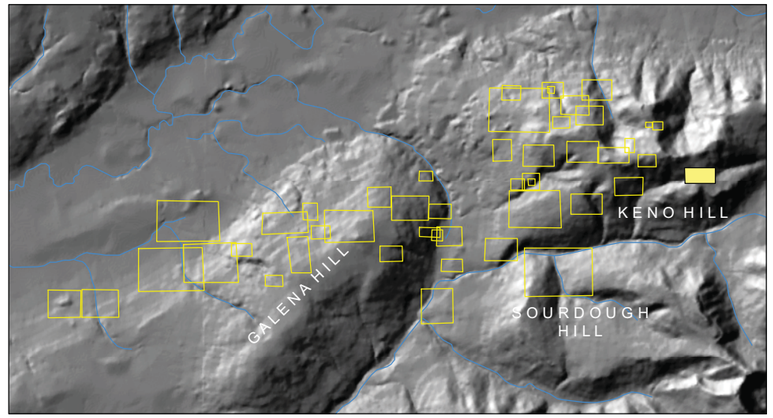
Trenching A
DV1a: do nothing

Trenching B
DV1b: do nothing

Meters
0 15 30 60 90 120

492200 492400 492600

7090200 7090000 7089800



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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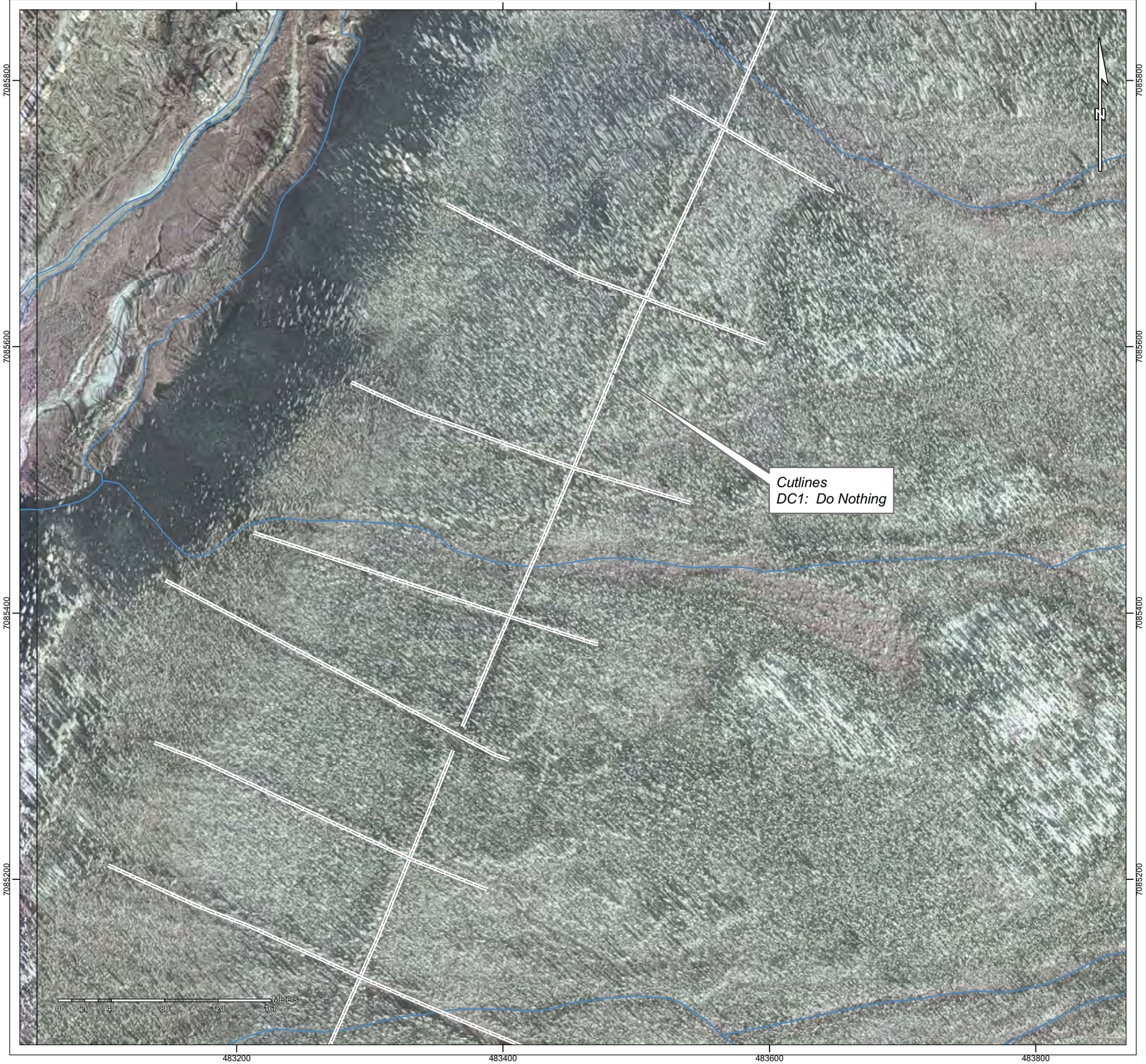
Keno Hill Silver District
Closure Options Report

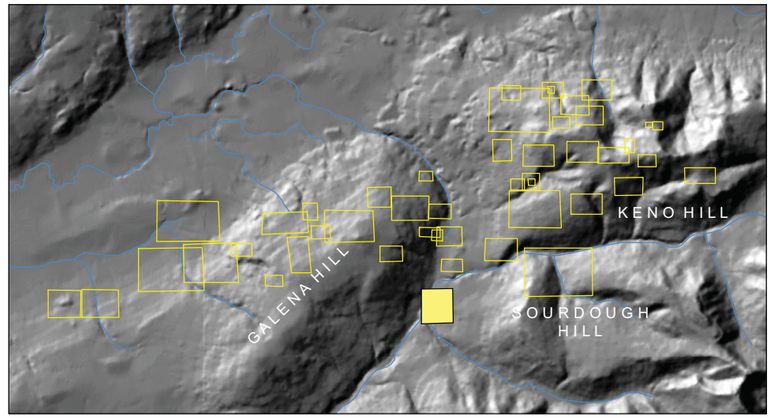
Figure 6.37

Divide

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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 6.38

Duncan Creek

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490400 490600 490800

7090600 7090400 7090200

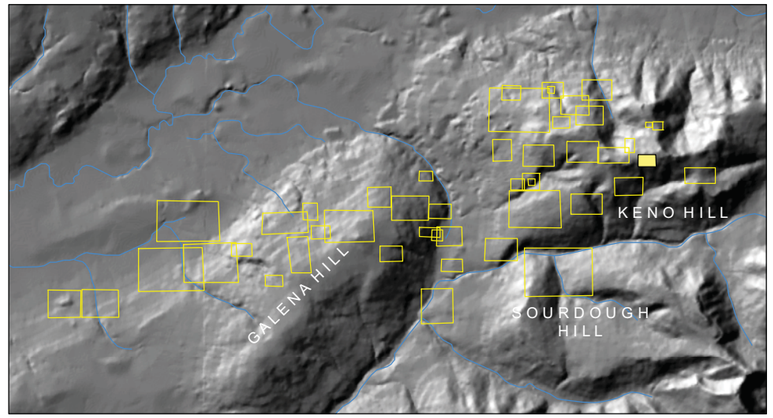
Discovery Shaft
GH2-1: fill if deemed to be a safety concern; otherwise do nothing

Trench
GH2-2: do nothing

Geotextile Fabric
GH2-3: remove to Elsa for cleanup

N

0 12.5 25 50 75 100 Meters



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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Closure Options Report

Figure 6.39

Gold Hill No. 2

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Table 6-35 Summary of Sadie Ladue 600 Site Closure Issues and Options

Common Site Name: **Sadie Ladue**

Site coordinates:	easting	northing
	486400	7092000

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		
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*

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

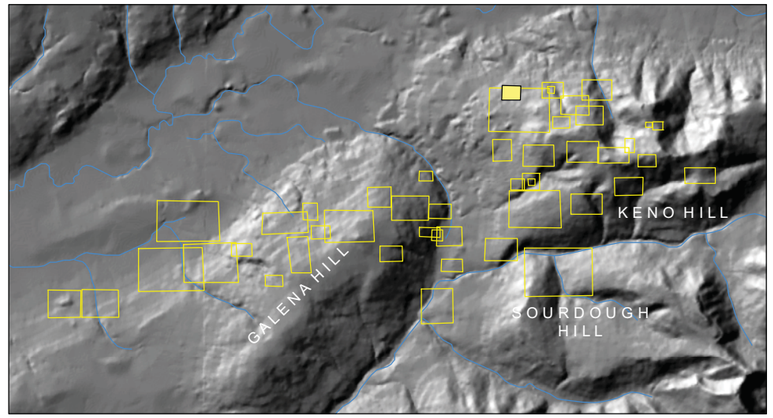
Debris
SL7: consolidate and bury in dump

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

Wenecke 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

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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Closure Options Report

Figure 6.40

Sadie Ladue 600

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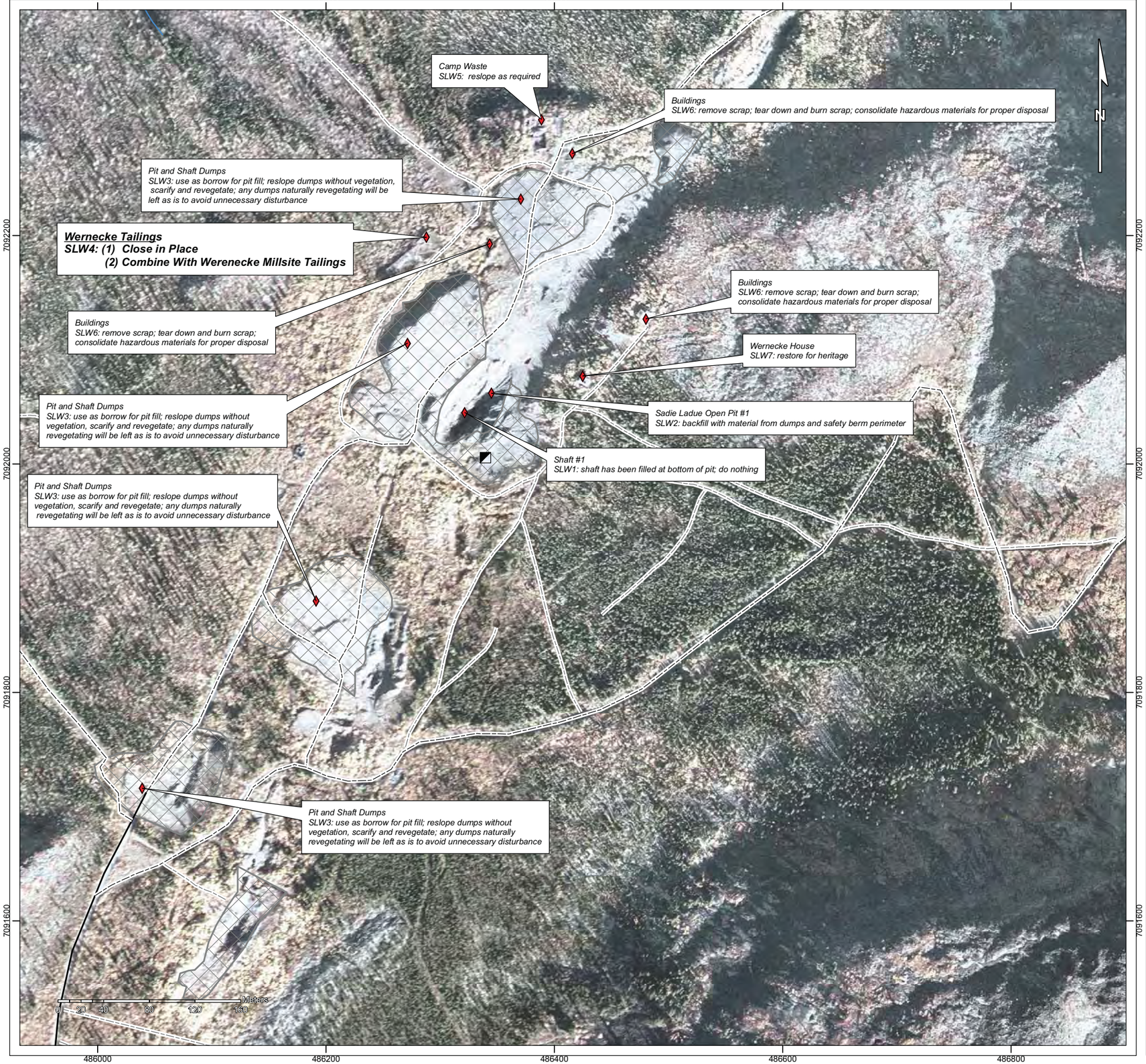
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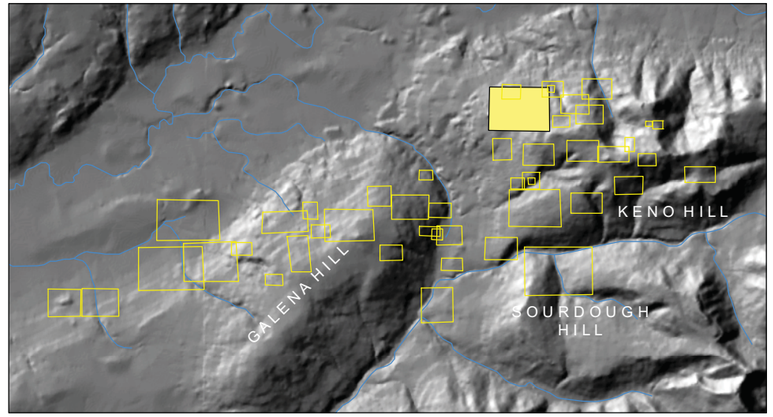
Table 6-36 Summary of Sadie Ladue/Wernecke Sites Closure Issues and Options

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
- 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 6.41

Sadie Ladue/Wernecke

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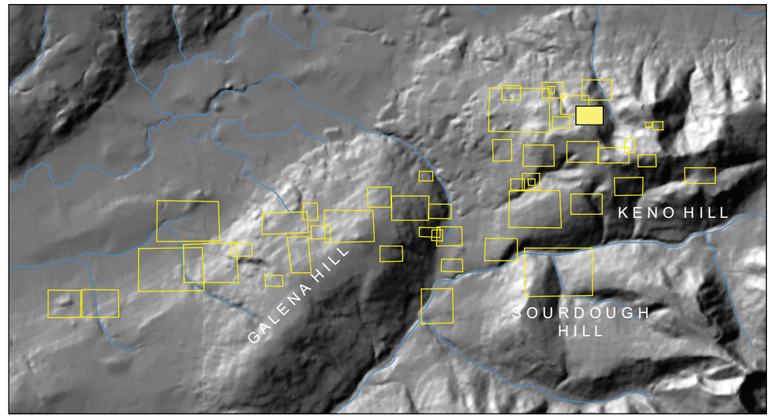
Table 6-37 Summary of Cub and Bunny Site Closure Issues and Options

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*	





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 6.42

Cub and Bunny

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Table 6-38 Summary of Highlander Site Closure Issues and Options

Common Site Name: **Highlander**

Site coordinates:	easting	northing
	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

487800

488000

7092400

7092200

N

Highlander Adit (north)
HL2: Rock pile at adit if workings still accessible

Adit Dump North
HL3: do nothing; access for remediation will disturb surrounding vegetation

Log Cabin
HL6: Possibly retain for heritage, pending heritage assessment

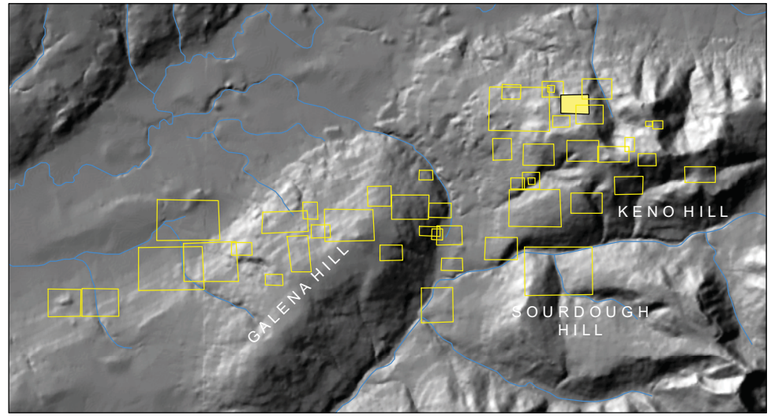
Ore Precessing Building
HL5: Possibly retain for heritage, pending heritage assessment

Bunkhouse
HL7: Possibly retain for heritage, pending heritage assessment

Highlander Adit (east)
HL1: Rock pile at adit if workings still accessible

Adit Dump South
HL4: do nothing; access for remediation will disturb surrounding vegetation

0 10 20 40 60 80 Meters



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 6.43

Highlander

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Table 6-39 Summary of Keno No. 9 Site Closure Issues and Options

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

N

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

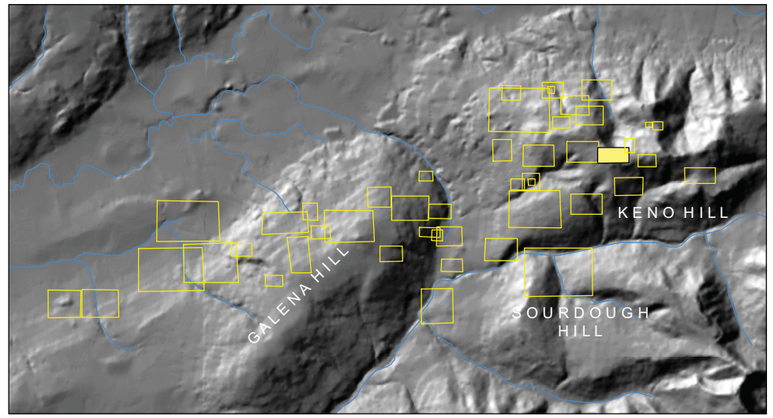
Wernecke Monument
K9S12: maintain for heritage

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

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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Closure Options Report
Figure 6.44

Keno No. 9

Drawn By: TL/JP APRIL 2011

Table 6-40 Summary of Lucky Queen Shaft Area Closure Issues and Options

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*	

487400 487500 487600 487700 487800

7091900 7091800 7091700 7091600 7091500

N

Lucky Queen WRSA
LQ4b: push out material to reslope 2.5H:1V cover (material in trenches as borrow) and revegetate

Shaft #1 Building
LQ5: Option #1: preserve building intact for heritage; Option #2: dismantle and remove

Tramline
LQ6: preserve intact for heritage

Lucky Queen Shaft #2
LQ2: concrete cap

Debris
LQ7: bury in dump

Lucky Queen Pit/Trench
LQ3c: Option #1: fill; Option #2: preserve as heritage and berm for safety (in both scenarios, dump material to be used as borrow for trenches)

Lucky Queen Shaft #1
LQ1: rock cap and fill

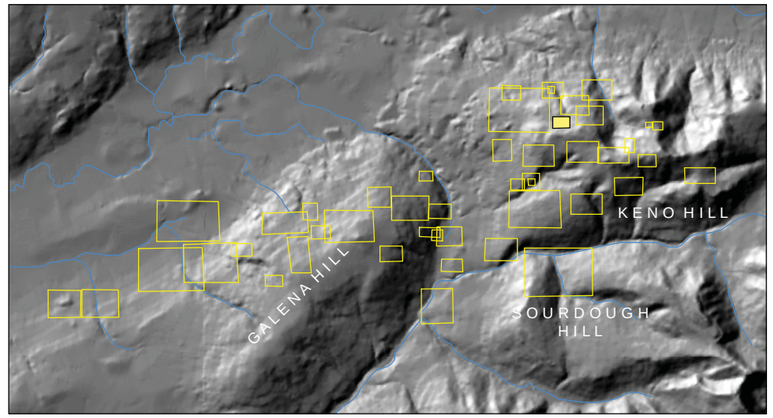
Lucky Queen WRSA
LQ4a: push out material to reslope 2.5H:1V cover (material in trenches as borrow) and revegetate

Lucky Queen Pit/Trench
LQ3b: Option #1: fill; Option #2: preserve as heritage and berm for safety (in both scenarios, dump material to be used as borrow for trenches)

Lucky Queen Pit/Trench
LQ3a: fill

Lucky Queen Pit/Trench
LQ3e: fill

0 10 20 40 60 80 Meters



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 6.45

Lucky Queen Shaft Area

Drawn By: TL/JP

APRIL 2011

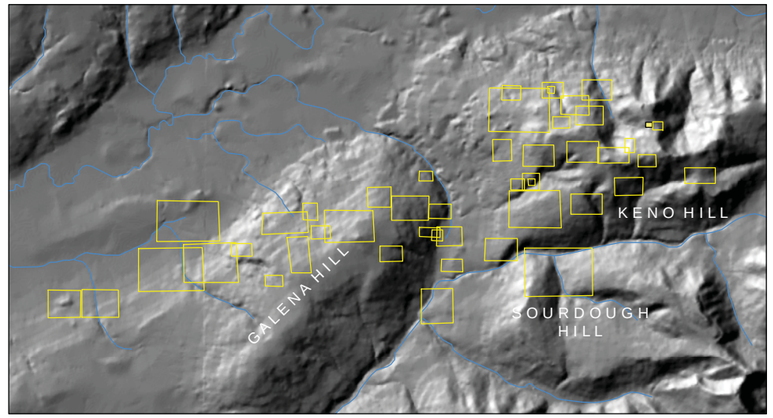
Table 6-41 Summary of Other Keno Ladue River Watershed Sites Closure Issues and Options

Common Site Name: **Keno Ladue River Watershed - Other Sites**										
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**		
Fox										
Trenching	*trenching*		overgrown and difficult to identify site						*do nothing*	
Gold Hill No.2										
Trenching	*trenching*	*GH1*								
Waste Rock	*dump*	*GH2*								
Site Debris	*misc.*	*GH3*								
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*
Monument & Ladue Fraction										
Adit	*adit*		no access			fully collapsed			*do nothing*	
Trenching	*trenching*								*do nothing*	
Waste rock	*dump*								*do nothing*	
Silver Basin										
Hand Shafts	*shaft*								*fill*	
Trenching	*trenching*								*do nothing*	
Waste rock	*dump*								*do nothing*	
Stone										
Adit	*adit*		access is difficult but possible			`			*upgrade rock pile; naturally revegetate*	
Waste rock	*dump*			minor staining					*do nothing*	
Buildings	*infrastructure*		buildings collapsed; contain asbestos			collapsed			*remove to Elsa for cleanup*	

490600
490800
7091600
7091400

Area of Trenching
Fox1: do nothing

Meters
0 5 10 20 30 40



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

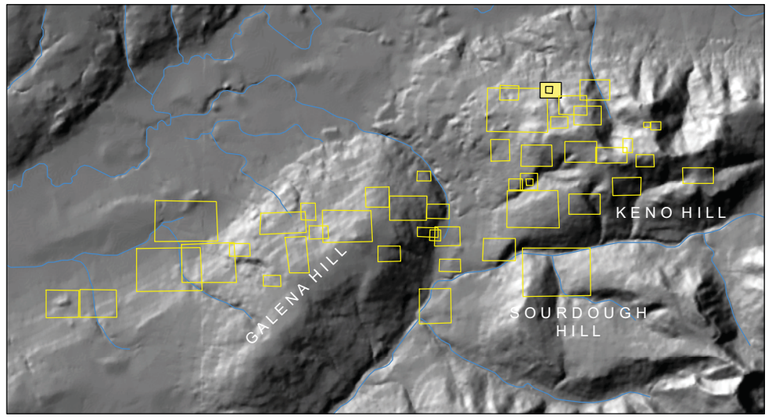
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Keno Hill Silver District
Closure Options Report
Figure 6.46

Fox

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

Figure 6.47

Lake

Drawn By: TL/JP

MARCH 2011

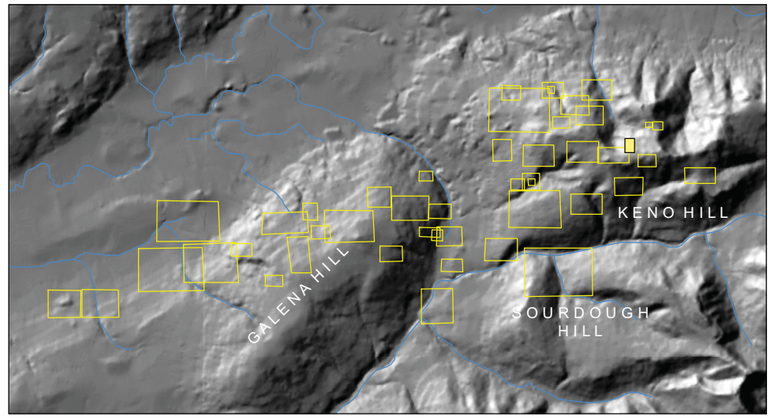
489800 490000 490200

7091200 7091000 7090800 7090600

N

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.

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 6.48

Monument and Ladue Fraction

Drawn By: TL/JP

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490600 490800 491000

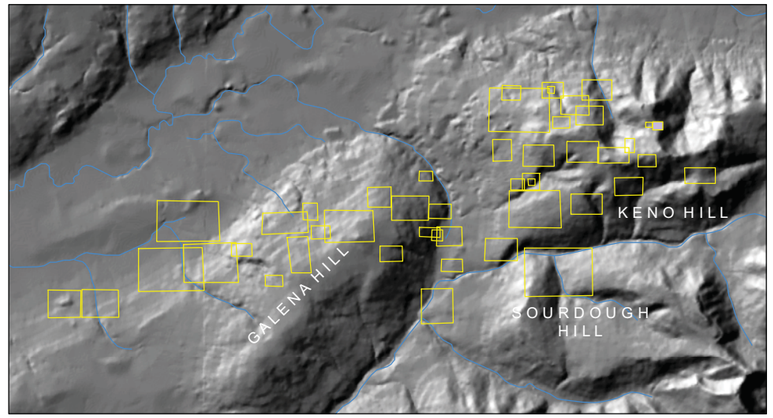
7091600

7091400

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

N

0 10 20 40 60 80 Meters



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 6.49

Silver Basin

Drawn By: TL/JP

APRIL 2011

488600 488800 489000

7092800 7092600 7092400

Lower Waste Rock
Stone2a: regrade as required to ensure stability; access from quad trails

Lower Adit Level
Stone1a: remove timber and debris; rock fill as required to prevent access

Middle Waste Rock
Stone2b: regrade as required to ensure stability; access from quad trails

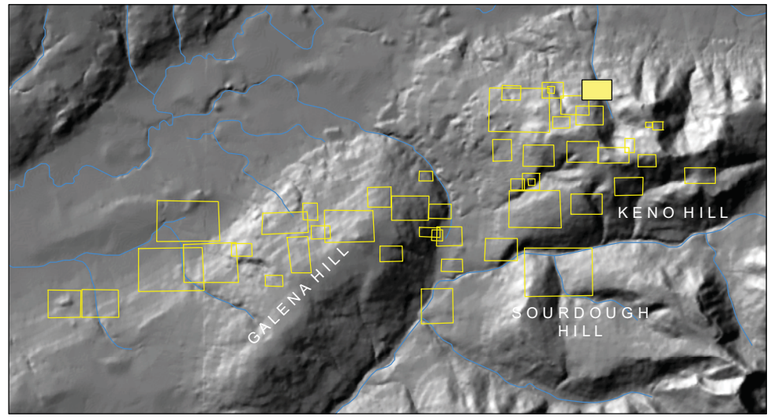
Middle Adit Level
Stone1b: remove timber and debris; rock fill as required to prevent access

Upper Waste Rock
Stone2c: regrade as required to ensure stability; access from quad trails

Upper Adit Level
Stone1c: remove timber and debris; rock fill as required to prevent access

N

0 12.5 25 50 75 100 Meters



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 6.50

Stone

Drawn By: TL/JP

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7 CLOSURE OPTION EVALUATION – COMPLEX SITES

As outlined earlier in this document, within the KHSD, there are a number of sites which require special attention and care in selecting a closure option. Closure issues identified at these sites have potential for a more significant level of adverse impact on the receiving environment than other sites, and in some cases are documented to have very significantly adverse effects. The impact of these sites can be measured in the water, sediment, vegetative (Withers 2008a) and benthic quality (Laberge 1994; 2008) of the receiving environment, as well as in other biological indicators. These "complex" sites are listed below by watershed:

Flat Creek:

- Husky SW shaft
- Silver King 100 level adit
- Valley Tailings

No Cash Bog:

- Bermingham adit
- Ruby adit
- Hector adit WRSA
- No Cash 500 level adit

Christal Creek:

- Galkeno 300 level adit
- Galkeno 900 level adit
- Mackeno tailings
- Onek 400 level adit

Lightning Creek:

- Keno 700 level adit

Keno Ladue River:

- Sadie Ladue Adit
- Wernecke tailings

For the most part, issues surrounding complex sites focus on chemical control and water management. With the exception of the Hector adit waste rock dump, all of the sites are underground mines that drain to a surface discharge or are tailings that are in contact with surface water drainage. These issues lend themselves to a range of diverse viable closure options, which are presented in Section 5 and 6. Options for treating adit/shaft water discharges are described in detail in section 5.3 and are summarized again in Section 7.1. In this section the performance of the closure options are evaluated based on predicted changes in stream loading.

The aim of this presentation is to evaluate and determine the closure options which, when combined together for all sites, together will form a closure approach that effectively meets the requirements of the agreed to Closure Objectives. This load-based evaluation forms the basis for the engineering and technical feasibility and cost metrics presented elsewhere. This loading model is a way to rank the relative effectiveness of each option by way of its chemical – and by extension biological – impacts.

The method by which the options described below will be evaluated is based on a combination of evaluating site-specific watershed goals and the relative predicted success of each option, either alone or in combination with others, in progress toward achievement of that goal. Minnow (2013b) have proposed interim water quality benchmarks of 0.075 mg/L zinc and 0.0003 mg/L cadmium. While water quality is not expected to achieve CCME in many of the downstream sub-watersheds, the water quality benchmarks provide conditions that will allow for the re-establishment of a viable benthic community and the protection of all life stages of resident fish populations within the affected watersheds. It is anticipated that these benchmark values should offer protection for resident species, and also be protective of Chinook salmon, Arctic grayling, less sensitive species and possibly slimy sculpin (Minnow 2013b; Appendix O).

It should be noted, detailed information relevant to the complex sites presented below such as meteorological data, treatment sites, surface and groundwater monitoring and proximal biological environment, can be found in the Closure Issues Report (2009) and the Environmental Conditions Report Version No. 2 (2011) prepared for ERDC by Access Consulting Group.

7.1 COMPLEX SITES OPTIONS WATER TREATMENT DESCRIPTION

Table 7-1 summarizes the types of water treatment options that are being considered for the sources of potential water based contamination at the site. These are the options that are considered potentially viable for at least some of the complex sites, while recognizing that there are a range of site-specific characteristics that would make some of the options more or less feasible at each site.

Table 7-1 Options for Treating Adit/Shaft Water Discharges

Treatment Option		Description
1	Managed Natural Attenuation	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 Treatment	Bioreactor utilizing sulphate-reducing processes, where water is discharged from the adit into a lined facility; treatment is accomplished by passage of the water through the lined bioreactor which contains permeable substrate that will 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 to provide a low biologic oxygen demand discharge; monitoring is performed at the discharge location prior to the receiving stream.
3	Mine Pool Treatment	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 or limited number of annual 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 prior to the receiving stream.
4	Active Water Treatment	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	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.

7.2 MASS BALANCE MODEL DEVELOPMENT

A mass loading model was originally developed by Access in 1996 in the Site Characterization Report (1996), and subsequently updated by ERDC in 2008 (Access 2009g) to determine relative loads from various sources of contamination to the three UKHM tributary watersheds and to the South McQuesten River. Over the years, this model was refined and updated to include more specific parameters for inputs which include various springs, point sources and meteoric runoff. The model did not adequately define the contribution of metals loading from diffuse sources such as the Mackeno Tailings, groundwater influences and waste rock piles. Moreover, this simple model lacked the predictive capacity to produce results for different scenarios, or to evaluate the sensitivity of assumptions.

In an effort to qualitatively evaluate closure options, the model was refined and modified to predict possible future outcomes for the various closure scenarios that have been shortlisted here.

In 2011, ERDC commissioned Interralogic to develop new loading models which would incorporate updated information collected between 2006 and 2011 to improve on input parameterization and provide a mechanism for modelling future and variable loading scenarios. The models have since been updated to include water quality data collected to mid-2013, allowing predictions to be refined. The model also made refinements to the conceptual model's hydrogeochemical process framework. The ITL models were developed in the GoldSim simulation framework, which provides capabilities to represent uncertainties in simulations through probabilistic simulations. These simulations are ultimately assembled into a probability distribution, which describes the level of uncertainty in the results (Interralogic 2013a; 2013b; 2013c). These improvements have allowed a quantification of the relative downstream impact from each process within the watershed, as well as a basis for determining the level of uncertainty in the results, given the assumptions.

The Goldsim models for Flat, Christal, and Lightning Creeks now provide insights into the relative benefits in terms of the metals load removal provided by each closure option. For this report, the load model is used in two ways:

- To rank the major sources of loading and the potential benefits that can be realized by implementing each option. The options are evaluated relative to the amount of COC load they are predicted to remove from each watershed. The assumptions made in predicting the loading impacts of each option are outlined in the loading model reports (Interralogic 2013a; 2013b; 2013c). These assumptions are based on past experience that ERDC has with each closure technology and are considered conservative.

- Minnow (2012) was given the loading model results to iteratively determine a water quality goal or objective for each watershed. The extent of predicted improvements are rated against the potential biological benefits to the receiving environment, to determine if there are thresholds of improvement to water quality as a result of implementing specific options combination that will be biologically relevant.

Depending on the location of the particular mine site in the watershed, a significant moderator of possible biological effects is the total amount of flow at that location compared to all upstream loads in combination with that particular site's load. The combination of the loading model and the biological sensitivity evaluation is to allow a semi-quantitative receiving environment-level prediction of the benefits of options combinations. From a practical perspective, concentrations at particular receiving environment stations, such as KV-41 in Lightning Creek, KV-7 in Christal Creek, and KV-9 in Flat Creek are locations where the integrated effects of a particular combination of closure options can be assessed. An important caveat to this approach is that the mass load simulation model is primarily suited for assessing relative changes in metal loads based on changes in mass releases. It is not specifically designed or calibrated to represent the temporal dynamics of water-quality concentrations that may occur as a result of short-term, seasonal, or long-term changes in the hydrochemistry of the watershed. Thus, the predicted Zn and Cd concentrations for each closure option are considered as approximations and will vary according to changes in water flow in the catchment throughout the year. As such, changes in metal loading rather than concentration are considered more reliable measures of the predicted performance of the closure options.

7.3 FLAT CREEK WATERSHED

Flat Creek has been characterized in a number of reports commissioned by ERDC during the closure planning process. These reports are summarized in the KHSD Environmental Conditions Report (Access Consulting 2011) and provide detailed information on Flat Creek's environment and biota, including the current condition of benthic communities and aquatic resources within the watershed. This catalogue of information will serve as a baseline for determining whether water quality goals are being met by the selected closure options.

7.3.1 Sites and Options

The following section presents a short description of each of the complex sites located in Flat Creek, together with a summary table of the options presented for that site.

7.3.1.1 Husky SW Shaft

Options for treating adit/shaft water discharges are presented in section 5.3. The options that are seen as potentially appropriate for this site are listed below.

Table 7-2 Husky SW Shaft Treatment Options

Husky SW Shaft		Treatment Option Number
1)	Managed natural attenuation	**1**
2)	Mine pool treatment	**3**
3)	Bioreactor treatment	**2**
4)	Active Water Treatment	**4**
5)	Reclamation Only aimed at reducing discharge contact with downgradient waste rock	**5**

7.3.1.2 Silver King 100

Options for treating adit/shaft water discharges are presented in section 5.3. The options that are seen as potentially appropriate for this site are listed below:

Table 7-3 Silver King 100 Treatment Options

Silver King 100 Adit		Treatment Option Number
1)	Active Water Treatment (continue operation of the existing treatment facility)	**4**
2)	Managed Natural Attenuation	**1**
3)	Mine pool treatment	**3**
4)	Bioreactor treatment	**2**

7.3.1.3 Valley Tailings

Section 5.2 provides a complete description of the Valley Tailings Facility and closure options. The closure options for the Valley Tailings are summarized below:

Table 7-4 Valley Tailings Closure Options

Valley Tailings	
1)	Cover in place
2)	Relocation-consolidation of shallow tailings and cover
	a) Water retention aspect of Dams no. 1, 2 and 3 remain
	b) Water retention aspect of Dams no. 1, 2 and 3 are removed
3)	Relocation-consolidation of all tailings to lined facility

7.3.2 Relative Impacts of Closure Options on Flat Creek

The potential impacts to stream water quality in Flat Creek from the three complex sites are presented graphically in Figures 7-1 through 7-3. The Valley Tailings are by far the largest loading source, but there are a number of dispersed tailings sources that are known within the Flat Creek drainage that will continue to affect the stream even with the immediate area around the Valley Tailings completely remediated.

Compared with the Valley Tailings, both Husky SW (<1%) and Silver King (<3%) have a limited potential mass loading to Flat Creek, and therefore the effect of implementing any of the various options at these sites on water quality will be limited in Flat Creek. At the present time, it appears that the load at the discharge location from Husky SW is being attenuated rapidly prior to entry into Flat Creek, and therefore almost no incremental benefit to water quality in Flat Creek will be realized as a result of implementing any remedial options at Husky SW. The requirement for implementation of any remedial options at Husky SW will therefore be driven by other considerations (i.e., to achieve closure objectives other than those related to protection of aquatic resources).

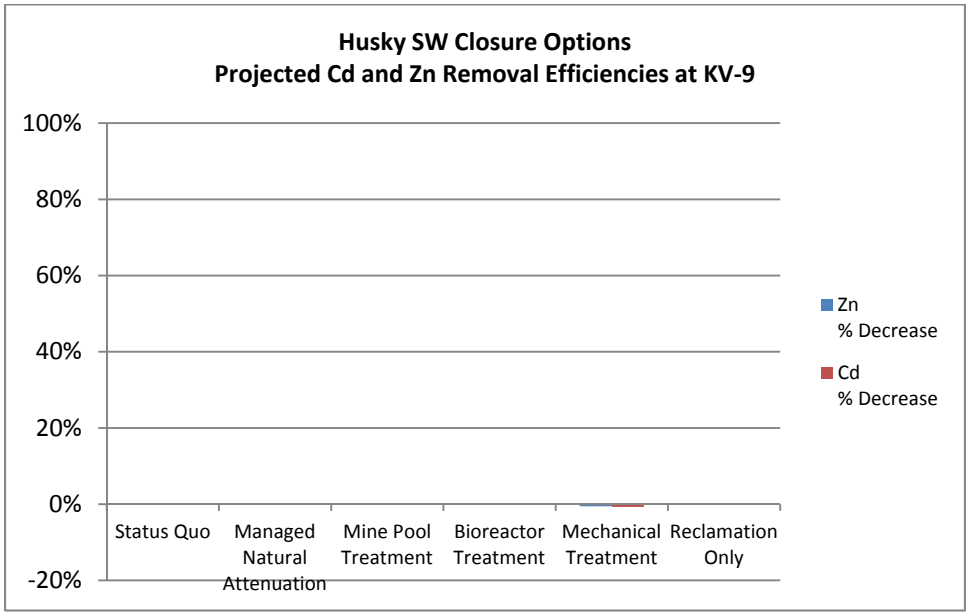


Figure 7-1 Husky SW Closure Options Projected Cd and Zn Removal Efficiencies at KV-9

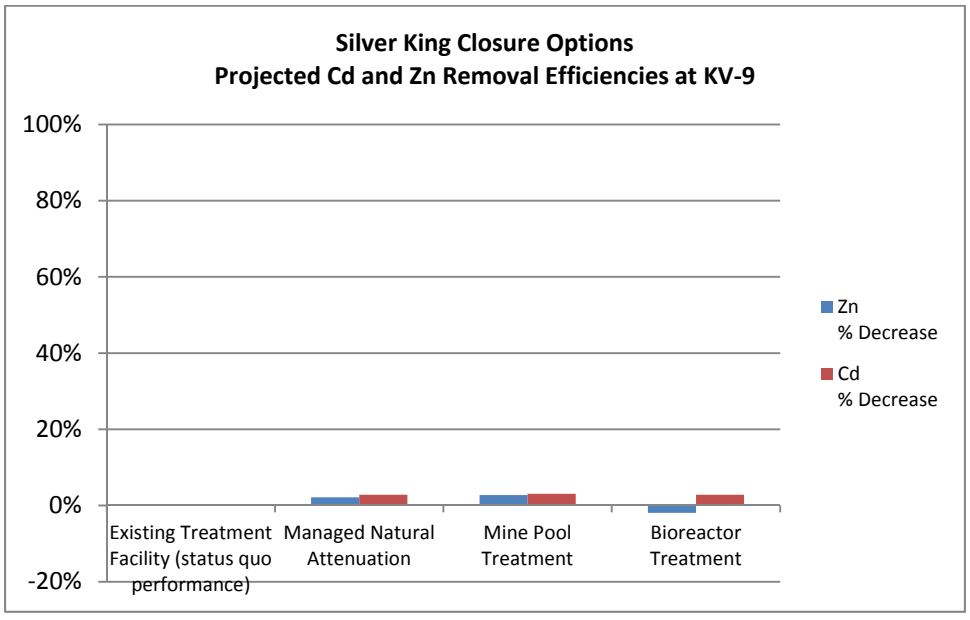


Figure 7-2 Silver King Closure Options Projected Cd and Zn Removal Efficiencies at KV-9

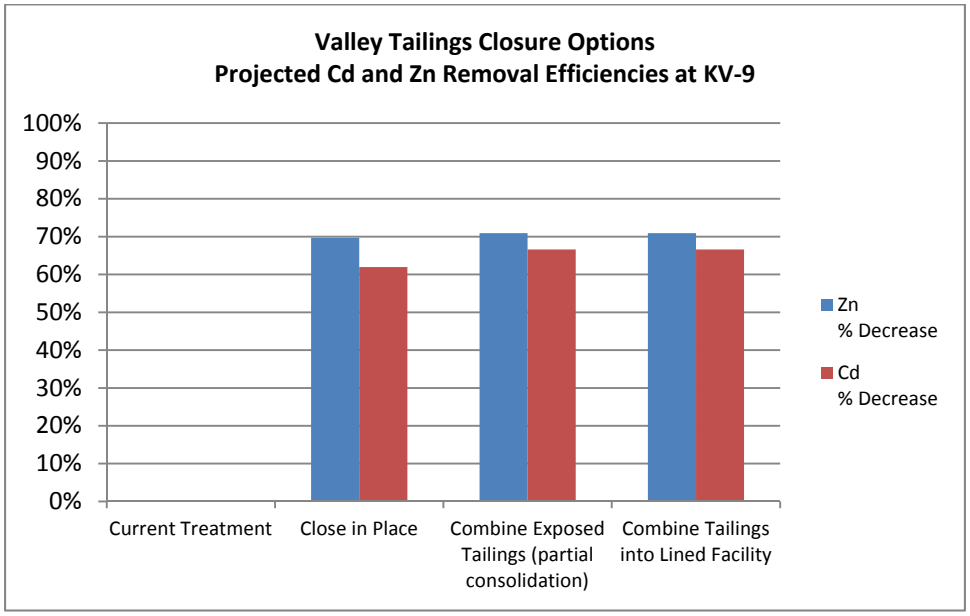


Figure 7-3 Valley Tailings Closure Options Projected Cd and Zn Removal Efficiencies at KV-9

Husky SW currently has a very effective treatment system that is naturally occurring, apparently due to the iron and manganese present in the mine drainage supporting attenuation of metals, and perhaps, if similar to No Cash bog processes, some incremental sulphate reduction based natural attenuation. The reason to consider some other active process is to increase the long term reliability of the treatment process, if the natural attenuation treatment processes are not considered sufficiently reliable.

As a current Care and Maintenance site, the potential mass loading from Silver King is already being removed by more than 90%. Any of the options are expected to have similar water quality improvements to what is in existence now, with the potential for some incremental benefit to water quality from sizing a treatment facility to have redundancy for higher flows, which should allow the facility to accomplish this goal in a more reliable manner.

The Valley Tailings currently has treatment ponds that treat a partial flow of tailings-affected water to below licence standards, and a diversion that diverts water around, but also through (in contact with) tailings. Any reclamation activity that effectively diverts water around the tailings, as well as limits the tailings contact with meteoric water by an effective cover, as well as the amendment of the tailings pore water with lime, and the continued utilization of the sub-tailings peat layer, should result in a marked improvement of loading of metals from these areas. However, it is recognized that dispersed tailings, both in the area around the existing tailings facility, tailings in the Elsa townsite area, and dispersed downgradient along Flat Creek, will limit the potential for recovery of the Flat Creek water quality.

In summary, the vast majority of the potential for water quality improvements in Flat Creek is related to the Valley Tailings. Broken up by reach, the Upper Flat Creek watershed (Elsa townsite, the hillside tailings, and Porcupine Diversion) represent approximately 83% of the cadmium and 92% of the zinc loading to Flat Creek. The second largest input, with respect to zinc, is related to tailings that are dispersed in the lower Flat Creek watershed, below the confluence of the Porcupine Diversion and Flat Creek.

Table 7-5 Simulated Long-term Future Metal Loads at KV-9 under Baseline Conditions (Interralogic 2013a)

	Annual Load (kg/year)								
	Upper Flat Creek Watershed	Valley Tailings Surface	Valley Tailings Subsurface	Husky SW	Middle Flat Creek Watershed	Galena Creek	Silver King	Lower Flat Creek Watershed	Total Load at KV-9
Cd (kg)	7.75	0.08	0.01	0	0	1.17	0.3	0	9.32
Zn (kg)	677	13.1	1.42	0.2	0	23	21.9	0	737

7.4 CHRISTAL CREEK WATERSHED

Like Flat Creek, Christal Creek has been characterized in a number of reports commissioned by ERDC during the closure planning process. These reports are summarized in the KHSD Environmental Conditions Report (Access Consulting 2011) and provide detailed information on Christal Creek's environment and biota, including the current condition of benthic communities and aquatic resources within the watershed. This catalogue of information will serve as a baseline for determining whether water quality goals are being met by the selected closure options.

7.4.1 Sites and Options

7.4.1.1 Galkeno 300 Level Adit

Options for treating adit/shaft water discharges are presented in section 5.3. The options that are seen as potentially appropriate for treatment of the high concentration, high flow Galkeno 300 adit are listed below:

Table 7-6 Galkeno 300 Treatment Options

Galkeno 300		Treatment Option Number
1)	Active Water Treatment (upgrade and continue operation of the existing treatment facility)	**4**
2)	Active Water Treatment at Elsa (discharge to Flat Creek watershed)	**4**
3)	Active Water Treatment at the Silver Trail Highway (discharge to Christal Creek watershed)	**4**

7.4.1.2 Galkeno 900 Level Adit

Options for treating adit/shaft water discharges are presented in section 5.3. The options that are seen as potentially appropriate for Galkeno 900 are listed below:

Table 7-7 Galkeno 900 Treatment Options

Galkeno 900		Treatment Option Number
1)	Bioreactor Treatment	**2**
2)	Active Water Treatment (similar in design to the current facility at Galkeno 300)	**4**
3)	Active Water Treatment at the Silver Trail Highway (discharge to Christal Creek watershed)	**4**

7.4.1.3 Onek 400 Level Adit

Options for treating adit/shaft water discharges are presented in section 5.3. The options that are seen as potentially appropriate for the Onek 400 adit are listed below:

Table 7-8 Onek 400 Treatment Options

Onek 400		Treatment Option Number
1)	Combination pre-treatment bioreactor and managed natural attenuation	**1 & 2**
2)	Active Water Treatment (install a small stand-alone mechanical plant similar in design to the current facility at Galkeno 300)	**4**
3)	Active Water Treatment at the Silver Trail Highway (discharge to Christal Creek watershed)	**4**
4)	Reclamation of Onek Pit combined with Managed Natural Attenuation	**1 & 5**

7.4.1.4 Mackeno Tailings

Options for closure of Mackeno Tailings are proposed to be the following:

Table 7-9 Mackeno Tailings Closure Options

Mackeno Tailings	
1)	Close in place, armouring the stream bank to prevent erosion
2)	Consolidate away from the stream bank and cover
3)	Combine with Valley Tailings to remove source

7.4.2 Relative Impacts of Closure Options on Christal Creek

What is provided below is a discussion of closure options for the above Christal Creek sites in terms of their potential relative impact to overall watershed health, as predicted by the GoldSim model. The model assumes a proportional response between the reduction of load sources through reclamation options and the downstream response in Christal Creek. This is important to bear in mind when assessing options, as a proportional response may not occur given that there are numerous chemical processes (most notably attenuation) occurring between the load sources and the downstream

environment that cannot be readily quantified. The most illustrative example of this is the non-proportional response in metals loading in Christal Creek following the removal of a significant proportion of Galkeno 300 adit loading from the watershed (Interralogic 2013b). The intention of this discussion is therefore to highlight on a general level the relative gains in watershed improvement to be realized by implementing various options. The purpose of this exercise is to facilitate the determination of a resource allocation scenario that will best meet the remediation goals of the watershed.

Table 7-10 Summary of Simulated Cd and Zn Loads at KV-7 for the Base Case of no Future Reclamation (Interralogic 2013b)

	Annual Load (kg/year)										
	Galkeno 300	Galkeno 900	Mackeno Tailings	Onek 400 Adit	All Waste Rock in Christal Creek Watershed	UN Adit	Groundwater to Christal Lake	Duncan Creek Road Seep	Formo and Paddy	Lucky Queen Adit	Total Load at KV-7
Zn	114	14.7	188	359	32.9	1.29	39.2	10.4	20.9	10.6	790
Cd	3.43	0.02	0.29	1.09	0.13	0.01	0.84	0.08	1.01	0.13	7.03

The closure scenarios listed above have all been simulated as a part of the modelling exercise, each in isolation from the others. The results of these simulations are presented in Figure 7-4 through Figure 7-7.

It can be observed by comparing these figures that, in general, the largest impacts to downstream metals loads occur between *sites*, and not between *options*. The range of zinc removal efficiencies expected to occur given the different options at Galkeno 300 is 10-14%, at Onek 400 it is 32-43%, at Galkeno 900 it is -1-2% and at the Mackeno Tailings it is 5-23%. This highlights the need to prioritize certain sites above others, giving priority to options selection at those sites which will produce the greatest degree of benefit downstream. In the case of the Christal Creek watershed, that site is the Onek 400 level adit. The options at Onek could potentially produce decreases in zinc by over 40% of the current load total.

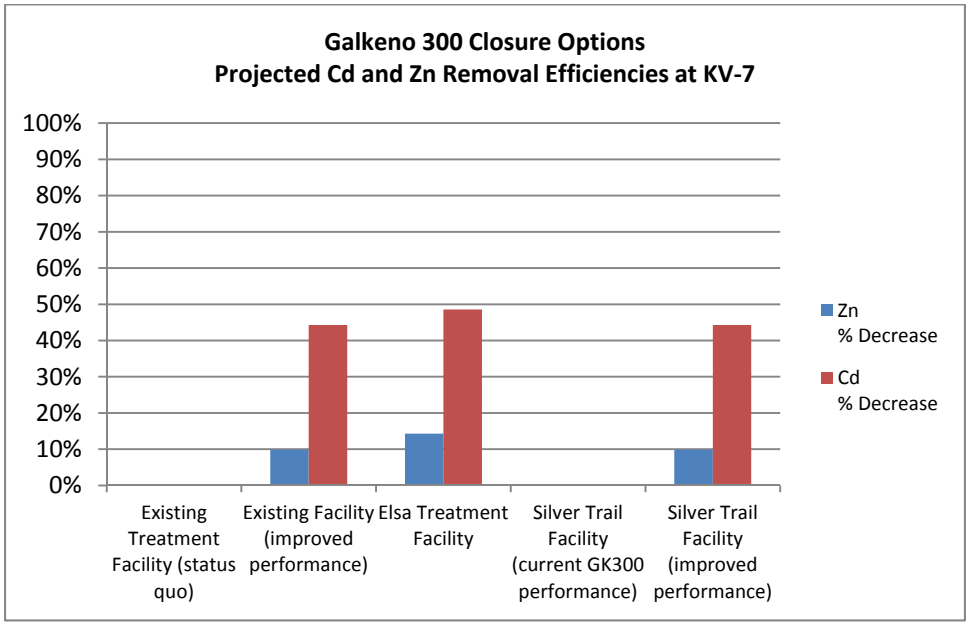


Figure 7-4 Galkeno 300 Closure Options Projected Cd and Zn Removal Efficiencies at KV-7

The Galkeno 300 treatment system is currently performing at a high level, though sludge removal and handling remains an issue. It is assumed with better process control and redundancy, and improved sludge handling, the system performance could be improved incrementally. However, because Galkeno 300 represents such a large source of metals in the Christal Creek drainage, even incremental improvement represents a potential for significant reduction of metals in the creek, especially with respect to cadmium.

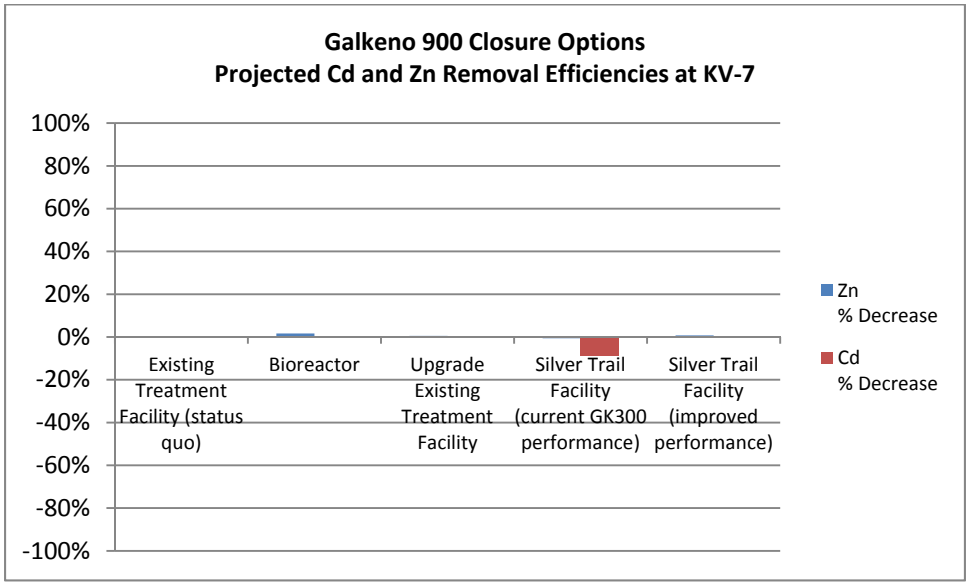


Figure 7-5 Galkeno 900 Closure Options Projected Cd and Zn Removal Efficiencies at KV-7

The Galkeno 900 treatment facility is treating a relatively small load compared to Galkeno 300, and as such has lower concentrations of Zn and Cd in its treated discharge than Galkeno 300. An efficiency improvement with respect to zinc removal could be achieved by providing treatment redundancy, better power backup, and better sludge handling; however, the effects will be small by comparison with other sites in the Christal Creek drainage.

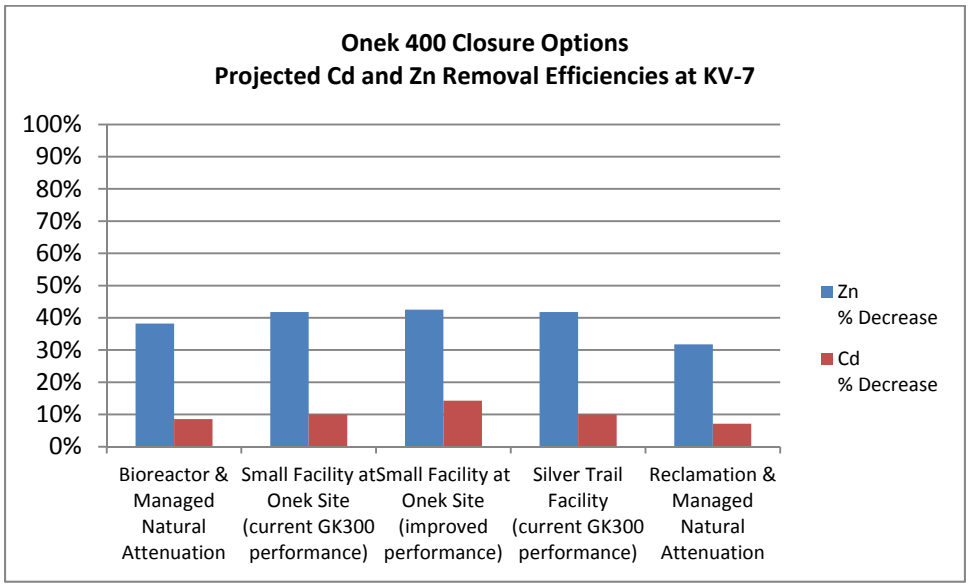


Figure 7-6 Onek 400 Closure Options Projected Cd and Zn Removal Efficiencies at KV-7

The Onek 400 site represents the largest untreated source in the Keno District. Because of its configuration as an open pit with the pit floor along the strike of the vein, the extensive underground workings creating a leachable source of metals, driven by oxidative dissolution of the natural vein materials (primarily sphalerite) , leading to high concentrations of zinc and cadmium in its adit waters. Elevated zinc and cadmium concentrations observed in adit waters during freshet may also reflect the dissolution of soluble zinc- and cadmium-bearing minerals formed via cryogenic precipitation over winter (Kwong et al., 1994). Because it is a very high initial concentration of metals, the bioreactor system was conservatively estimated to only have a 90% metals decrease, which only incremental improves the loading of metals by a small percentage over the existing natural attenuation in the current configuration. Managed natural attenuation assumes that over 70% of the Onek 400 load can be reduced by simply covering the mine pit and diverting water away from the pit, and that the existing effective attenuation process will continue at the same rate. These appear to be reasonable assumptions, but the potential for substantially different outcomes is high. The installation of the treatment systems provides a higher reliability outcome. In any case, Onek 400 appears to have the largest effect on the zinc loading at KV-7 in its current configuration (Table 7-10; Interralogic 2013b).

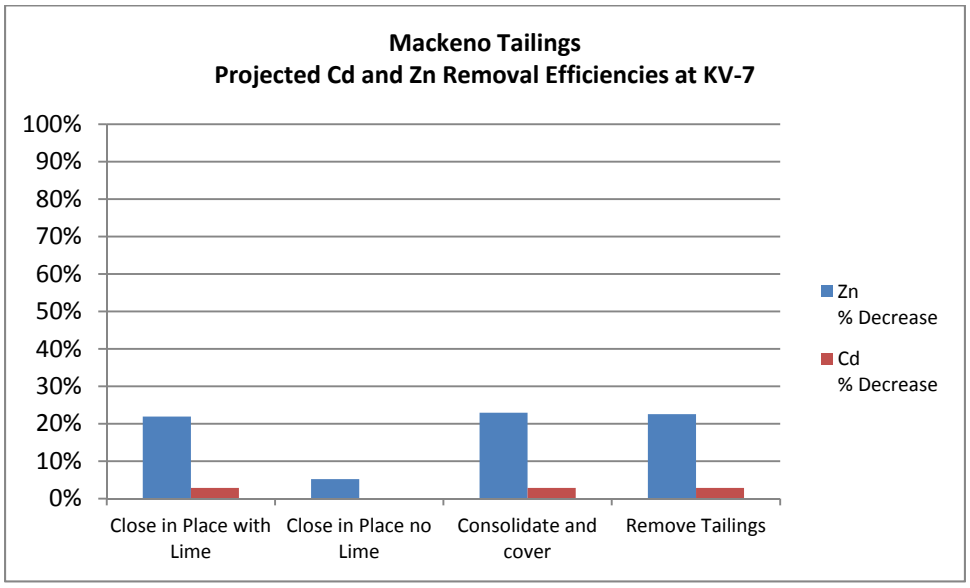


Figure 7-7 Mackeno Tailings Projected Cd and Zn Removal Efficiencies at KV-7

The Mackeno tailings appear to be a significant source especially of zinc to Christal Creek, based on shallow piezometers sampling the tailings pore water at this site. The closure of the Mackeno Tailings is primarily aimed at effectively covering the tailings and avoiding water contact with the tailings. The close in place scenario, with lime, is assumed to result in a 90% decrease of zinc concentrations in tailings porewater (Interralogic 2013b), which translates to a 22% drop in zinc loading at KV-7. Consolidation of the tailings represents a 40% less footprint for water to contact tailings, which achieves a minor improvement to water quality in the stream over the limed close in place scenario, though the long term reliability by consolidating and pulling materials back from the Christal Creek

edge is recognized. Removal of the tailings to the Valley Tailings is assumed to be 95% effective, recognizing that some residual tailings will remain even with some over-excavation.

7.5 LIGHTNING CREEK WATERSHED

Like Flat Creek and Christal Creek, Lightning Creek has been characterized in a number of reports commissioned by ERDC during the closure planning process. These reports are summarized in the KHSD Environmental Conditions Report (Access Consulting 2011) and provide detailed information on Lightning Creek's environment and biota, including the current condition of benthic communities and aquatic resources within the watershed. This catalogue of information will serve as a baseline for determining whether water quality goals are being met by the selected closure options.

7.5.1 Sites and Options

7.5.1.1 Keno 700

The Keno 700 adit is located 6 km east-northeast of Keno City along Keno Hill Road. This adit is on Keno Hill, southwest of Monument Hill. The adit drains the workings atop Keno Hill, having a late freshet period and an early freeze-up as a consequence of its altitude and aspect. The adit is difficult to access, and thus is not monitored as frequently as many other sites. The site infrastructure, which was wedged into the steep slope of Keno Hill, was removed in 2009 under the physical hazards reduction program (Access 2010a). The adit is located at the top of the surface disturbance and waste rock below and downslope. The adit flow passes out through a trough and cascades over the edge of the dump, which has resulted in a significant amount of mass wasting. It is not known what the potential contamination may be from contact with the dump, although it is classified non-potential acid generating (PAG) (SRK 2008c).

Table 7-11 Keno 700 Closure Options

Keno 700		Treatment Option Number
1)	Bioreactor Treatment	**2**
2)	Mine Pool Treatment	**3**
3)	Managed Natural Attenuation	**1**
4)	Active Water Treatment Plant	**4**

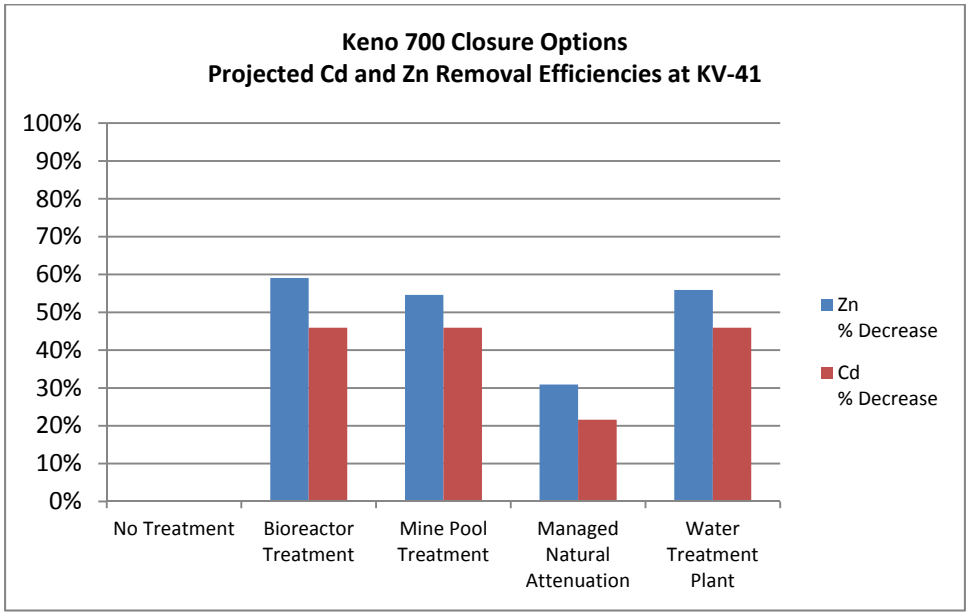


Figure 7-8 Keno 700 Closure Options Projected Cd and Zn Removal Efficiencies at KV-41

Keno 700 represents a very significant fraction of the metals load at KV-41. The bioreactor, mine pool and water treatment plant closure options have the potential to remove greater than 50% of the Zn loading and approximately 46% of the Cd loading at KV-41 (Figure 7-8), with the bioreactor option showing the highest removal efficiency (59% Zn; 462% Cd). The managed natural attenuation approach, which relies on a long pipeline to transport the water to the Christal Creek drainage, and thus represents full removal of Keno 700 from the Lightning Creek drainage, shows comparatively poorer Zn (31%) and Cd (22%) removal.

7.6 NO CASH BOG WATERSHED

A series of other seeps and disconnected streams drain Galena Hill parallel to No Cash Creek (NCC), creating a large peat bog in the areas east and north of the stream channel. No Cash Creek is not a direct tributary of any other streams but instead terminates in a small pond in a low lying boggy area of the valley approximately 2 km south of the South McQuesten River.

There is no known direct surface connection between NCC and the South McQuesten River. Much of the NCC drainage and surrounding wetland area is underlain by discontinuous permafrost of variable extent and thickness. There are seeps along the south and east sides of the river that may be down gradient of the terminus of NCC, but whether the creek is gaining or losing inflow to groundwater has not been established.

7.6.1 Sites and Options

7.6.1.1 Bermingham Adit

Options for treating adit/shaft water discharges are presented in section 5.3. The options that are seen as potentially appropriate for the Bermingham adit are listed below:

Table 7-12 Bermingham Adit Closure Options

Bermingham Adit		Treatment Option Number
1)	Managed Natural Attenuation	**1**
2)	Mine Pool Treatment	**3**
3)	Bioreactor Treatment	**2**
4)	Active Water Treatment (includes stand-alone option or central plant in Elsa)	**4**

7.6.1.2 Ruby Adit

Options for treating adit/shaft water discharges are presented in section 5.3. The options that are seen as potentially appropriate for the Ruby adit are listed below:

Table 7-13 Ruby Adit Closure Options

Ruby Adit		Treatment Option Number
1)	Managed Natural Attenuation	**1**
2)	Mine Pool Treatment	**3**
3)	Bioreactor Treatment	**2**
4)	Active Water Treatment (includes stand-alone option or central plant in Elsa)	**4**

7.6.1.3 No Cash 500 Level Adit

Options for treating adit/shaft water discharges are presented in section 5.3. The options that are seen as potentially appropriate for the No Cash 500 adit are listed below:

Table 7-14 No Cash 500 Level Adit Closure Options

No Cash 500 Level Adit		Treatment Option Number
1)	Active Water Treatment (Upgrade and continue operation of the existing treatment facility)	**4**
2)	Mine Pool Treatment	**3**
3)	Bioreactor Treatment	**2**
4)	Active Water Treatment (includes stand-alone option or central plant in Elsa)	**4**

7.6.1.4 Hector Adit Dump

Options for closure of the Hector Adit WRSA are proposed to be the following:

Table 7-15 Hector Adit WRSA Closure Options

Hector Adit WRSA	
1)	Cover and revegetate
2)	Optimized cover for reduced infiltration and source control
3)	Reclaim with no cover

7.7 KENO LADUE WATERSHED

The goals for the Keno Ladue watershed have not been established. A synoptic sampling program was carried out in the fall of 2012 to better understand the relative thickness and volumes of dispersed tailings in the primary lobe near to the former Wernecke Mill site in addition to the main tailings deposit. The off-claim tailings deposited from the Wernecke Mill show the potential for recontaminating any water that is treated on-claim. A workplan was initiated in September 2013 to characterize the distribution, thickness and geochemistry of the off-claim Wernecke tailings with a view to providing closure options for these off-site tailings.

7.7.1 Sites and Options

7.7.1.1 Sadie Ladue Adit

The Sadie Ladue 600 adit is located approximately 7km north of Keno City. It is 1 km northwest of Gambler Gulch Trail on the northwest side of Keno Hill. Access is via quad on an overgrown trail.

The flow from Sadie Ladue has historically been higher than flows observed from other adits in the District, with the discharge flowing out from the schistose, collapsed adit entrance. At times of the year, the full headwaters of the stream to which Sadie Ladue discharges is entirely from the adit itself.

Options for treating adit/shaft water discharges are presented in section 5.3. The options that are seen as potentially appropriate for the Sadie Ladue 600 adit are listed below:

Table 7-16 Sadie Ladue 600 Level Adit Closure Options

Sadie Ladue 600 Level Adit		Treatment Option Number
1)	Reclamation Only—no water treatment required if reclamation is successful	**5**
2)	Managed Natural Attenuation	**1**
3)	Bioreactor Treatment	**2**

7.7.1.2 Wernecke On-Claim Tailings

The options for closure of the Wernecke Tailings are proposed to be the following:

Table 7-17 Wernecke On-Claim Tailings Closure Options

Wernecke On-Claim Tailings	
1)	Close in place
2)	Combine with Wernecke mill site tailings, cover and revegetate

7.7.1.3 Wernecke Off-Claim Tailings

The options for closure of the Wernecke off claim Tailings are proposed to be the following:

Table 7-18 Wernecke Tailings Closure Options

Wernecke Off-Claim Tailings	
1)	Cover in place
2)	Consolidation
3)	Enhance Natural Recovery

7.8 QUALITATIVE PREDICTIONS OF WATER QUALITY IMPROVEMENT

The simulation models built by Interralogic were primarily designed to predict changes in COC loads in response to different reclamation scenarios. Estimates of COC concentration were subsequently extracted from the models, however, it must be noted that such concentrations are estimates based on predicted COC loads and water flow rates. They can be considered as qualitative approximations of the concentration ranges expected to occur over yearly to longer timescales, rather than precise day-today concentrations. The median and maximum predicted zinc and cadmium concentrations for the selected closure options in the Christal, Flat and Lightning Creek watersheds are listed in Table 7-19 to Table 7-22. The water quality predictions for all the options can be found in the load reports in Appendix D, but only those that result in the largest predicted water quality improvements are shown here due to space constraints. The modelled zinc and cadmium concentrations are compared to CCME water quality guideline and toxicity threshold values for a range of freshwater species to help stakeholders evaluate the chemical and biological improvements to water quality that might be expected from the implementation of each option. The focus is on the identified COCs zinc and cadmium, however, data regarding mass load reductions for the other elements including arsenic, lead, and silver can also be found in the load model reports in Appendix D.

The water quality goals should initially aim to prevent further degradation of water quality such that the existing diversity and abundance of the existing resident biota is protected. Routine monitoring conducted as part of the Long-Term Aquatic Monitoring Program (Minnow 2011b) should be assessed annually to ensure conditions are stable or improved relative to previous conditions and background and the effects of these goals should be verified through routine biological monitoring. It is expected that as conditions improve and stabilize as a result of closure option implementation, as well as other reclamation activities, the magnitude and frequency of monitoring will be reduced. The goals presented in Table 7-19 to Table 7-22 show a range of possible receiving environment water concentrations that may be achieved through implementation of different combinations of closure options based on the predicted performance of each option. It is important to note that a number of the source loadings within Flat Creek and Christal Creek do not directly discharge as surface point

sources and as a result the actual final water quality in the receiving environment may not meet the concentrations shown. Once the closure option selection process has been completed, watershed goals will be further refined, however, the model is currently robust enough for stakeholders to make informed decisions regarding the impact each option will have on metal loading in each watershed.

Table 7-19 Comparison of maximum predicted cadmium concentrations to water quality guidelines and toxicity thresholds (mg/L).

			Zinc	Toxicity Threshold [d]			
			mg/L	Sensitive Algae & Invertebrates	Sensitive salmonids[f]	Chinook salmon	Less Sensitive Biota
CCME at 100 mg/L Hardness (long-term value) [b]			**0.03**				
Toxicity Thresholds				0.011	0.0911	0.236	0.239
Tributary	**Condition**						
Christal Creek	Baseline at KV-7[a]		0.11	yes	possibly	no	no
	Predicted at KV-7 [c]	Improve Treatment at Galkeno 300 & 900	0.10	yes	possibly	no	no
		Treat Mackeno Tailings and Onek	0.04	yes	no	no	no
		Improve Treatment at Galkeno 300 & 900, Treat Mackeno Tailings and Onek, reclaim waste rock sites	0.024	yes	no	no	no
Flat Creek[e]	Baseline at KV-9[a]		0.053	yes	no	no	no
	Predicted at KV-9 [c]	Valley Tailings: Close in Place	0.017	yes	no	no	no
		Husky SW: Natural Attenuation	0.053	yes	no	no	no
		Silver King: Natural Attenuation	0.051	yes	no	no	no
Lightning Creek	Baseline at KV-41[a]		0.021	yes	no	no	no
	Predicted at KV-41 [c]	Keno 700: Bioreactor	0.005	no	no	no	no
		Keno 700: Natural Attenuation	0.012	possibly	no	no	no

[a] - Baseline assumes that no further remediation measures are implemented

[b] - Zinc interim CCME value hardness dependant (based on 100mg/L hardness; CCME 2012) with no short term value provided

[c] - predicted values from Interralogic (Christal Creek, November 12, 2013, Lightning Creek, November 5, 2013 and Flat Creek November 2013)

[d] - toxicity thresholds based on water hardness of 100 mg/L (Minnow 2010).

[e] - the option with the lowest concentration is presented for each of; the valley tailings, Husky South West and Silver King.

[f] - sensitive salmonid based on rainbow trout.

yes - baseline or predicted value above toxicity threshold and effects to these organisms would be expected.

no - baseline or predicted value below toxicity threshold and effects to these organisms would not be expected.

possibly - baseline or predicted value is near threshold

Value exceeds CCME

Value is less than CCME

Table 7-20 Comparison of maximum predicted cadmium concentrations to water quality guidelines and toxicity thresholds (mg/L).

			Zinc	Toxicity Threshold [e]				
			mg/L	Sensitive Algae & Invertebrates	Sensitive salmonids[g]	Chinook salmon	Less Sensitive Biota	Arctic Grayling [b]
CCME at 100 mg/L Hardness (long-term value) [c]			**0.03**					
Toxicity Thresholds				0.011	0.0911	0.236	0.239	0.171
Tributary	**Condition**							
Christal Creek	Baseline at KV-7 [a]		0.430	yes	yes	yes	yes	yes
	Predicted at KV-7 [d]	Improve Treatment at Galkeno 300 & 900	0.420	yes	yes	yes	yes	yes
		Treat Mackeno Tailings and Onek	0.100	yes	possibly	no	no	no
		Improve Treatment at Galkeno 300 & 900, Treat Mackeno Tailings and Onek, reclaim waste rock sites	0.065	yes	no	no	no	no
Flat Creek[f]	Baseline at KV-9 [a]		0.067	yes	no	no	no	no
	Predicted at KV-9 [d]	Valley Tailings: Close in Place	0.019	yes	no	no	no	no
		Husky SW: Natural Attenuation	0.067	yes	no	no	no	no
		Silver King: Natural Attenuation	0.064	yes	no	no	no	no
Lightning Creek	Baseline at KV-41 [a]		0.038	yes	no	no	no	no
	Predicted at KV-41 [d]	Keno 700: Bioreactor	0.021	yes	no	no	no	no
		Keno 700: Natural Attenuation	0.031	yes	no	no	no	no

[a] - Baseline assumes that no further remediation measures are implemented

[b] - Arctic grayling toxicity threshold is based on geometric mean of LC50 (acute) values established at 50 mg/L hardness (Buhl and Hamilton 1990)

[c] - Zinc interim CCME value hardness dependant (based on 100mg/L hardness; CCME 2012) with no short term value provided

[d] - predicted values from Interralogic (Christal Creek, November 12, 2013, Lightning Creek, November 5, 2013 and Flat Creek November 5, 2013)

[e] - toxicity thresholds based on water hardness of 100 mg/L (Minnow 2010).

[f] - the option with the lowest concentration is presented for each of; the valley tailings, Husky South West and Silver King.

[g] - sensitive salmonid based on rainbow trout.

yes - baseline or predicted value above toxicity threshold and effects to these organisms would be expected.

no - baseline or predicted value below toxicity threshold and effects to these organisms would not be expected.

possibly - baseline or predicted value is near threshold

Value exceeds CCME

Value is less than CCME

Table 7-21 Comparison of maximum predicted cadmium concentrations to water quality guidelines and toxicity thresholds (mg/L).

			Cadmium	Toxicity Threshold [d]			
			mg/L	Sensitive Algae & Invertebrates	Sensitive salmonids[f]	Chinook salmon	Less Sensitive Biota
CCME at 100 mg/L Hardness (long-term value) [c]			0.000158				
Toxicity Thresholds				0.00008	0.00036	0.0054	0.0056
Tributary	**Condition**						
Christal Creek	Baseline at KV-7[a]		0.0008	yes	possibly [g]	no	no
	Predicted at KV-7 [c]	Improve Treatment at Galkeno 300 & 900	0.0004	yes	possibly [g]	no	no
		Treat Mackeno Tailings and Onek	0.0006	yes	possibly [g]	no	no
		Improve Treatment at Galkeno 300 & 900, Treat Mackeno Tailings and Onek, reclaim waste rock sites	0.0002	yes	no	no	no
Flat Creek [e]	Baseline at KV-9[a]		0.00067	yes	yes	no	no
	Predicted at KV-9 [c]	Valley Tailings: Close in Place	0.00025	yes	no	no	no
		Husky SW: Natural Attenuation	0.00067	yes	yes	no	no
		Silver King: Natural Attenuation	0.00063	yes	yes	no	no
Lightning Creek	Baseline at KV-41[a]		0.0002	yes	no	no	no
	Predicted at KV-41 [c]	Keno 700: Bioreactor	0.00007	no	no	no	no
		Keno 700: Natural Attenuation	0.00015	yes	no	no	no

[a] - Baseline assumes that no further remediation measures are implemented

[b] - predicted values from Interralogic (Christal Creek, November 12, 2013, Lightning Creek, November 5, 2013 and Flat Creek November 2013)

[c] - Cadmium CCME values based on 100 mg/L hardness CCME draft guideline October 2012

[d] - toxicity thresholds based on water hardness of 100 mg/L (Minnow 2010).

[e] - the option with the lowest concentration is presented for each of; the valley tailings, Husky South West and Silver King.

[f] - sensitive salmonid based on rainbow trout.

[g] - the toxicity threshold for sensitive salmonids is for rainbow trout and is based on a 65 week test and an MTAC for delay of ovary production. It is possible that at this higher concentration no population level effects will be observed.

yes - baseline or predicted value above toxicity threshold and effects to these organisms would be expected.

no - baseline or predicted value below toxicity threshold and effects to these organisms would not be expected.

possibly - baseline or predicted value is near threshold.

Value exceeds CCME

Value is less than CCME

Table 7-22 Comparison of maximum predicted cadmium concentrations to water quality guidelines and toxicity thresholds (mg/L)

			Cadmium	Toxicity Threshold [e]				
			mg/L	Sensitive Algae & Invertebrates	Sensitive salmonids[g]	Chinook salmon	Less Sensitive Biota	Arctic Grayling [b]
CCME at 100 mg/L Hardness (short-term value) [c]			0.0021					
Toxicity Thresholds				0.00008	0.00036	0.0054	0.0056	0.005
Tributary	**Condition**							
Christal Creek	Baseline at KV-7 [a]		0.0021	yes	yes	no	no	no
	Predicted at KV-7 [d]	Improve Treatment at Galkeno 300 & 900	0.0010	yes	possibly [h]	no	no	no
		Treat Mackeno Tailings and Onek	0.0018	yes	possibly [h]	no	no	no
		Improve Treatment at Galkeno 300 & 900, Treat Mackeno Tailings and Onek, reclaim waste rock sites	0.0007	yes	possibly [h]	no	no	no
Flat Creek[f]	Baseline at KV-9 [a]		0.00074	yes	yes	no	no	no
	Predicted at KV-9 [d]	Valley Tailings: Close in Place	0.00026	yes	no	no	no	no
		Husky SW: Natural Attenuation	0.00074	yes	yes	no	no	no
		Silver King: Natural Attenuation	0.00070	yes	yes	no	no	no
Lightning Creek	Baseline at KV-41 [a]		0.0004	yes	possibly	no	no	no
	Predicted at KV-41 [d]	Keno 700: Bioreactor	0.00026	yes	no	no	no	no
		Keno 700: Natural Attenuation	0.00033	yes	possibly	no	no	no

[a] - Baseline assumes that no further remediation measures are implemented

[b] - Arctic grayling toxicity threshold is based on LC50 (acute) value established at 50 mg/L hardness (Buhl and Hamilton 1991)

[c] - Cadmium CCME values based on 100 mg/L hardness CCME draft guideline October 2012

[d] - predicted values from Interralogic (Christal Creek, November 12, 2013, Lightning Creek, November 5, 2013 and Flat Creek November 2013)

[e] - toxicity thresholds based on water hardness of 100 mg/L (Minnow 2010).

[f] - the option with the lowest concentration is presented for each of; the valley tailings, Husky South West and Silver King.

[g] - sensitive salmonid based on rainbow trout.

[h] - the toxicity threshold for sensitive salmonids is for rainbow trout and is based on a 65 week test and an MTAC for delay of ovary production. It is possible that at this higher concentration no population level effects will be observed.

yes - baseline or predicted value above toxicity threshold and effects to these organisms would be expected.

no - baseline or predicted value below toxicity threshold and effects to these organisms would not be expected.

possibly - baseline or predicted value is near threshold

Value exceeds CCME

Value is less than CCME

7.8.1 Flat Creek Watershed Goals

Each closure option proposed for Husky SW and Silver King had similar performance in terms of the predicted zinc and cadmium concentration (Interralogic 2013a), thus only one option is presented in Table 7-19 to Table 7-22. The closure options for both Husky and Silver King are predicted to provide only marginal improvements in zinc and cadmium water quality in the Flat Creek watershed. This is due to (1) the effectiveness of the water treatment plant in operation at Silver King 100 and the natural attenuation that removes zinc and cadmium from the Husky SW watercourse; and (2) the relatively minor contribution of these two metal point sources to the Flat Creek watershed in comparison to the Valley tailings. Although the Valley Tailings Closure options 2 and 3 produced slightly lower zinc and cadmium loadings, the load model suggested that option 1 would yield slightly lower aqueous concentrations of zinc and cadmium, primarily due to differences in the predicted hydrologic response of the watershed between these options. Closure of the Valley Tailings is predicted to bring zinc concentrations at KV-9 below the CCME guideline, and be protective of a range of biota, with the exception of sensitive algae and invertebrates.

7.8.2 Christal Creek Water Quality Improvement

The data presented in Table 7-199 to Table 7-22 show the range of possible zinc and cadmium concentrations at Christal Creek site KV-7 that may be achieved through implementation of different combinations of selected closure options based on the predicted performance of each option. Further options combinations are presented in the Christal Creek load model report (Interralogic 2013b). None of the options are predicted to meet CCME Zn and Cd concentrations, although a combination of active water treatment of Galkeno 300, Galkeno 900, and Onek 400, alongside reclamation of the Mackeno tailings and waste rock sites is predicted to bring median zinc and cadmium concentrations close to CCME levels (Interralogic 2013b). Such combined treatment is predicted to be protective of all freshwater biota considered, with the exception of sensitive algal and invertebrate species.

7.8.3 Lightning Creek Water Quality Improvement

Lightning Creek currently meets CCME for most parameters, however there are still some sources associated with the historical UKHM claims that influence water quality within this stream. The goal of this Creek is to achieve CCME for metals that are related to the UKHM activities (i.e., cadmium and zinc are currently identified as COCs), recognizing that TSS related to placer mine activity may remain elevated. Indeed, elevated TSS levels have been associated with increased total concentrations of a range of elements. Closer inspection of these TSS events has revealed that the dissolved portion of these elements, which is the bioavailable fraction, was below CWQG and/or background concentrations with the exception of the identified COCs, zinc and cadmium (Minnow 2013a).

All the closure options proposed for Keno 700 meet CCME short and long-term zinc and cadmium concentration guidelines, with the marginal exception of natural attenuation. The bioreactor, mine pool treatment, and water treatment plant options all returned similar predicted median and

maximum cadmium and zinc concentrations (Interralogic 2013c), which would be protective of most freshwater species considered, with the possible exception of sensitive algae and invertebrates.

7.8.4 South McQuesten River Watershed Goals

The South McQuesten River, into which both Flat Creek and Christal Creek flow, contains a wide variety of fish habitats and fish species typical of those found elsewhere in the Yukon River drainage. A variety of flow regimes occur along the river in the study area, the most predominant being gravel bottomed riffle/ glide areas followed by deep, often silted pools.

Fish were encountered at all sites sampled on the South McQuesten River. All species recorded were found utilizing the South McQuesten River. Most species occurred at all sample sites. The exceptions were least cisco found only at the outlet of McQuesten Lake, lake chubb found only upstream of Christal Creek, and Chinook salmon which were not found upstream of the confluence with Haggart Creek.

As noted above, concentrations of cadmium and zinc have been increasing downstream of UKHM as a result of increasing concentrations upstream. Until the concentrations upstream are reduced or stabilize, a single water quality criterion cannot reasonably be employed downstream in the South McQuesten River. Therefore, downstream water quality objectives for cadmium and zinc and possibly other contaminants should be linked to concentrations upstream of UKHM (i.e., KV-1) such that no further degradation of water quality occurs downstream of UKHM (KV-4 and KV-5) relative to upstream conditions. A possible approach to evaluating water quality within the South McQuesten River might include:

1) An annual evaluation of monthly water samples collected at KV-1, KV-4 and KV-5, relative to all substances associated with UKHM, particularly cadmium and zinc.

2) The mean annual concentrations of cadmium and zinc at KV-4 and KV-5 should not exceed those measured upstream at KV-1. Means should be statistically compared using ANOVA. An increase in mean cadmium and/or zinc that is not statistically significant should still be investigated to determine if it may be an early indicator of an increasing trend associated with historic UKHM inputs (e.g., perhaps examine trends in water quality monitoring data from upstream source areas based on both concentrations and loads).

3) Water quality trends at all areas should be evaluated by a qualified professional at a frequency consistent with detailed watershed reporting as recommended in the Long-Term Aquatic Monitoring Program (LTAMP; Minnow 2011).

4) The slope of downstream concentrations (KV-4 and KV-5) should be statistically compared to KV-1 (ANCOVA) to confirm that the rates of change downstream are equal to or less than that measured upstream.

8 POST IMPLEMENTATION MONITORING

Ongoing monitoring at closure sites will be a requirement and will include the following broad indicator areas:

- Geotechnical
    - Adits;
    - Shafts; and
    - Tailings dams.
- Water
    - Surface water; and
    - Groundwater.
- Biota
    - Vegetation;
    - Sediment and benthic invertebrates; and
    - Fish and aquatic species.

Routine assessments are useful to establish and maintain a database of information which can be used to determine initial and steady state conditions. By conducting regular monitoring programs the onset of problems can easily be identified by comparing to previous monitoring events. The following sections provide an overview of these programs and the regularity of which the investigations will be conducted.

8.1 GEOTECHNICAL

8.1.1 Adits

As part of the closure, geotechnical requirements for monitoring of adits will include semi-annual site visits to the following adits, which are also associated with water monitoring stations, which are discussed in section 8.3 in detail. The adits are listed below and the associated water monitoring station is also listed in brackets:

- Silver King Adit (KV-13)
- Husky South West Adit (KV-17)
- Bermingham Adit (KV-18)

- Ruby Adit (KV-19)
- No Cash 500 Adit (KV-20)
- Galkeno 300 Adit (KV-27)
- Galkeno 900 Adit (KV-31)
- Keno 700 Adit (KV-33)
- Lucky Queen Adit (KV-34)
- Sadie Ladue Adit (KV-35)
- Onek Adit (KV-45)
- UN Adit (KV-53)
- Klondike Keno Adit (KV-66)
- Keno 200 Adit (KV-67)
- Brewis Red Lake Adit (KV-68)

Each site visit will be conducted by an engineer professionally licensed in Yukon and will include a walk over at each location, with a thorough checklist documenting current conditions/status of each adit, including site photographs. A geotechnical report summarizing findings will be released on a semi-annual basis, and should it be determined, recommendations for any specific modifications required at a particular location. The proposed frequency of the site visits are as follows:

- Annual for years 0 - 3
- Semi-annually for years 3 - 10
- Every 5 years for years 10 - 30

Should it be determined that maintenance work is required for a particular location, the corrective work will be completed, and site visits will be stepped up to the above monitoring frequency for that particular location.

8.1.2 Shafts

Similar to adit inspections, geotechnical focused shaft monitoring inspections will be a requirement after closure. Prior to closure, existing shafts will be properly capped, and inspections will be conducted with the same frequency of adit inspections to maximize efficiencies for site visits and reporting. Each site visit will be conducted by a geotechnical engineer professionally licensed in the Yukon, and will include a walk over at each location, with a thorough checklist documenting the current conditions/status of each shaft. A geotechnical report summarizing findings will be released

on a semi-annual basis, and if required, maintenance work will be completed to address deficiencies noted in the inspection. The proposed frequency of the site visits are as follows:

- Annual for years 0 - 3
- Semi-annually for years 3 - 10
- Every 5 years for years 10 - 30

Should it be determined that maintenance work is required for a particular location, the corrective work will be completed, and site visits will be stepped up to the above monitoring frequency for that particular location.

8.1.3 Tailings Dams

Depending on the preferred closure option selected for the Valley Tailings Facility there is a possibility that tailings dams will remain at the site following the post implementation period. Should tailings dams remain at the site then there will be a need to conduct geotechnical inspections of these structures. A geotechnical inspection of the VTF dams will be carried out in accordance with the most recent Dam Safety Guidelines issued by the Canadian Dam Association (CDA 2007) and will be completed by a Professional Engineer licenced to practice in Yukon. A report on the inspection shall be submitted as part of the annual report. The report will document the following:

- Inspection locations and methodologies;
- Inspection findings;
- All problems identified; and
- Remedial measures recommended.

The proposed frequency of the site visits are as follows:

- Annual for years 0 - 3
- Semiannually for years 3 - 10
- Every 5 years for years 10 - 30

Site visits will be conducted concurrently with shafts and adits to maintain efficiency for costs in the closure phase. Should it be determined that maintenance work is required, the corrective work will be completed or an explanation regarding the non-implementation of corrective action will be included.

Details of any maintenance, inspection and/or surveillance activities undertaken in the previous year in relation to dam safety shall be included in the annual report.

8.2 WATER

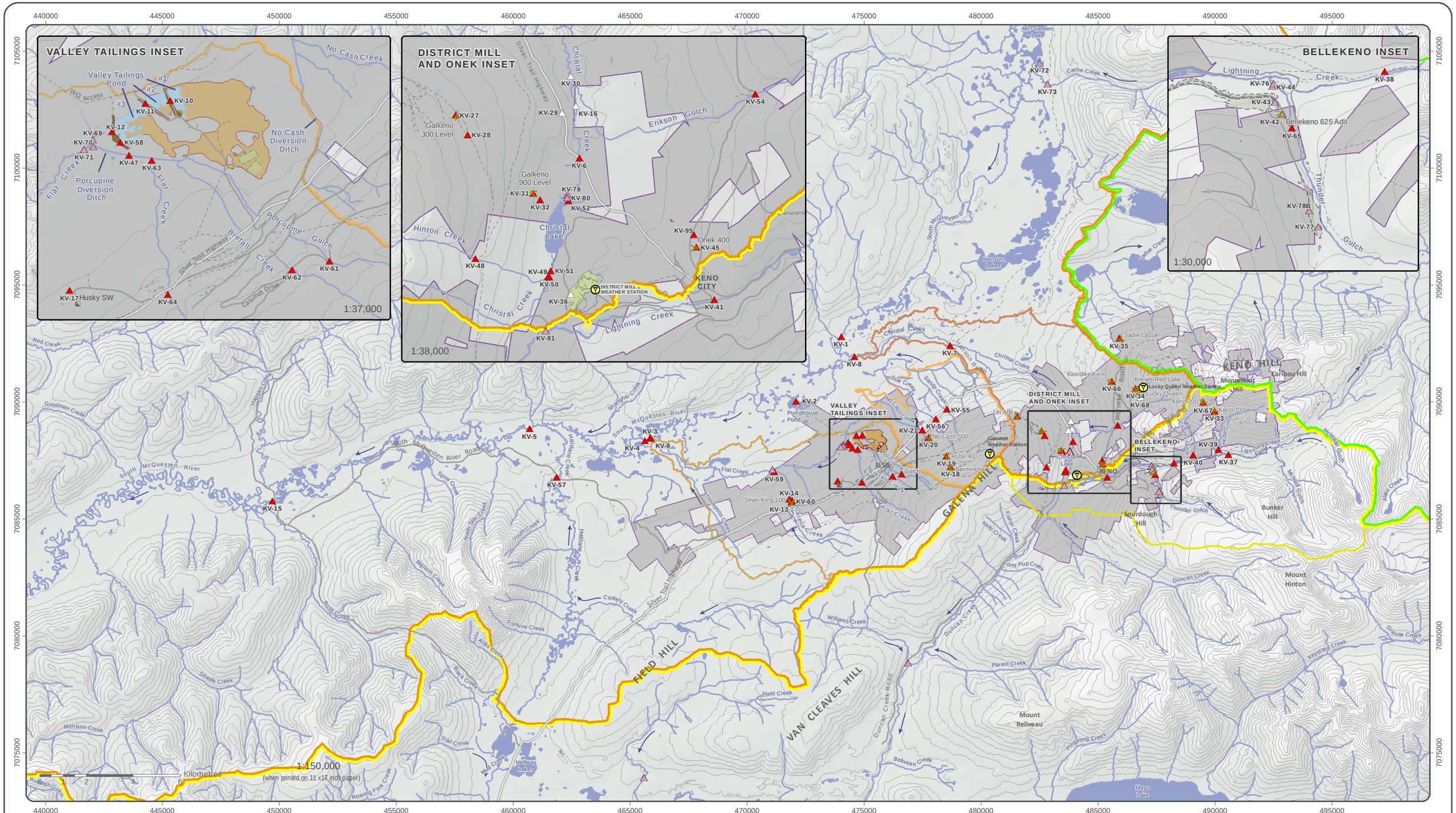
8.2.1 Surface Water

Surface water is currently monitored at 60 monitoring stations located throughout this District (Figure 8-1) and highlighted in Yukon Water Board Water Use Licence QZ12-057 Schedule A, Part I Monitoring Stations, for the following water quality parameters:

- ICP metals (dissolved and total) including:
    - Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Magnesium, Manganese, Molybdenum, Nickel, Potassium, Selenium, Silicon, Silver, Sodium, Strontium, Sulfur, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc and Zirconium.
- Hardness
- Sulphate, alkalinity, ammonia, , DOC
- pH
- Conductivity
- Total suspended solids (TSS)
- LT50

Laboratory analytical results will be compared against the site-specific Water Quality Goals developed for the individual watershed or the Canadian Council of Ministers of the Environment (CCME) 1999 Surface Water Quality Guidelines established for the protection of freshwater aquatic life. Individual events and ongoing trends will be assessed against the guidelines to determine improvements and or deterioration in surface water quality.

The proposed frequency of the site visits is assumed to be the same as that currently contained in Water Use Licence QZ12-057, however it is expected that the frequency of sampling can be reduced in half every ten years.



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

- Other Monitored Station
- QZ12-057 Licensed Active Monitored Station
- QZ12-057 Licensed Decommissioned Monitoring Station
- Shaft
- Adit
- Weather Station
- Highway
- Secondary Road
- Track
- Settling Pond
- Valley Tailings
- Keno District Mill Site

Catchments
- Keno Ladue River
- Mayo River
- South McQuesten River

Subcatchments
- Christal Creek
- No Cash Bog
- Flat Creek
- Lightning Creek

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CLOSURE OPTIONS REPORT

FIGURE 8-1

KENO HILL SURFACE WATER QUALITY STATION LOCATIONS

FEBRUARY 2013

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8.2.2 Groundwater

The purpose of the groundwater monitoring program shall be to:

- Continue to assess impacts of those sites which were initiated as requirements of the Water Use License currently have treatment, or where elevated levels of contaminants of potential concern have been found to exist;
- Continue to assess the groundwater flow direction;
- Continue to assess vertical and horizontal hydraulic gradients;
- Continue to monitor the potential flux of contaminants in groundwater in all receptors as described in Water Use Register QZ12-057; and
- Continue water balance and load modeling.

There will be approximately 45 groundwater monitoring wells (Figure 8-2) throughout the District. Historic mine workings such as adits will require monitoring wells to be located in close proximity to assess impacts to groundwater.

In general the following water quality parameters will be collected:

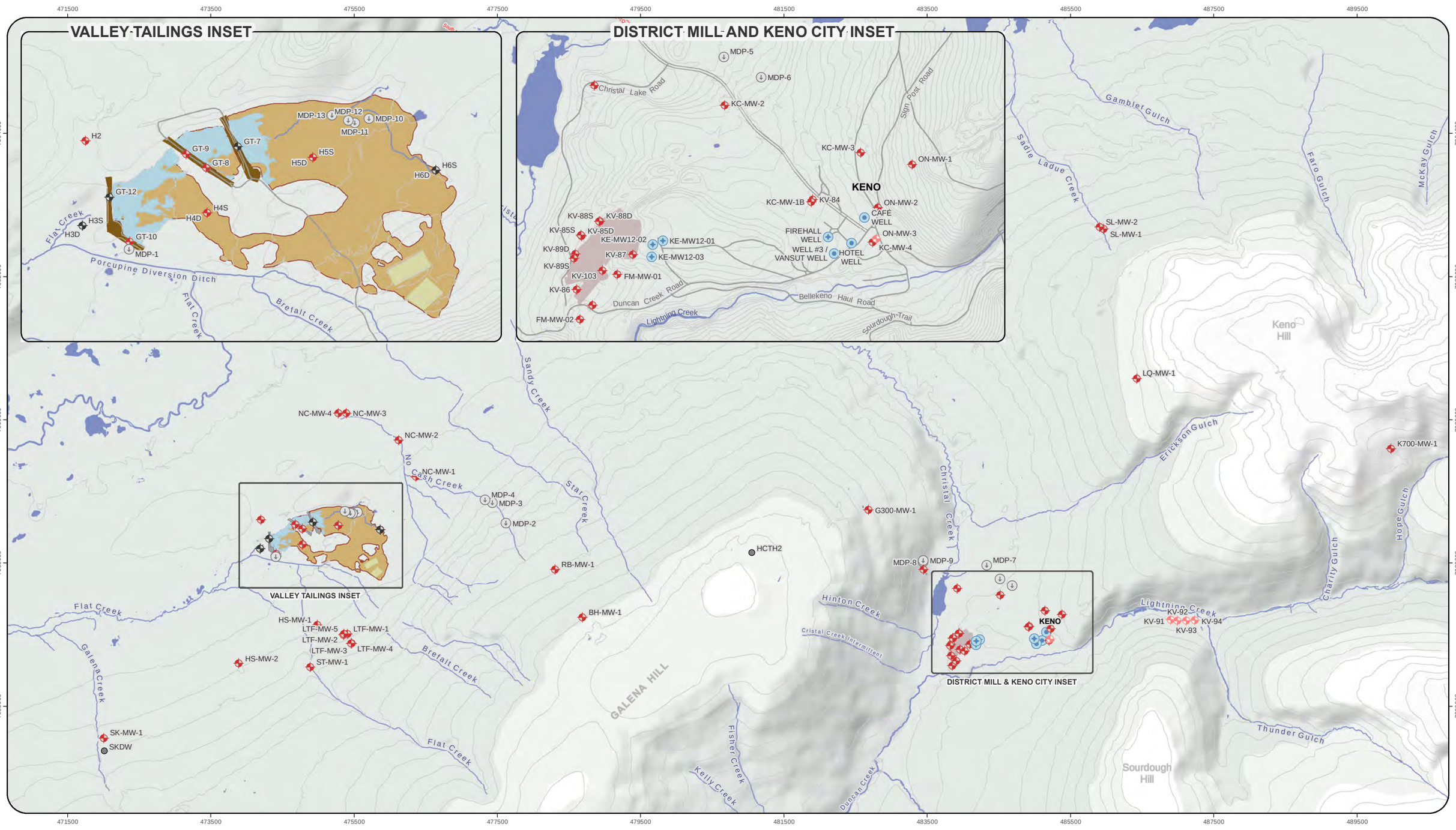
- ICP metals (dissolved and total) including:
- Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Magnesium, Manganese, Molybdenum, Nickel, Potassium, Selenium, Silicon, Silver, Sodium, Strontium, Sulfur, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc and Zirconium.
- Hardness
- pH
- Conductivity
- Total suspended solids (TSS)
- Median Lethal Time (LT_{50})

Laboratory analytical results will be compared against the site-specific Water Quality Goals developed for the individual watershed or the Canadian Council of Ministers of the Environment (CCME) 1999 Surface Water Quality Guidelines established for the protection of freshwater aquatic life. Individual events and ongoing trends will be assessed against the guidelines to determine improvements and or deterioration in groundwater quality.

The proposed frequency of the site visits are as follows:

- Quarterly for years 0 - 10
- Annually for years 11 - 20
- Semi-annually for years 21 - 30

Site visits will be conducted concurrently with the geotechnical site visits where possible to have concurrent site visits and corresponding data to compare potential geotechnical issues with changes in groundwater quality data. Deterioration in water quality data may be an indicator of deterioration of waste structures and or decommissioned/closed mine shafts or adits.



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

- Monitoring Well
- Pending Monitoring Well
- Decommissioned Monitoring Well
- Private Drilled Well
- Public Drilled Well
- Water Supply Well
- Manual Drive Point
- Decommissioned Manual Drive Point
- Drill Hole
- Highway
- Secondary Road
- Contours (50m intervals)
- District Mill Site
- Valley Tailings
- Valley Tailings Sludge
- Valley Tailings Dam
- Valley Tailings Ponds

* S = shallow well, D = deep well; usually these wells are right next to each other and appear as one single point on the map

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CLOSURE OPTIONS REPORT

FIGURE 8-2
GROUNDWATER MONITORING STATION LOCATIONS

NOVEMBER 2013

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8.3 BIOTA SEDIMENT AND BENTHIC ORGANISMS AND VEGETATION

8.3.1 Sediment and Benthic Organisms

Sediment and benthic monitoring will be conducted, consistent with National Protocols for Environmental Effects Monitoring, during the term of the licence, sampling and analysis conducted as described below at the following sampling stations found in clause 35 of WUL QZ12-057 for each program:

- KV –I
- KV-3
- KV-4
- KV-9
- KV-7

The studies will be carried out by persons qualified to do so by education and/or experience.

Sediment samples will be collected, dried and screened, using progressively smaller sieves as determined by the following ASTM standard (ASTM-E 11 -61). A sub-sample composed of material passing through the 100 mesh number sieve shall be analyzed for metals by a 33 element ICP scan. Loss on ignition shall also be determined by heating the sample to 600 degrees C.

Benthic invertebrate samples shall be taken from each station/area following the CABIN protocol:

- Benthic samples shall be preserved, and identified to the lowest possible taxon (usually genus) and counted; and
- Stream information collected at the time of the benthos collection will include stream channel velocity, stream depth, stream temperature, substrate conditions and riparian conditions.

The proposed frequency of the site visits are as follows:

- Every three years for years 0 - 30

Site visits will be conducted concurrently with the other data collection requirements where possible to have concurrent site visits and corresponding data to compare impacts with potential geotechnical issues, and or water quality data. Deterioration in sediment quality and or benthic quality may correspond with deterioration of waste containment structures, decommissioned/closed mine shafts or adits, and or a decline in water quality for surface water and or groundwater.

8.3.2 Soil and Vegetation

Soil and vegetation monitoring will assess the success of the establishment of sustainable plant communities. Monitoring will include quantitative attributes of vegetation such as percent cover, plant height, survival rates for plugs or seedlings, vigour and biomass of soil covers, previously disturbed sites and reclaimed sites.

This restoration program aims to restore natural succession, ecosystem function and structure, and resiliency to reclaimed areas throughout the District. Vegetation will be monitored annually for three years following implementation. Beginning in year four, monitoring rotation will occur once every two years or until the plant community is self-sustaining. Performance criteria will be drawn from comparative analysis of less disturbed sites, permanent plots, and from relevant literature sources.

Soil and vegetation will be assessed using:

- ICP metals (dissolved and total) including:
    - Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Magnesium, Manganese, Molybdenum, Nickel, Potassium, Selenium, Silicon, Silver, Sodium, Strontium, Sulfur, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc and Zirconium.
- pH
- N-P-K

The proposed frequency of the site visits are as follows:

- Annually for years 0 - 3
- Semiannually for years 4 - 10
- Once every five years for years 10 +

9 CLOSURE OPTION COSTING

9.1 CLOSURE COST ESTIMATE PREPARATION AND USE

This section describes the estimated closure costs for the individual simple and complex sites on a watershed basis. Cost is one of the criteria that will be used to evaluate closure options. The cost estimate information presented in this report was generated with input from Alexco Environmental Group, EBA Engineering Consultants, Interralogic, and SRK. Copies of the individual memos and documents related to the development of costs are referenced in this section of the report. Modifications to the costing have been conducted since the first draft of this report based on ongoing site investigations in order to attempt and refine the level of accuracy of the costing estimate.

The costs presented in this report are considered as being accurate to "Level 5" criteria (+100% to -50%). The costs presented are for implementation of the closure and reclamation of all site mine components associated with the historic UKHM liability, and include 30 years of operations, in 2012 dollars, including maintenance, monitoring, and reporting, as required. Refinement of the costing presented in this report will be refined following the closure options selection process in order to achieve an Indicative Level with an associated accuracy of $\pm$ 20% – 30%. This level of costing accuracy is required by Canada for compliance with Treasury Board requirements, prior to the ESM Reclamation Plan being submitted for assessment by the Yukon Environmental Socio-economic Assessment Board.

Costing associated with post-implementation monitoring requirements for the individual sites are discussed at the end of this section.

9.2 BASIC COSTING ASSUMPTIONS (EARTHWORKS)

Interralogic developed costing related to the waste rock dumps and backfilling of open pits where this activity is being considered (Interralogic 2011a). This section described the assumptions that were used in their costing. Earthworks costing developed by ERDC for units not included by ITL (e.g. optional covers at Ruby or Townsite) are presented as standalone costing sheets.

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 in Section 5.4. In each figure, 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 where WRSA or tailings sites are adjacent to streams 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. The cross sectional area of the berm was 3.75 m^2, which was sized for the largest watershed and applied to all WRSA. 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 covers, including loading, hauling, placing the cover, and seeding was $9.71/square meter.

The method for estimating costs for the 1.0 m infiltration-prevention 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-prevention 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 unit 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. The Onek costing has been subsequently refined based on ongoing discussions around Onek Production Unit boundaries and as such the updated costing developed by ERDC is what has been presented in this section of the report.

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, but will be placed in a sloped configuration to assist runoff. The average unit cost of the cover for the pit backfill areas was $14.80/cubic meter.

9.3 BASIC COSTING ASSUMPTIONS (ADITS AND SHAFT)

EBA prepared a summary of estimated construction costs for shaft closure at the various sites across Keno Hill (EBA 2011). These costs are considered as being to a preliminary design level 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, an alternative would be to employ an on-site batch plant using 1 yd^3 bulk bags of dry ready-mix, although this would be more expensive than what is in the estimate now;

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.

9.4 BASIC COSTING INFORMATION (COMPLEX SITES)

This section describes the information used by ERDC in the development of costing associated with the treatment of water at complex sites associated with adits (ERDC 2013a).

9.4.1 Managed Natural Attenuation

Managed Natural Attenuation (MNA) requires proper setup to ensure performance. The basic set-up required for MNA to be effective includes:

- Initial aeration where water, once collected from the adit, is tumbled through a buried cascading structure and aerated;
- A settling basin where heavier particulates are allowed to settle; and,
- Passive injection trenches where water is collected and then discharged through permeable trenches or infiltration gallery sections that are installed perpendicular to the slope. This disperses the discharged water and provides non-destructive attenuation as existing biomass filters the water.

The long-term monitoring of the site is necessary and requires the largest amount of costs associated with this treatment system when conducting MNA. Monitoring is required to demonstrate that contaminant concentrations continue to decrease at a rate sufficient to ensure regulatory criteria, as well as provide direction in the event that additional reagents are necessary for treatment. ERDC proposes initial monthly monitoring studies conducted at each MNA adit as well as the receiving environment. Once the MNA system is proven to be effective, monitoring will be reduced to quarterly studies for five years, and then transitioning to annually for 5 years, and finally transitioning to every five years until closure. Settling basin cleanout is recognized to be a site-specific variable that will be evaluated further if this option is selected for a particular site.

9.4.2 Mine Pool Treatment

Earlier closure studies performed by SRK (2008c) included an assessment of closure options for 70 known adits in the District on behalf of ERDC. Closure options were considered for each adit, with objectives for each adit closure including preventing public access, water control, and water treatment. For eight adits, adit plugs were recommended for primary consideration. An adit plug would provide the ability to control mine drainage rate and timing, potentially allowing for treatment in seasonal campaigns or for temporary control of drainage during maintenance of treatment projects outside of the adit. An adit plug may also be part of an underground water treatment project where the underground mine pool behind the adit plug could be the vessel for water treatment. The adits where adit plugs were recommended were Silver King 100, No Cash 500, Galkeno 300, Galkeno 900, Onek

400, Keno 700, and Sadie Ladue 600. Each of these locations is a "complex site" where there is an existing discharge that is being treated or may be treated in the future.

The sites where mine pool treatment is being considered are: Keno 700 and Silver King 100 (which discharge from mine pools); Bermingham (which is sourced from has a small pit lake/mine pool that is drained from the Bermingham 200 adit); Husky SW shaft (which is understood to be connected to both the Husky SW and Husky flooded underground mines and through underground connections also receives drainage from the Elsa mine); and 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.

The analysis in this document is intended to define costs associated with the initial installation of a mine pool injection and monitoring system, as well as the estimate for 30 years of reagent costs and long-term monitoring costs associated with treatment.

The common elements of an underground mine pool treatment facility therefore includes:

- Adit plug to allow controlled discharge and potential recycle into the mine as the mine pool treatment chemistry develops. It is not anticipated that this adit plug would create an elevated mine pool above what is already present, other than perhaps the level that the adit plug would be located on;

- Injections point(s) that allow for reagents to be injected into the mine pool at a distance sufficiently far from the adit discharge, either through the adit plug, or through a drilled well or surface pit infiltration area;

- A reagent injection station will be installed above the injection point(s) to provide reagent injection storage and management; and

- Monitoring of the mine pool will be used to manage the treatment process.

9.4.3 Bioreactor Treatment

Section 5.3.3 discusses sulphate reducing bioreactor technology, and testing this technology for its potential application in the Keno District. The adit locations where a bioreactor appears to be a feasible technology to be implemented for at least a portion of the treatment requirements include the Flat Creek drainage sites (Silver King 100 and Husky SW), the No Cash drainage sites (No Cash 500, Ruby, and Bermingham), the Christal Creek sites (Galkeno 900, and Onek 400), the Keno Ladue River drainage site at Sadie Ladue 600, and the Lightning Creek site at Keno 700.

The common elements of bioreactor facilities therefore will include:

- Collection and conveyance structures to take water from the mine adit and transport it into the bioreactor cell(s);
- Lined bioreactor cells will be constructed to receive flow from the adit, and structures will be used to direct the flow through permeable media in which the sulphate reduction process can occur;
- Facilities to inject soluble carbon into the bioreactor;
- Monitoring of ports in the bioreactor and at its discharge will be used to modify treatment as necessary; and
- Aeration of bioreactor discharge so that it is aerated prior to surface water.

9.4.4 Active Water Treatment Facility

The installation, operation, and maintenance of an actively managed Water Treatment Facility (WTF) is another option of ensuring effluent waters meet emission standards. However, the design, build, and operation/maintenance of an active treatment facility can be expensive, typically ranging from $3M to $12M for a thirty year operation cycle at flow rates between 2.0 to 14.0 litres per second.

The Water Treatment Facilities quoted in this report include similar proposed designs, with the process of active treatment as follows:

- Adit discharge water is collected in a pipe and is either pumped or gravity flows to the treatment facility;
- Water first enters the Reactor Chamber of a Clarifier where it is actively mixed and amended with a lime slurry, an iron source, and/or a flocculent;
- Water then up-wells along the settling plates of the Clarifier. This process separates cleaner water which is decanted from the top of the Clarifier, while heavier particles accumulate as a sludge at the base of the Clarifier;
- If no additional treatment is required, the decanted water is then discharged to either a lined settling pond or to the receiving environment through either a pipe discharged to a stream or a pipe buried along an injection trench;
- At smaller treatment facilities, the collected sludge may be pumped into geotextile bags which then slowly densifies and dewaters the sludge;
- Another option is to discharge the collected sludge to a filter press where the sludge is manually dewatered and disposed of;
- For larger treatment facilities, the collected sludge may be sent to a Thickener where the sludge is compacted further before it is discharged to a Filter Press; and

- The Filter Press provides a final compaction step where 2/3 of the water is removed and sent back to the Reactor for re-treatment. The remaining water and solids from the Filter Press form a "cake" of solid material that can be hauled and disposed of in a landfill.

A visual layout of the system described above can be found in Figure 9-1 below:

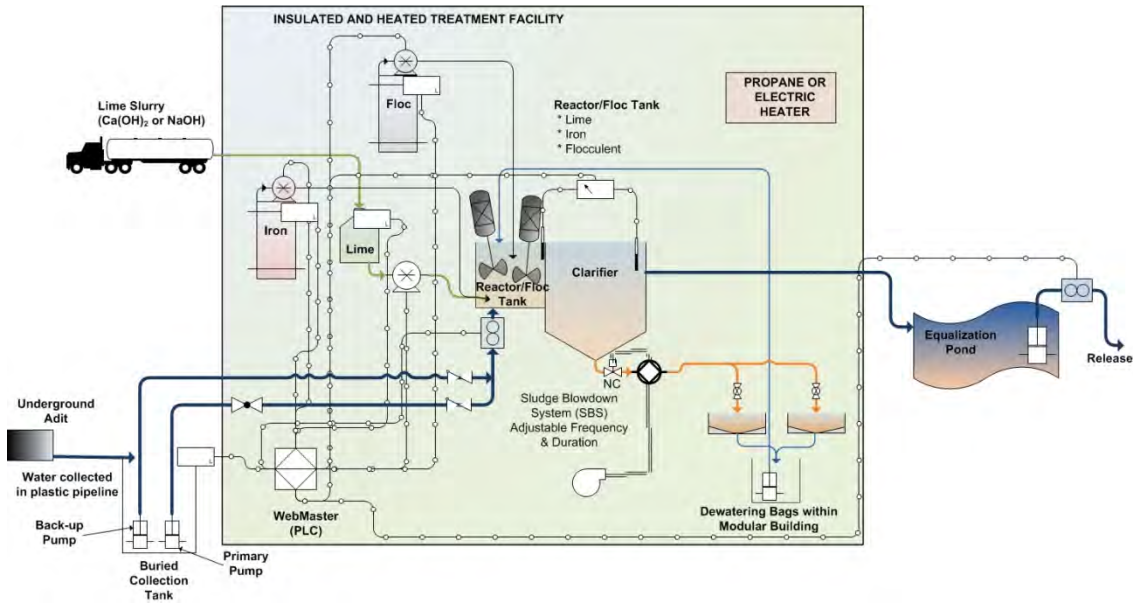


Figure 9-1 Layout of Water Treatment Facility

With most water treatment facilities, the majority of costs come from the required reagents (lime, iron, and flocculants) and the labor required for operation and maintenance. In addition, because water treatment facilities only treat the discharged water and not the source of underground contamination, water treatment facilities must be operated indefinitely to ensure effluent waters meet standards.

Similar to other treatment methods, long-term monitoring of the water treatment facility's influent/effluent is necessary. Monitoring is required to demonstrate that contaminant concentrations in the receiving environment remain unchanged or decrease at a rate sufficient to meet regulatory requirements.

9.5 FLAT CREEK WATERSHED

9.5.1 Husky SW

Table 9-1 shows the summary closure costs for the Husky SW site for the common elements proposed for implementation at this site. Table 9-2 shows the closure costs for the different closure options being evaluated to address metal loading from the underground workings for all options. The cost for

the demolition and removal of debris associated with the Husky SW headframe and hoist raise building are covered in the Physical Hazards Reduction Program for the District and not included in this report. Other site debris removal costs are also included in the costing under that program.

Table 9-1 Husky SW Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Husky SW Shaft	Installation of concrete cap with drainage pipe for discharge of water from underground workings	l.s.	1	$ 100,000.00	$ 100,000.00
				Sub-total:	$ 100,000.00
Waste Rock Storage Area and Earthworks					
	Recontouring of waste rock to minimize concentration of water	l.s.	1	$ 3,000.00	$ 2,500.00
	Removal of slough material adjacent to Husky SW headframe and install catch berm (spoil material placed onto adjacent waste rock area)	l.s.	1	$ 18,500.00	$ 18,500.00
	Revegetation of waste rock dump surface	l.s.	1	$ 14,000.00	$ 14,000.00
				Sub-total:	$ 35,000.00
Estimated Cost of Common Closure Element for Husky SW Site					**$ 135,000.00**

Table 9-2 Husky SW Closure Options Costs

Site Name:	*Husky SW Adit*			
Water Discharge Rate (lps):	*0.4*			
Work Item	**Description**	**Qnty**	**Unit Cost**	**Total Cost**
	Managed Natural Attenuation			
CapEx	Initial Installation of Support Facility	1	$ -	$ -
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 70,000.00	$ 70,000.00
OpEx	Operation & Maintenance for 30 years	1	$ 192,000.00	$ 192,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ -	$ -
OpEx	Additional Oversight/Taxes/etc.	1	$ 126,000.00	$ 126,000.00
			Sub-total:	**$ 388,000.00**
	Mine Pool Treatment			
CapEx	Initial Installation of Injection Facility	1	$ 54,000.00	$ 54,000.00
CapEx	Initial Installation of Injection Control & Monitoring System	1	$ 119,000.00	$ 119,000.00
OpEx	Operation & Maintenance for 30 years	1	$ 150,000.00	$ 150,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 94,000.00	$ 94,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 200,000.00	$ 200,000.00
			Sub-total:	**$ 617,000.00**
	Bioreactor			
CapEx	Initial Installation of Support Facility	1	$ 54,000.00	$ 54,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 147,000.00	$ 147,000.00
CapEx	Capital Replacement Costs after 20 years Operation	1	$ 220,500.00	$ 220,500.00
OpEx	Operation & Maintenance for 30 years	1	$ 219,000.00	$ 219,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 18,000.00	$ 18,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 210,000.00	$ 210,000.00
			Sub-total:	**$ 868,500.00**
	Active Water Treatment Facility			
CapEx	Initial Installation of Water Treatment Facility	1	$ 284,000.00	$ 284,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 77,000.00	$ 77,000.00
CapEx	Capital Replacement Costs for 30 years Operation	1	$ 330,658.00	$ 330,658.00
OpEx	Operation & Maintenance for 30 years	1	$ 531,000.00	$ 531,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 190,000.00	$ 190,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 519,000.00	$ 519,000.00
			Sub-total:	**$ 1,931,658.00**
	Reclamation Only			
CapEx	Initial Installation of Support Facility	1	$ -	$ -
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 61,000.00	$ 61,000.00
OpEx	Operation & Maintenance for 30 years	1	$ 84,000.00	$ 84,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ -	$ -
OpEx	Additional Oversight/Taxes/etc.	1	$ 70,000.00	$ 70,000.00
			Sub-total:	**$ 215,000.00**

9.5.2 Silver King

Table 9-3 shows the summary closure costs for the Silver King site for the common elements proposed for implementation at this site.

Table 9-3 Silver King Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
75 Adit Plug	Installation of waterproof seal, rip-rap Galena Creek adjacent to adit	l.s.	1	$ 45,000.00	$ 45,000.00
100 Adit Rehab	Adit rehab and installation of water collection and conveyance infrastructure	l.s.	1	$ 571.000.00	$ 571.000.00
Vent Raise	Concrete Cap and debris removal	l.s.	1	$ 37,000.00	$ 37,000.00
Shaft #1 (Open Pit)	Concrete Cap	l.s.	1	$ 25,000.00	$ 25,000.00
Shaft #2	Dry Seal	l.s.	1	$ 10,000.00	$ 10,000.00
Raise #1	Dry Seal	l.s.	1	$ 10,000.00	$ 10,000.00
				Sub-total:	$127,000.00
100 Area Waste Rock Storage Area					
	Pullback waste rock from adjacent to Galena Creek and old treatment pond recontouring	l.s.	1	$ 2,500.00	$ 2,500.00
	Rip-rap bank near to Galena Creek	l.s.	1	$ 80,200.00	$ 80,200.00
	Remove load-out and site debris	l.s.	1	$ 12,400.00	$ 12,400.00
	Seed dump area	l.s.	1	$ 2,200.00	$ 2,200.00
				Sub-total:	$ 97,300.00
Decommission Existing Treatment Site					
	Decommission building and remove piping	l.s.	1	$ 2,300.00	$ 2,300.00
	De-sludge pond	l.s.	1	$ 1,100.00	$ 1,100.00
	Remove liner and pond infrastructure	l.s.	1	$ 8,500.00	$ 8,500.00
	Revegetation of area	l.s.	1	$ 2,300.00	$ 2,300.00
	Equipment mob-demob	l.s.	1	$ 1,100.00	$ 1,100.00
				Sub-total:	$ 15,300.00
Open Pit and Associated Waste Rock Storage Area					
	Recountouring dump face to 2.5H:1V	l.s.	1	$ 10,000.00	$ 10,000.00
	Highwall safety and diversion berms	l.s.	1	$ 26,000.00	$ 26,000.00
	Armouring of drainage channel for diverted water (rip-rap + filter fabric)	l.s.	1	$ 3,100.00	$ 3,100.00
	Backfill pit to free-draining	l.s.	1	$ 9,100.00	$ 9,100.00
	Install soil cover onto pit area	l.s.	1	$ 118,700.00	$ 118,700.00
	Revegetation of pit and dump area	l.s.	1	$ 10,400.00	$ 10,400.00
				Sub-total:	$ 177,300.00
Estimated Cost of Common Closure Element for Silver King Site					**$416,900.00**

Table 9-4 shows the closure costs for the different closure options being evaluated to address metal loading from the underground workings.

Table 9-4 Silver King Closure Options Costs

Site Name:	*Silver King 100 Adit*			
Water Discharge Rate (lps):	*5.6*			
Work Item	**Description**	**Qnty**	**Unit Cost**	**Total Cost**
	Managed Natural Attenuation			
CapEx	Initial Installation of Support Facility	1	$ -	$ -
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 130,000.00	$ 130,000.00
OpEx	Operation & Maintenance for 30 years	1	$ 220,000.00	$ 220,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 89,000.00	$ 89,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 211,000.00	$ 211,000.00
			Sub-total:	**$ 650,000.00**
	Mine Pool Treatment			
CapEx	Initial Installation of Injection Facility	1	$ 54,000.00	$ 54,000.00
CapEx	Initial Installation of Injection Control & Monitoring System	1	$ 319,000.00	$ 319,000.00
OpEx	Operation & Maintenance for 30 years	1	$ 185,000.00	$ 185,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 994,000.00	$ 994,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 744,000.00	$ 744,000.00
			Sub-total:	**$ 2,296,000.00**
	Bioreactor			
CapEx	Initial Installation of Support Facility	1	$ 54,000.00	$ 54,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 327,000.00	$ 327,000.00
CapEx	Capital Replacement Costs after 20 years Operation	1	$ 490,500.00	$ 490,500.00
OpEx	Operation & Maintenance for 30 years	1	$ 289,000.00	$ 289,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 250,000.00	$ 250,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 441,000.00	$ 441,000.00
			Sub-total:	**$ 1,851,500.00**
	Active Water Treatment Facility			
CapEx	Initial Installation of Water Treatment Facility	1	$ 418,000.00	$ 418,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 212,000.00	$ 212,000.00
CapEx	Capital Replacement Costs for 30 years Operation	1	$ 625,796.00	$ 625,796.00
OpEx	Operation & Maintenance for 30 years	1	$ 1,339,000.00	$ 1,339,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 2,647,000.00	$ 2,647,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 2,212,000.00	$ 2,212,000.00
			Sub-total:	**$ 7,453,796.00**

9.5.3 Valley Tailings Facility

Table 9-5 shows the summary closure costs for the Valley Tailings site for the common elements proposed for implementation at this site. Detailed costing information and background information on the development of the costing is contained in the Interralogic Remedial Options Evaluation memo on the Valley Tailings Facility (Interralogic 2011b) and an updated costing memo developed by ERDC which includes costing associated with the dispersed tailings (ERDC 2013b) which are appended to this report.

Table 9-5 Valley Tailings Closure Options Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Valley Tailings Alternative 1					
	Clear and Grub Borrow Area to Stockpile	l.s.	1	$290,000.00	$290,000.00
	Reclaim Borrow Area By Replacing Stockpile	l.s.	1	$254,300.00	$254,300.00
	Tailings to be Relocated	l.s.	1	$788,600.00	$788,600.00
	Revegetation Cover, Reseed, Fertilize	l.s.	1	$3,422,400.00	$3,422,400.00
	Diversion Channels	l.s.	1	$509,400.00	$509,400.00
	Channel Rehab	l.s.	1	$566,300.00	$566,300.00
	Lime Added	l.s.	1	$4,985,800.00	$4,985,800.00
	Water Treatment	l.s.	1	$543,600.00	$543,600.00
	Dam Rehab	l.s.	1	$532,200.00	$532,200.00
	Compost	l.s.	1	$2,910,800.00	$2,910,800.00
	Manpower	l.s.	1	$602,000.00	$602,000.00
	Closure Indirect Costs (45% of Direct Costs)	l.s.	1	$6,994,100.00	$6,994,100.00
				Sub-total:	$22,399,500.00
Valley Tailings Alternative 2A					
	Clear and Grub Borrow Area to Stockpile	l.s.	1	$290,000	$290,000.00
	Reclaim Borrow Area by Replacing Stockpile	l.s.	1	$254,300	$254,300.00
	Tailings and Over Excavation to be Relocated	l.s.	1	$290,000.00	$3,230,200.00
	Revegetation Cover, Reseed, Fertilize	l.s.	1	$254,300.00	$2,414,300.00
	Diversion Channel	l.s.	1	$3,230,200.00	$509,400.00
	Channel Rehab	l.s.	1	$2,414,300.00	$566,300.00
	Lime Added	l.s.	1	$509,400.00	$4,797,200.00
	Water Treatment	l.s.	1	$566,300.00	$543,600.00
	Dam Rehab	l.s.	1	$4,797,200.00	$532,200.00
	Compost	l.s.	1	$543,600.00	$2,837,200.00
	Manpower	l.s.	1	$532,200.00	$602,000.00
	Closure Indirect Costs (45% of Direct Costs)	l.s.	1	$2,837,200.00	$7,525,900.00
				Sub-total:	$24,102,600.00
Valley Tailings Alternative 2B					
	Clear and Grub Borrow Area to Stockpile	l.s.	1	$290,000.00	$290,000.00
	Reclaim Borrow Area by Replacing Stockpile	l.s.	1	$254,300.00	$254,300.00
	Tailings and Over Excavation to be Relocated	l.s.	1	$3,230,200.00	$3,230,200.00
	Revegetation Cover, Reseed, Fertilize	l.s.	1	$3,887,800.00	$3,887,800.00

	Diversion Channels	l.s.	1	$514,400.00	$514,400.00
	Channel Rehab	l.s.	1	$566,300.00	$566,300.00
	Lime Added	l.s.	1	$5,868,500.00	$5,868,500.00
	Water Treatment	l.s.	1	$543,600.00	$543,600.00
	Dam Removal	l.s.	1	$28,500.00	$28,500.00
	Compost	l.s.	1	$3,453,000.00	$3,453,000.00
	Manpower	l.s.	1	$602,000.00	$602,000.00
	Closure Indirect Costs (45% of Direct Costs)	l.s.	1	$8,734,400.00	$8,734,400.00
				Sub-total:	$27,973,000.00
Valley Tailings Alternative 3					
	Clear and Grub Borrow Area to Stockpile	l.s.	1	$290,000.00	$290,000.00
	Reclaim Borrow Area by Replacing Stockpile	l.s.	1	$254,300.00	$254,300.00
	Tailings and Over Excavation to be Relocated	l.s.	1	$6,782,600.00	$6,782,600.00
	Revegetation Cover, Reseed, Fertilize	l.s.	1	$3,738,700.00	$3,738,700.00
	Diversion Channels	l.s.	1	$401,600.00	$401,600.00
	Channel Rehab	l.s.	1	$566,300.00	$566,300.00
	Lime Added	l.s.	1	$13,909,900.00	$13,909,900.00
	Water Treatment	l.s.	1	$543,600.00	$543,600.00
	Dam Removal	l.s.	1	$28,700.00	$28,700.00
	Compost	l.s.	1	$4,441,300.00	$4,441,300.00
	Submerged Tailings Pumping	l.s.	1	$3,788,300.00	$3,788,300.00
	Closure Indirect Costs (45% of Direct Costs)	l.s.	1	$18,082,800.00	$18,082,800.00
				Sub-total:	$52,828,100.00
Valley Dispersed Tailings					
	Initial Helicopter Mob/Demob	l.s.	1	$9,000.00	$9,000.00
	Rental of Argos to Transport Staff/Equipment	l.s.	1	$30,000.00	$30,000.00
	Stabilize Shoreline	l.s.	1	$66,400.00	$66,400.00
	Revegetate Tailings Islands	l.s.	1	$31,300.00	$31,300.00
	Remove Tailings Islands	l.s.	1	$36,200.00	$36,200.00
	Final Helicopter Mob/Demob	l.s.	1	$9,000.00	$9,000.00
	Indirect Costs (45% of Direct Costs)	l.s.	1	$81,900.00	$81,900.00
				Sub-total:	$263,800.00
Estimated Cost of Closure Alternative 1 for Valley Tailings					**$22,399,500.00**
Estimated Cost of Closure Alternative 2A for Valley Tailings					**$24,102,600.00**
Estimated Cost of Closure Alternative 2B for Valley Tailings					**$27,973,000.00**
Estimated Cost of Closure Alternative 3 for Valley Tailings					**$52,828,100.00**
Estimated Cost of Dispersed Tailings Remediation for Valley Tailings					**$263,800.00**

9.5.4 Coral and Wigwam

Table 9-7 shows the summary closure costs for the Coral and Wigwam site for the common elements proposed for implementation at this site. Only minor works are proposed at this site.

Table 9-6 Coral and Wigwam Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Main shaft	Concrete cap	l.s.	1	$ 15,000.00	$ 15,000.00
				Sub-total:	$ 15,000.00
Trenches and Other Minor Shafts					
	Backfill	l.s.	1	$ 5,000.00	$ 5,000.00
				Sub-total:	$ 5,000.00
Estimated Cost of Common Closure Element for Coral and Wigwam Site					**$ 20,000.00**

9.5.5 Elsa Mine

The Elsa Mine site encompasses the existing Elsa Townsite in addition to a number of tributary adits that are located in the immediate proximity of the townsite. ERDC and the Alexco Keno Hill Mining Company are currently occupying a small portion of the townsite based on the existence of prior infrastructure that was occupied for Care and Maintenance support services prior to ERDC becoming involved in the Keno closure program. The costing presented for this area does not include the cost of demolition of existing buildings as those costs are being presented as part of the Physical Hazards Reduction Program.

There are a number of satellite underground access points (6 adits and 2 raises in total) that were developed historically in order to access the ore body. The location of most of these structures is known however additional field investigations will be required in order to confirm field conditions prior to detailed design. These additional works do not affect the overall level of costing associated with this report. Table 9-8 contains a cost for treating each of these sites as a single unit as opposed to breaking them out individually.

Table 9-7 Elsa Mine Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Unknown Shaft	Installation of concrete cap	l.s.	1	$ 10,000.00	$ 10,000.00
				Sub-total:	$ 10,000.00
Elsa Townsite Area Clean-up and Misc.					
	Removal of Garbage	l.s.	1	$ 22,500.00	$ 22,500.00
	Site re-contouring and crib wall removal	l.s.	1	$ 34,100.00	$ 34,100.00
	Steel and Other Non-Heritage Value Cleanup	l.s.	1	$ 43,400.00	$ 43,400.00
	Landfill of Garbage Dump and Other Materials	l.s.	1	$ 15,800.00	$ 15,800.00
	Mob/demob	l.s.	1	$ 1,000.00	$ 1,000.00
	Revegetation	l.s.	1	$ 11,500.00	$ 11,500.00
				Sub-total:	$128,300.00
Elsa WRSA Clean-up					
	Recontouring of Dumps	l.s.	1	$ 22,100.00	$ 22,100.00
	Debris Removal	l.s.	1	$ 37,100.00	$ 37,100.00
				Sub-total:	$ 59,200.00
Elsa Optional Cover over Mineralized Waste Rock (assuming 5 ha of cover at 0.5 m thickness)					
		l.s.	1	$236,900.00	$236,900.00
Estimated Cost of Elsa					**$197,500.00**
Estimated Cost of Elsa Closure with Optional Cover					**$434,400.00**

9.5.6 Gerlitski

Historical information pertaining to the Gerlitski site indicates that there are only two trenches existing at this site with no other known infrastructure or development. Access to the site has become revegetated and there are no previously documented drainages that intersect the historical development. ERDC proposes that the site be left in its current condition. Leaving the site in its current conditions would reduce the potential effects of re-opening the access into the site on sediment transport and wildlife.

Should it be determined that works are required at this site to address the historical trenching works then it is currently estimated that approximately 3 days of work for a D7 sized dozer or equivalent sized piece of equipment would be required. Additional costs for rehabbing of the access to the site and miscellaneous site works would require approximately 1 to 1.5 days of excavator time plus approximately $2,000 in revegetation costs.

9.5.7 Husky

Table 9-8 shows the summary closure costs for the Husky site for the common elements proposed for implementation at this site. The cost for the demolition and removal of debris associated with the Husky SW headframe and hoist raise building are covered in the Physical Hazards Reduction Program

for the District and not included in this report. Other site debris removals are also included in the costing under that program.

Table 9-8 Husky Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Husky Shaft	Installation of concrete cap with drainage pipe for discharge of water from underground workings	l.s.	1	$ 80,000.00	$ 80,000.00
Husky Raise	Installation of concrete cap	l.s.	1	$ 35,000,00	$ 35,000,00
				Sub-total:	$115,000.00
Waste Rock Storage Area and Earthworks					
	Recontouring of waste rock and site to minimize concentration of water	l.s.	1	$ 12,000.00	$ 12,000.00
	Soil cover onto mineralized waste rock (0.5 m) (optional)	m^3	5,250	$ 15.11	$ 79,300.00
	Revegetation of waste rock dump surface	l.s.	1	$ 11,050.00	$ 11,100.00
	Installation of drainage controls on access road (cross ditches and waterbars)	l.s.	1	$ 5,000.00	$ 5,000.00
				Sub-total:	$107,400.00
Estimated Cost of Common Closure Element for Husky Site					**$ 143,100.00**
Estimated Cost for Husky Site including mineralized waste rock cover					**$ 222,400.00**

9.6 NO CASH BOG

9.6.1 Bermingham

Table 9-10 shows the summary closure costs for the Bermingham site for the common elements proposed for implementation at this site. Table 9-11 shows the closure costs for the different closure options being evaluated to address metal loading from the underground workings.

Table 9-9 Bermingham Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Adit	Adit upgrades and installation of low pressure hydraulic plug	l.s.	1	$ 289,000.00	$ 289,000.00
				Sub-total:	$ 289,000.00
Waste Rock Storage Area and Earthworks					
	Re-contouring of waste rock to minimize erosion of dump faces	l.s.	1	$ 64,800.00	$ 64,800.00
	Revegetation of waste rock dump surface and rehabilitated areas	l.s.	1	$ 26,400.00	$ 26,400.00
	Construct drainage channel for adit discharge (includes filter fabric and rip-rap)	l.s.	1	$ 15,800.00	$ 15,800.00
				Sub-total:	$107,000.00
Open Pit					
	Construct highwall safety berm	l.s.	1	$ 60,800.00	$ 60,800.00
				Sub-total:	$ 60,800.00
Debris Removal					
	Debris removal/disposal	l.s.	1	$ 12,400.00	$ 12,400.00
				Sub-total:	$ 12,400.00
Estimated Cost of Common Closure Element for Bermingham Site					**$ 469,200.00**

Table 9-10 Bermingham Closure Options Costs

Site Name:	*Bermingham 200 Adit*			
Water Discharge Rate (lps):	*2.0*			
Work Item	Description	Qnty	Unit Cost	Total Cost
	Managed Natural Attenuation			
CapEx	Initial Installation of Support Facility	1	$ -	$ -
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 105,000.00	$ 105,000.00
OpEx	Operation & Maintenance for 30 years	1	$ 192,000.00	$ 192,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ -	$ -
OpEx	Additional Oversight/Taxes/etc.	1	$ 143,000.00	$ 143,000.00
			Sub-total:	**$ 440,000.00**
	Mine Pool Treatment			
CapEx	Initial Installation of Injection Facility	1	$ 54,000.00	$ 54,000.00
CapEx	Initial Installation of Injection Control & Monitoring System	1	$ 96,000.00	$ 96,000.00
OpEx	Operation & Maintenance for 30 years	1	$ 150,000.00	$ 150,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 508,000.00	$ 508,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 388,000.00	$ 388,000.00
			Sub-total:	**$ 1,196,000.00**
	Bioreactor			
CapEx	Initial Installation of Support Facility	1	$ 54,000.00	$ 54,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 198,000.00	$ 198,000.00
CapEx	Capital Replacement Costs after 20 years Operation	1	$ 297,000.00	$ 297,000.00
OpEx	Operation & Maintenance for 30 years	1	$ 219,000.00	$ 219,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 90,000.00	$ 90,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 269,000.00	$ 269,000.00
			Sub-total:	**$ 1,127,000.00**
	Active Water Treatment Facility			
CapEx	Initial Installation of Water Treatment Facility	1	$ 364,000.00	$ 364,000.00
OpEx	Initial Installation of Treatment & Monitoring System	1	$ 139,000.00	$ 139,000.00
CapEx	Capital Replacement Costs for 30 years Operation	1	$ 480,638.00	$ 480,638.00
OpEx	Operation & Maintenance for 30 years	1	$ 1,086,000.00	$ 1,086,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 946,000.00	$ 946,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 1,215,000.00	$ 1,215,000.00
			Sub-total:	**$ 4,230,638.00**
	New WTF at Elsa [a]			
CapEx	Initial Installation of Support Facility	1	$ 332,000.00	$ 332,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ -	$ -
CapEx	Capital Replacement Costs for 30 years Operation	1	$ 259,624.00	$ 259,624.00
OpEx	Operation & Maintenance for 30 years	1	$ 136,000.00	$ 136,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 946,000.00	$ 946,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 678,000.00	$ 678,000.00
			Sub-total:	**$ 2,351,624.00**

[a] The costs of the initial installation of the treatment and monitoring system at the Elsa facility are bourne in the Galkeno 300 costing table, since it represents the single largest contributor to the plant. The costs listed here are the incremental costs associated with treatment of Bermingham adit water at the Elsa WTF.

9.6.2 No Cash 500 Level Adit

Table 9-12 shows the summary closure costs for the No Cash 500 site for the common elements proposed for implementation at this site. Table 9-12 shows the closure costs for the different closure options being evaluated to address metal loading from the underground workings.

Table 9-11 No Cash 500 Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
500 Level Adit	Upgrade adit and install bulkhead with drainage pipe to ensure free drainage, remove adit debris	l.s.	1	$ 311,000.00	$ 311,000.00
				Sub-total:	$311,000.00
Waste Rock Storage Area, Pit and Earthworks					
	Re-contouring of waste rock to minimize erosion of dump surface.	l.s.	1	$ 4,500.00	$ 4,500.00
	Adit drainage channel construction (including rip-rap and filter fabric)	l.s.	1	$ 11,200.00	$ 11,200.00
	Low Permeability cover installation onto surface of adit dump	l.s.	1	$ 7,600.00	$ 7,600.00
	Revegetation of waste rock dump surface and area	l.s.	1	$ 4,300.00	$ 4,300.00
				Sub-total:	$ 27,600.00
Loadout and Debris Removal					
	Loadout, adit building and debris removal/disposal	l.s.	1	$ 12,400.00	$ 12,400.00
				Sub-total:	$ 12,400.00
Estimated Cost of Common Closure Element for No Cash 500 Site					**$ 352,800.00**

The loadout materials will be disposed of at the site either through burial within the recontoured dump or dispersed onto the surface to provide organic matter for the assist in the development of a post implementation soils.

Table 9-12 No Cash 500 Closure Options Costs

Site Name:	*No Cash 500*			
Water Discharge Rate (lps):	*5.5*			
Work Item	**Description**	**Qnty**	**Unit Cost**	**Total Cost**
	Managed Natural Attenuation			
CapEx	Initial Installation of Support Facility	1	$ -	$ -
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 122,000.00	$ 122,000.00
CapEx	Treatment and monitoring system replacement	0.5	$ 122,000.00	$ 61,000.00
OpEx	Operation & Maintenance for 30 years	1	$ 220,000.00	$ 220,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ -	$ -
OpEx	Additional Oversight/Taxes/etc.	1	$ 164,000.00	$ 164,000.00
			Sub-total:	**$ 506,000.00**
	Mine Pool Treatment			
CapEx	Initial Installation of Injection Facility	1	$ 54,000.00	$ 54,000.00
CapEx	Initial Installation of Injection Control & Monitoring System	1	$ 199,000.00	$ 199,000.00
CapEx	Injection control and monitoring system replacement	0.25	$ 253,000.00	$ 63,250.00
OpEx	Operation & Maintenance for 30 years	1	$ 184,000.00	$ 184,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 569,000.00	$ 569,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 482,000.00	$ 482,000.00
			Sub-total:	**$ 1,488,000.00**
	Bioreactor			
CapEx	Initial Installation of Support Facility	1	$ 54,000.00	$ 54,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 327,000.00	$ 327,000.00
CapEx	Capital Replacement Costs after 20 years Operation	1	$ 490,500.00	$ 490,500.00
OpEx	Operation & Maintenance for 30 years	1	$ 287,000.00	$ 287,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 245,000.00	$ 245,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 438,000.00	$ 438,000.00
			Sub-total:	**$ 1,841,500.00**
	Active Water Treatment Facility			
CapEx	Initial Installation of Water Treatment Facility	1	$ 386,000.00	$ 386,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 212,000.00	$ 212,000.00
CapEx	Capital Replacement Costs for 30 years Operation	1	$ 600,772.00	$ 600,772.00
OpEx	Operation & Maintenance for 30 years	1	$ 1,336,000.00	$ 1,336,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 2,600,000.00	$ 2,600,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 2,172,000.00	$ 2,172,000.00
			Sub-total:	**$ 7,306,772.00**
	New WTF at Elsa			
CapEx	Initial Installation of Support Facility	1	$ 207,000.00	$ 207,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ -	$ -
CapEx	Capital Replacement Costs for 30 years Operation	1	$ 161,874.00	$ 161,874.00
OpEx	Operation & Maintenance for 30 years	1	$ 292,000.00	$ 292,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 2,600,000.00	$ 2,600,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 1,485,000.00	$ 1,485,000.00
			Sub-total:	**$ 4,745,874.00**

[a] The costs of the initial installation of the treatment and monitoring system at the Elsa facility are bourne in the Galkeno 300 costing table, since it represents the single largest contributor to the plant. The costs listed here are the incremental costs associated with treatment of No Cash 500 adit water at the Elsa WTF.

9.6.3 Ruby

Table 9-14 shows the summary closure costs for the Ruby site for the common elements proposed for implementation at this site. The Ruby waste rock dump is constructed from mineralized wastes and as a result the cost of an optional soil cover has also been included for this site. Table 9-14 shows the closure costs for the different closure options being evaluated to address metal loading from the underground workings.

Table 9-13 Ruby Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Ruby Adit	Adit upgrades and installation of low pressure hydraulic plug	l.s.	1	$ 302,000.00	$ 302,000.00
Ruby Shaft	Concrete Cap	l.s.	1	$ 10,000.00	$ 10,000.00
				Sub-total:	$312,000.00
Waste Rock Storage Area, Pit and Earthworks					
	Re-contouring of waste rock to minimize erosion of dump surfaces	l.s.	1	$ 8,900.00	$ 8,900.00
	Adit drainage channel construction (including rip-rap and filter fabric)	l.s.	1	$ 6,100.00	$ 6,100.00
	Revegetation of waste rock dump surface and area	l.s.	1	$ 2,900.00	$ 2,900.00
	Low Permeability 1m cover installation onto surface of adit dump (optional)	l.s.	5,313	$14.73	$ 78,300.00
				Sub-total:	$96,200.00
Loadout and Debris Removal					
	Loadout, adit building and debris removal/disposal	l.s.	1	$ 12,400.00	$ 12,40.00
				Sub-total:	$ 12,400.00
Estimated Cost of Common Closure Element for Ruby Site					**$ 342,300.00**
Estimated Cost for Ruby Site including optional cover over mineralized waste					**$ 420,600.00**

The loadout materials will be disposed of at the site either through burial within the recontoured dump or dispersed onto the surface to provide organic matter for the assist in the development of a post implementation soils.

Table 9-14 Ruby Closure Options Costs

Site Name:	*Ruby 400 Adit*			
Water Discharge Rate (lps):	*1.0*			
Work Item	**Description**	**Qnty**	**Unit Cost**	**Total Cost**
	Managed Natural Attenuation			
CapEx	Initial Installation of Support Facility	1	$ -	$ -
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 84,000.00	$ 84,000.00
OpEx	Operation & Maintenance for 30 years	1	$ 186,000.00	$ 186,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ -	$ -
OpEx	Additional Oversight/Taxes/etc.	1	$ 130,000.00	$ 130,000.00
			Sub-total:	**$ 400,000.00**
	Mine Pool Treatment			
CapEx	Initial Installation of Injection Facility	1	$ 54,000.00	$ 54,000.00
CapEx	Initial Installation of Injection Control & Monitoring System	1	$ 176,000.00	$ 176,000.00
OpEx	Operation & Maintenance for 30 years	1	$ 140,000.00	$ 140,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 274,000.00	$ 274,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 309,000.00	$ 309,000.00
			Sub-total:	**$ 953,000.00**
	Bioreactor			
CapEx	Initial Installation of Support Facility	1	$ 54,000.00	$ 54,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 198,000.00	$ 198,000.00
CapEx	Capital Replacement Costs after 20 years Operation	1	$ 297,000.00	$ 297,000.00
OpEx	Operation & Maintenance for 30 years	1	$ 199,000.00	$ 199,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 45,000.00	$ 45,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 238,000.00	$ 238,000.00
			Sub-total:	**$ 1,031,000.00**
	Active Water Treatment Facility			
CapEx	Initial Installation of Water Treatment Facility	1	$ 279,000.00	$ 279,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 139,000.00	$ 139,000.00
CapEx	Capital Replacement Costs for 30 years Operation	1	$ 414,168.00	$ 414,168.00
OpEx	Operation & Maintenance for 30 years	1	$ 586,000.00	$ 586,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 473,000.00	$ 473,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 708,000.00	$ 708,000.00
			Sub-total:	**$ 2,599,168.00**
	New WTF at Elsa [a]			
CapEx	Initial Installation of Support Facility	1	$ 315,000.00	$ 315,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ -	$ -
CapEx	Capital Replacement Costs for 30 years Operation	1	$ 246,330.00	$ 246,330.00
OpEx	Operation & Maintenance for 30 years	1	$ 105,000.00	$ 105,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 473,000.00	$ 473,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 428,000.00	$ 428,000.00
			Sub-total:	**$ 1,567,330.00**

[a] The costs of the initial installation of the treatment and monitoring system at the Elsa facility are bourne in the Galkeno 300 costing table, since it represents the single largest contributor to the plant. The costs listed here are the incremental costs associated with treatment of Ruby adit water at the Elsa WTF.

9.6.4 Betty

Table 9-16 shows the summary closure costs for the Betty site for the common elements proposed for implementation at this site. Only minor works are proposed at this site.

Table 9-15 Betty Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Betty Shafts	Concrete cap	l.s.	1	$ 20,000.00	$ 20,000.00
				Sub-total:	$ 20,000.00
Estimated Cost of Common Closure Element for Betty Site					**$ 20,000.00**

The cabins at this site will be left to rot in place as there are no identified hazardous materials. The small trenches at the site will also be left as they are not deep enough to warrant remediation.

9.6.5 Dixie

Table 9-17 shows the summary closure costs for the Dixie site for the common elements proposed for implementation at this site. The Dixie waste rock dump is constructed from mineralized wastes and as a result the cost of an optional soil cover has also been included for this site.

Table 9-16 Dixie Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Dixie Shaft	Installation of concrete cap	l.s.	1	$ 25,000.00	$ 25,000.00
Dixie Portal	Free draining rock plug	l.s.	1	$ 5,000.00	$ 5,000.00
Vent Raises (2)	Installation of concrete cap	l.s.	2	$ 10,000.00	$ 20,000.00
				Sub-total:	$50,000.00
Waste Rock Storage Area and Earthworks					
	Recontouring of waste rock to address gullying and promote shedding of water	l.s.	1	$ 2,000.00	$ 2,000.00
	1 m thick soil cover onto mineralized waste rock (optional)	m^3	5,040	$7.39	$ 39,100.00
	Revegetation of waste rock dump surface	l.s.	1	$ 1,900.00	$ 1,900.00
				Sub-total:	$ 43,000.00
Loadout and Building Debris Removal					
	Loadout and building debris removal	l.s.	1	$ 12,400.00	$ 12,400.00
				Sub-total:	$ 12,400.00
Estimated Cost of Common Closure Element for Dixie Site					**$ 66,300.00**
Estimated Cost for Dixie Site including optional cover over mineralized waste					**$ 105,400.00**

The waste rock for the portal plug will be source from the adjacent dump and be placed into the portal using a skidsteer unit. Following placement of waste rock inside the portal to form the interior portion of the plug, a larger excavator will be used to pile waste rock up against the portal. The removal of the load-out and building debris will be conducted at the start of the project. The wooden debris from the loadout is unpainted wood and will be buried at the site while the building will be demolished and hauled to a landfill in Elsa based on the presence of asbestos containing materials. Contaminated soils identified at this site will be hauled to the District Land Treatment Facility (LTF) and treated for hydrocarbon contamination.

9.6.6 No Cash 100 Level Adit

Table 9-18 shows the summary closure costs for the No Cash 100 site for the common elements proposed for implementation at this site.

Table 9-17 No Cash 100 Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
100 Level Adit	Upgrade adit and install bulkhead with drainage pipe to ensure free drainage	l.s.	1	$ 115,000.00	$ 115,000.00
Brefault Shaft	Concrete cap	l.s.	1	$ 40,000.00	$ 40,000.00
				Sub-total:	$155,000.00
Waste Rock Storage Area and Pit					
	Re-contouring of waste rock to minimize erosion of dump surface	l.s.	1	$ 4,500.00	$ 4,500.00
	Drainage channel construction (including rip-rap and filter fabric)	l.s.	1	$ 20,500.00	$ 20,500.00
	Rehabilitation of site access roads	l.s.	1	$ 7,000.00	$ 7,000.00
	Revegetation of waste rock dump surface and rehabilitated areas	l.s.	1	$ 6,000.00	$ 6,000.00
				Sub-total:	$ 38,000.00
Debris Removal					
	Debris removal/disposal	l.s.	1	$ 12,400.00	$ 12,400.00
				Sub-total:	$ 12,400.00
Estimated Cost of Common Closure Element for No Cash 100 Site					**$ 205,400.00**

9.6.7 Townsite

Table 9-19 shows the summary closure costs for the Townsite site for the common elements proposed for implementation at this site. The Townsite waste rock dump is constructed from mineralized wastes and as a result the cost of an optional soil cover has also been included for this site.

Table 9-18 Townsite Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Townsite Adit	Adit was covered with rock in 2007 as part of Hazards Reduction Program and requires no further works				
				Sub-total:	2007
Waste Rock Storage Area and Earthworks					
	Recontouring of waste rock to minimize erosion and promote shedding of water	l.s.	1	$ 8,300.00	$ 8,300.00
	Low Permeability 1m cover installation onto surface of adit dump (optional)	m^3	5,641	$ 17.50	$ 98,700.00
	Revegetation of waste rock dump surface	l.s.	1	$ 4,700.00	$ 4,700.00
				Sub-total:	$ 13,000.00
Loadout and Building Debris Removal					
	Loadout and building debris removal	l.s.	1	$ 12,400.00	$ 12,400.00
				Sub-total:	$ 12,400.00
Estimated Cost of Common Closure Element for Townsite Site					**$ 75,400.00**
Estimated Cost for Townsite Site including optional cover over mineralized waste					**$ 174,100.00**

The loadout materials will be disposed of at the site either through burial within the recontoured dump or dispersed onto the surface to provide organic matter for the assist in the development of a post implementation soils.

9.7 CHRISTAL CREEK WATERSHED

9.7.1 Galkeno (300 level and Sime Pits) Site

Table 9-20 shows the summary closure costs for the Galkeno (300 level and Sime Pits) site for the common elements proposed for implementation at this site. Table 9-21 shows the closure costs for the different closure options being evaluated to address metal loading from the underground workings.

Table 9-19 Galkeno (300 and Sime Pits) Site Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Galkeno 300 Adit	Adit upgrades and installation of low pressure hydraulic plug	l.s.	1	$ 316,000.00	$ 316,000.00
McLeod Shaft	Dry seal	l.s.	1	$ 10,000.00	$ 10,000.00
				Sub-total:	$326,000.00
Waste Rock Storage Area and Earthworks					
	Recontouring of waste rock dumps	l.s.	1	$ 77,800.00	$ 77,800.00
	Construct safety berm	l.s.	1	$ 81,300.00	$ 81,300.00
	Water diversion channel (including rip-rap and filter fabric)	l.s.	1	$ 25,700.00	$ 25,700.00
	Revegetation of waste rock dump surface	l.s.	1	$ 34,200.00	$ 34,200.00
				Sub-total:	$219,000.00
Decommission Existing Treatment Site					
	Decommission building and remove piping	l.s.	1	$ 20,700.00	$ 20,700.00
	De-sludge pond	l.s.	1	$ 2,200.00	$ 2,200.00
	Remove liner and pond infrastructure	l.s.	1	$ 24,200.00	$ 24,200.00
	Revegetation of area	l.s.	1	$ 2,300.00	$ 2,300.00
	Equipment mob-demob	l.s.	1	$ 1,500.00	$ 1,500.00
				Sub-total:	$ 50,900.00
Debris Removal					
	Debris removal	l.s.	1	$ 12,400.00	$ 12,400.00
				Sub-total:	$ 12,400.00
Estimated Cost of Common Closure Element for Galkeno (300 level and Sime) Site					**$608,300.00**

Table 9-20 Galkeno (300 and Sime Pits) Closure Options Costs

Site Name:	*Galkeno 300 Adit*			
Water Discharge Rate (lps):	*14*			
Work Item	**Description**	**Qnty**	**Unit Cost**	**Total Cost**
	Mine Pool Treatment			
CapEx	Initial Installation of Injection Facility	1	$ 54,000.00	$ 54,000.00
CapEx	Initial Installation of Injection Control & Monitoring System	1	$ 792,000.00	$ 792,000.00
OpEx	Operation & Maintenance for 30 years	1	$ 247,000.00	$ 247,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 2,515,000.00	$ 2,515,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 1,729,000.00	$ 1,729,000.00
			Sub-total:	**$ 5,337,000.00**
	Upgrade at Galkeno 300			
CapEx	Initial Installation of Support Facility	1	$ 301,000.00	$ 301,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 92,000.00	$ 92,000.00
CapEx	Capital Replacement Costs for 30 years Operation	1	$ 365,102.00	$ 365,102.00
OpEx	Operation & Maintenance for 30 years	1	$ 1,747,000.00	$ 1,747,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 5,672,000.00	$ 5,672,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 3,742,000.00	$ 3,742,000.00
			Sub-total:	**$ 11,919,102.00**
	New WTF at Elsa [a]			
CapEx	Initial Installation of Injection Facility	1	$ 1,652,000.00	$ 1,652,000.00
CapEx	Initial Installation of Injection Control & Monitoring System	1	$ 214,000.00	$ 214,000.00
CapEx	Capital Replacement Costs for 30 years Operation	1	$ 1,593,604.00	$ 1,593,604.00
OpEx	Operation & Maintenance for 30 years	1	$ 2,639,000.00	$ 2,639,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 6,617,000.00	$ 6,617,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 5,328,000.00	$ 5,328,000.00
			Sub-total:	**$ 18,043,604.00**
	New WTF at ST Hwy near Galkeno 900 [a]			
CapEx	Initial Installation of Support Facility	1	$ 1,001,000.00	$ 1,001,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 214,000.00	$ 214,000.00
CapEx	Capital Replacement Costs for 30 years Operation	1	$ 1,084,522.00	$ 1,084,522.00
OpEx	Operation & Maintenance for 30 years	1	$ 2,639,000.00	$ 2,639,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 6,617,000.00	$ 6,617,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 5,016,000.00	$ 5,016,000.00
			Sub-total:	**$ 16,571,522.00**

[a] The costs of the initial installation of the treatment and monitoring system at the Elsa and Silver Trail facility are bourne in the Galkeno 300 costing table, since it represents the single largest contributor to the plant. The other costs listed are the incremental costs associated with treatment of Galkeno 300 adit water at the Elsa or Silver Trail WTF.

9.7.2 Galkeno 900 Level Adit

Table 9-22 shows the summary closure costs for the Galkeno 900 level site for the common elements proposed for implementation at this site which includes removal of the existing treatment site. Table 9-23 shows the closure costs for the different closure options being evaluated to address metal loading from the underground workings.

Table 9-21 Galkeno 900 Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Decommission Existing Treatment Site					
	Decommission building and remove piping	l.s.	1	$ 3,600.00	$ 3,600.00
	De-sludge pond	l.s.	1	$ 1,100.00	$ 1,100.00
	Remove liner and pond infrastructure	l.s.	1	$ 13,000.00	$ 13,000.00
	Revegetation of area	l.s.	1	$ 2,300.00	$ 2,300.00
	Equipment mob-demob	l.s.	1	$ 1,300.00	$ 1,300.00
				Sub-total:	$ 21,300.00
Debris Removal					
	Debris removal	l.s.	1	$ 2500.00	$ 2,500.00
				Sub-total:	$ 2,500.00
Estimated Cost of Common Closure Element for Galkeno 900 Site					**$23,800.00**

The current costing for this site does not include any contingencies related to the existing GK900 high pressure adit plug which was installed by UKHM in 1993. The installation/replacement of a second high pressure adit plug would have considerable cost and may be on the order of $750,000 to $1,000,000 depending on the degree to which the underground working would need to be rehabilitated to access the plug area. ERDC is currently proposing that the potential replacement cost of this structure be included in the costing associated with the Preferred Options Report.

Table 9-22 Galkeno 900 Closure Options Costs

Site Name:	*Galkeno 900 Adit*			
Water Discharge Rate (lps):	***3.1***			
Work Item	**Description**	**Qnty**	**Unit Cost**	**Total Cost**
	Bioreactor treatment			
CapEx	Initial Installation of Support Facility	1	$ 54,000.00	$ 54,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 327,000.00	$ 327,000.00
CapEx	Capital Replacement Costs after 20 years Operation	1	$ 490,500.00	$ 490,500.00
OpEx	Operation & Maintenance for 30 years	1	$ 240,000.00	$ 240,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 138,000.00	$ 138,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 364,000.00	$ 364,000.00
			Sub-total:	**$ 1,613,500.00**
	Stand-alone small WTF			
CapEx	Initial Installation of Injection Facility	1	$ 386,000.00	$ 386,000.00
CapEx	Initial Installation of Injection Control & Monitoring System	1	$ 212,000.00	$ 212,000.00
CapEx	Capital Replacement Costs for 30 years Operation	1	$ 600,772.00	$ 600,772.00
OpEx	Operation & Maintenance for 30 years	1	$ 1,182,000.00	$ 1,182,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 1,466,000.00	$ 1,466,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 1,555,000.00	$ 1,555,000.00
			Sub-total:	**$ 5,401,772.00**
	New WTF at ST Hwy near Galkeno 900 [a]			
CapEx	Initial Installation of Support Facility	1	$ 353,000.00	$ 353,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 62,000.00	$ 62,000.00
CapEx	Capital Replacement Costs for 30 years Operation	1	$ 363,466.00	$ 363,466.00
OpEx	Operation & Maintenance for 30 years	1	$ 192,000.00	$ 192,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 1,466,000.00	$ 1,466,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 993,000.00	$ 993,000.00
			Sub-total:	**$ 3,429,466.00**

[a] The costs of the initial installation of the treatment and monitoring system at the Silver Trail facility are bourne in the Galkeno 300 costing table, since it represents the single largest contributor to the plant. The costs listed here are the incremental costs associated with treatment of Galkeno 900 adit water at the Silver Trail WTF.

9.7.3 Hector Calumet

Table 9-24 shows the summary closure costs for the Hector Calumet site for the common elements proposed for implementation at this site. Table 9-24 shows the closure costs for the different closure options proposed for the Hector 400 WRSA. The third closure option (reclaim with no cover) is not included since its costs are included as part of the common costs associated with the remediation of the Hector Calumet site.

Table 9-23 Hector Calumet Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Hector 400 Adit	Rock pile inside adit to preserve outside entrance.	l.s.	1	$ 10,000.00	$ 10,000.00
Jock Shaft	Dry seal	l.s.	1	$ 10,000.00	$ 10,000.00
				Sub-total:	$20,000.00
Waste Rock Storage Areas and Earthworks					
Hector 400 Adit WRSA	Recontouring of waste rock dump	l.s.	1	$ 39,500.00	$ 39,500.00
	Removal of timber crib walls and recontouring	l.s.	1	$ 25,000.00	$ 25,000.00
Calumet Pit WRSA	Recontouring of waste rock dump	l.s.	1	$ 17,000.00	$ 17,000.00
	Revegetation of waste rock dump area	l.s.	1	$ 8,300.00	$ 8,300.00
Hector Pit WRSA	Recontouring of waste rock dump	l.s.	1	$ 134,000.00	$ 134,000.00
	Revegetation of waste rock dump area	l.s.	1	$ 11,700.00	$ 11,700.00
				Sub-total:	$235,500.00
Open Pit Areas					
Calumet Pits	Highwall safety berms	l.s.	1	$ 41,000.00	$ 41,000.00
	Highwall water diversion berms(includes rip-rap + filter fabric)	l.s.	1	$ 13,800.00	$ 13,800.00
	Access improvements to allow for berm construction	l.s.	1	$ 10,000.00	$ 10,000.00
Hector Pit	Highwall safety berms	l.s.	1	$ 64,100.00	$ 64,100.00
	Highwall water diversion berms(includes rip-rap + filter fabric)	l.s.	1	$ 17,400.00	$ 17,400.00
	Access improvements to allow for berm construction	l.s.	1	$ 10,000.00	$ 10,000.00
				Sub-total:	$156,300.00
Debris Removal and Consolidation for burial at 400 level WRSA					
	Debris removal from Hector Pit area	l.s.	1	$ 6,200.00	$ 6,200.00
	Debris consolidation 400 WRSA area	l.s.	1	$ 6,200.00	$ 6,200.00
				Sub-total:	$ 12,400.00
Estimated Cost of Common Closure Element for Hector-Calumet Site					**$424,200.00**

It is not feasible to revegetate all of the waste rock storage areas associated with the pits. Revegetation efforts would focus on bench surfaces where there are fine grained materials present.

Table 9-24 Hector 400 Adit WRSA Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Hector 400 Adit WRSA Alternative 1 – Cover for Revegetation					
	Vegetational Cover	l.s.	1	$458,600	$458,600
	Closure Indirect Costs (45% of Direct Costs)	l.s.	1	$206,400	$206,400
				Sub-total:	$665,000
Hector 400 Adit WRSA Alternative 2 – Cover for Reduced Infiltration and Source Control					
	Infiltration Cover including Clay Amendment	l.s.	1	$1,289,200	$1,289,200
	Closure Indirect Costs (45% of Direct Costs)	l.s.	1	$580,100	$76,100
				Sub-total:	$1,869,300
Estimated Cost of Closure Alternative 1 for Hector 400 Adit WRSA					**$665,000**
Estimated Cost of Closure Alternative 2 for Hector 400 Adit WRSA					**$1,869,300**

9.7.4 Mackeno Mill and Tailings

There are no works proposed for the Mackeno Mill site. Table 9-25 shows the closure costs for the different closure options being evaluated to address metal loading from the tailings at this site. Costing information and background information on the development of the tailings remediation costing was based on Interralogic costing spreadsheets for the Mackeno Tailings which are included with the updated costing memo developed by ERDC which includes costing associated with the dispersed tailings (ERDC 2013b).

Table 9-25 Mackeno Tailings Closure Options Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Mackeno Tailings Alternative 1 – Cover and Stabilize					
	Borrow for cover in place	l.s.	1	$78,000	$78,000
	Creek Rehab	l.s.	1	$4,000	$4,000
	Lime Added	l.s.	1	$38,400	$38,400
	Organics	l.s.	1	$22,100	$22,100
	Relocate Tails at Head of Christal Creek	l.s.	1	$15,300	$15,300
	Site Access	l.s.	1	$7,000	$7,000
	Closure Indirect Costs (45% of Direct Costs)	l.s.	1	$74,800	$74,800
				Sub-total:	$239,600
Mackeno Tailings Alternative 2 – Move and Stabilize					
	Relocate Tailings	l.s.	1	$110,500	$110,500
	Creek Rehab	l.s.	1	$4,000	$4,000
	Lime Added	l.s.	1	$30,800	$30,800
	Relocate Tails at Head of Christal Creek	l.s.	1	$15,300	$15,300
	Site Access	l.s.	1	$7,000	$7,000
	Closure Indirect Costs (45% of Direct Costs)	l.s.	1	$76,100	$76,100
				Sub-total:	$243,700
Mackeno Dispersed Tailings					
	Total Direct Costs	l.s.	1	$76,500	$76,500
	Total Indirect Costs (45% of Direct Costs)	l.s.	1	$34,400	$34,400
				Sub-total:	$110,900
Estimated Cost of Closure Alternative 1 for Mackeno Tailings					**$239,600**
Estimated Cost of Closure Alternative 2 for Mackeno Tailings					**$243,700**
Estimated Cost of Dispersed Tailings Remediation for Mackeno Tailings					**$110,900**

9.7.5 Onek

Table 9-26 shows the summary closure costs for the Onek site for the common elements proposed for implementation at this site. Table 9-27 shows the closure costs for the different closure options being evaluated to address metal loading from the underground workings.

Table 9-26 Onek Closure Summary Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
400 Adit	Adit rehab and installation of low pressure water retaining plug	l.s.	1	$ 273,000.00	$ 273,000.00
Lonestar Shaft	Remove debris from shaft and install watertight cap	l.s.	1	$ 66,200.00	$ 66,200.00
Fisher Shaft	Remove debris from shaft and install watertight cap	l.s.	1	$ 66,200.00	$ 66,200.00
				Sub-total:	$405,400.00
Waste Rock Storage Areas					
	Recontouring of waste rock dumps by pit	l.s.	1	$ 42,900.00	$ 42,900.00
	Relocation of 400 adit dump waste rock to pit waste rock dump	l.s.	1	$ 35,400.00	$ 35,400.00
	Lime amendment of mineralized adit waste rock	l.s.	1	$ 38,900.00	$ 38,900.00
	Granular cover installation onto surface of waste rock dump	l.s.	1	$ 106,600.00	$ 106,600.00
	Revegetation of waste rock dump areas	l.s.	1	$ 10,900.00	$ 10,900.00
				Sub-total:	$234,700.00
Open Pit Area					
	Backfill pit to make free-draining	l.s.	1	$ 482,000.00	$ 482,000.00
	Highwall safety and diversion berms	l.s.	1	$ 43,300.00	$ 43,300.00
	Pit drainage channel (includes rip-rap + filter fabric)	l.s.	1	$ 2,200.00	$ 2,200.00
	Install soil cover onto pit area	l.s.	1	$ 172,200.00	$ 172,200.00
	Revegetation of pit and dump area	l.s.	1	$ 10,800.00	$ 10,800.00
				Sub-total:	$710,500.00
Estimated Cost of Common Closure Element for Onek Site					**$1,350,200.00**

Table 9-27 Onek Closure Options Costs

Site Name:	*Onek 400 Adit*			
Water Discharge Rate (lps):	***2.3***			
Work Item	**Description**	**Qnty**	**Unit Cost**	**Total Cost**
	Bioreactor treatment with natural attenuation			
CapEx	Initial Installation of Support Facility	1	$ 107,000.00	$ 107,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 149,000.00	$ 149,000.00
CapEx	Capital Replacement Costs after 20 years Operation	1	$ 223,500.00	$ 223,500.00
OpEx	Operation & Maintenance for 30 years	1	$ 191,000.00	$ 191,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 139,000.00	$ 139,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 281,000.00	$ 281,000.00
			Sub-total:	**$ 1,090,500.00**
	Stand-alone small WTF			
CapEx	Initial Installation of Injection Facility	1	$ 386,000.00	$ 386,000.00
CapEx	Initial Installation of Injection Control & Monitoring System	1	$ 212,000.00	$ 212,000.00
CapEx	Capital Replacement Costs for 30 years Operation	1	$ 600,772.00	$ 600,772.00
OpEx	Operation & Maintenance for 30 years	1	$ 1,150,000.00	$ 1,150,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 1,088,000.00	$ 1,088,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 1,359,000.00	$ 1,359,000.00
			Sub-total:	**$ 4,795,772.00**
	New WTF at ST Hwy near Galkeno 900 [a]			
CapEx	Initial Installation of Support Facility	1	$ 343,000.00	$ 343,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ -	$ -
CapEx	Capital Replacement Costs for 30 years Operation	1	$ 268,226.00	$ 268,226.00
OpEx	Operation & Maintenance for 30 years	1	$ 161,000.00	$ 161,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 1,088,000.00	$ 1,088,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 763,000.00	$ 763,000.00
			Sub-total:	**$ 2,623,226.00**

[a] The costs of the initial installation of the treatment and monitoring system at the Silver Trail facility are bourne in the Galkeno 300 costing table, since it represents the single largest contributor to the plant. The costs listed here are the incremental costs associated with treatment of Onek 400 adit water at the Silver Trail WTF.

9.7.6 Bluebird

This site is difficult to access but is identified as containing some asbestos containing materials which will be addressed under the Physical Hazards Reduction program that is being implemented under a separate project. The Closure Issues Report for the site identifies that there are two shafts which are approximately 12.2 and 7 m deep but this has not been able to be field verified in order to identify if these shafts represent a hazard. No works are proposed for this site due to difficult access conditions.

9.7.7 Christal (Dorothy)

Table 9-28 shows the summary closure costs for the Christal (Dorothy) site for the common elements proposed for implementation at this site.

Table 9-28 Christal (Dorothy) Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Christal Shaft #1	Dry Seal	l.s.	1	$ 12,500.00	$ 12,500.00
Christal Shaft #2	Dry Seal	l.s.	1	$ 12,500.00	$ 12,500.00
Lower Lake Shaft	Dry Seal	l.s.	1	$ 10,000.00	$ 10,000.00
Upper Lake Shaft	Dry Seal	l.s.	1	$ 10,000.00	$ 10,000.00
				Sub-total:	$ 45,000.00
Site Access					
	Rehabilitate and revegetate site access	l.s.	1	$ 5,000.00	$ 5,000.00
				Sub-total:	$ 5,000.00
Estimated Cost of Common Closure Element for Christal (Dorothy) Site					**$ 50,000.00**

9.7.8 Croesus #1

No works are proposed for this site.

9.7.9 Dragon (UN) and Miller

Table 9-29 shows the summary closure costs for the Dragon (UN) and Miller site for the common elements proposed for implementation at this site.

Table 9-29 Dragon (UN) and Miller Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
UN Adit	Coarse rock pile to prevent access and ensure free draining conditions	l.s.	1	$ 10,000.00	$ 10,000.00
				Sub-total:	$ 10,000.00
	Safety berm around pit	l.s.	1	$ 20,000.00	$ 20,000.00
				Sub-total:	$ 20,000.00
Estimated Cost of Common Closure Element for Dragon (UN) and Miller Site					**$ 30,000.00**

9.7.10 Eagle

Table 9-30 shows the summary closure costs for the Eagle site for the common elements proposed for implementation at this site.

Table 9-30 Eagle Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Jock Shaft (collapsed)	Fill shaft to above ground surface to allow for future settlement	l.s.	1	$ 5,000.00	$ 5,000.00
				Sub-total:	$ 5,000.00
Waste rock dump and other earthworks					
	Recontouring of waste rock dump and road run-off to address minor erosion issues	l.s.	1	$ 3,500.00	$ 3,500.00
				Sub-total:	$ 3,500.00
Estimated Cost of Common Closure Element for Eagle Site					**$ 8,500.00**

9.7.11 Kijo

No works are proposed for this site.

9.7.12 Klondike Keno

Table 9-31 shows the summary closure costs for the Klondike Keno site for the common elements proposed for implementation at this site.

Table 9-31 Klondike Keno Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
UN Adit	Coarse rock pile to prevent access and ensure free draining conditions	l.s.	1	$ 15,000.00	$ 15,000.00
				Sub-total:	$ 15,000.00
Open Pit					
	Safety berm around pit	l.s.	1	$ 20,000.00	$ 20,000.00
				Sub-total:	$ 20,000.00
Estimated Cost of Common Closure Element for Klondike Keno Site					**$ 35,000.00**

9.7.13 Rico

Table 9-32 shows the summary closure costs for the Rico site for the common elements proposed for implementation at this site.

Table 9-32 Rico Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Rico Shaft	Dry seal	l.s.	1	$ 15,000.00	$ 15,000.00
				Sub-total:	$ 15,000.00
Access Road					
	Following works surface to be scarified and revegetated with berm installed to prevent access	l.s.	1	$ 3,500.00	$ 3,500.00
				Sub-total:	$ 3,500.00
Estimated Cost of Common Closure Element for Rico Site					**$ 18,500.00**

9.7.14 Shamrock

Table 9-33 shows the summary closure costs for the Shamrock site for the common elements proposed for implementation at this site.

Table 9-33 Shamrock Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Shamrock "J" Raise (Prospect Shaft)	Dry seal	l.s.	1	$ 15,000.00	$ 15,000.00
				Sub-total:	$ 15,000.00
Open Pits					
	Safety Berm construction	l.s.	1	$ 43,000.00	$ 43,000.00
				Sub-total:	$ 43,000.00
Access Road					
	Scarify portion of road following completion of works	l.s.	1	$ 1,500.00	$ 1,500.00
				Sub-total:	$ 1,500.00
Debris Removal					
	Debris disposal	l.s.	1	$ 5,000.00	$ 5,000.00
				Sub-total:	$ 5,000.00
Estimated Cost of Common Closure Element for Shamrock Site					**$ 64,500.00**

9.7.15 Tin Can

Table 9-34 shows the summary closure costs for the Tin Can site for the common elements proposed for implementation at this site.

Table 9-34 Tin Can Summary Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Shaft #1	Dry seal	l.s.	1	$ 15,000.00	$ 15,000.00
Shaft #2	Dry seal	l.s.	1	$ 15,000.00	$ 15,000.00
				Sub-total:	$ 30,000.00
Site Access					
	Mob and De-mob for materials	l.s.	1	$ 7,500.00	$ 7,500.00
Estimated Cost of Common Closure Element for Tin Can Site					**$ 37,500.00**

9.8 LIGHTNING CREEK WATERSHED

9.8.1 Keno 700

Table 9-35 shows the summary closure costs for the Keno 700 site for the common elements proposed for implementation on the WRSA at this site. Table 9-36 shows the closure costs for the different closure options being evaluated to address metal loading from the adit.

Table 9-35 Keno 700 Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Keno 700					
	Re-contouring of Waste Rock Dump	l.s.	1	$7,100.00	$7,100.00
	Drainage Control	l.s.	1	$3,200.00	$3,200.00
	Waste Rock for Rip Rap	l.s.	1	$3,000.00	$3,000.00
	Mob/demob	l.s.	1	$600.00	$ 600.00
Estimated Cost of Common Closure of Keno 700 WRSA					**$13,900.00**

Table 9-36 Keno 700 Closure Options Costs

Site Name:	*Keno 700 Adit*			
Water Discharge Rate (lps):	*3.4*			
Work Item	**Description**	**Qnty**	**Unit Cost**	**Total Cost**
	Managed Natural Attenuation			
CapEx	Initial Installation of Support Facility	1	$ -	$ -
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 148,000.00	$ 148,000.00
OpEx	Operation & Maintenance for 30 years	1	$ 199,000.00	$ 199,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 105,000.00	$ 105,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 217,000.00	$ 217,000.00
			Sub-total:	**$ 669,000.00**
	Mine Pool Treatment			
CapEx	Initial Installation of Injection Facility	1	$ 54,000.00	$ 54,000.00
CapEx	Initial Installation of Injection Control & Monitoring System	1	$ 919,000.00	$ 919,000.00
OpEx	Operation & Maintenance for 30 years	1	$ 163,000.00	$ 163,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 557,000.00	$ 557,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 811,000.00	$ 811,000.00
			Sub-total:	**$ 2,504,000.00**
	Bioreactor			
CapEx	Initial Installation of Support Facility	1	$ 54,000.00	$ 54,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 327,000.00	$ 327,000.00
CapEx	Capital Replacement Costs after 20 years Operation	1	$ 490,500.00	$ 490,500.00
OpEx	Operation & Maintenance for 30 years	1	$ 197,000.00	$ 197,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 152,000.00	$ 152,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 350,000.00	$ 350,000.00
			Sub-total:	**$ 1,570,500.00**
	Active Water Treatment Facility			
CapEx	Initial Installation of Water Treatment Facility	1	$ 418,000.00	$ 418,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 212,000.00	$ 212,000.00
CapEx	Capital Replacement Costs for 30 years Operation	1	$ 625,796.00	$ 625,796.00
OpEx	Operation & Maintenance for 30 years	1	$ 1,138,000.00	$ 1,138,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 1,607,000.00	$ 1,607,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 1,617,000.00	$ 1,617,000.00
			Sub-total:	**$ 5,617,796.00**

9.8.2 5-2 Adit

The work proposed for this site involves capping of the old shaft. Table 9-37 shows the estimated cost for this activity.

Table 9-37 5-2 Adit Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Shaft near to 5-2 adit	Dry seal	l.s.	1	$ 10,000.00	$ 10,000.00
				Sub-total:	$ 10,000.00
Estimated Cost of Common Closure Element for 5-2 Site					**$ 10,000.00**

9.8.3 Apex

The work proposed for this site involves capping of the old shaft. Table 9-38 shows the estimated cost for this activity.

Table 9-38 Apex Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Shaft	Dry seal	l.s.	1	$ 12,500.00	$ 12,500.00
				Sub-total:	$ 12,500.00
Estimated Cost of Common Closure Element for Apex Site					**$ 12,500.00**

9.8.4 Divide

Works proposed for this site involve clean-up of debris at the site including an old oil barrel and a collapsed building. Table 9-39 shows the estimated cost for these activities.

Table 9-39 Divide Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Debris Removal					
	Debris disposal to Elsa for disposal	l.s.	1	$ 4,000.00	$ 4,000.00
				Sub-total:	$ 4,000.00
Estimated Cost of Common Closure Element for Divide Site					**$ 4,000.00**

9.8.5 Duncan Creek

No works are proposed at this site.

9.8.6 Gold Hill No. 2

The only works proposed for this site involve clean-up of metal debris. Table 9-40 shows the estimated cost for this activity.

Table 9-40 Gold Hill No. 2 Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Debris Removal					
	Debris disposal	l.s.	1	$ 2,000.00	$ 2,000.00
				Sub-total:	$ 2,000.00
Estimated Cost of Common Closure Element for Gold Hill No. 2 Site					**$ 2,000.00**

9.8.7 Keno 200

Table 9-41 shows the estimated cost for remedial activities at the Keno 200 site for the common elements proposed for implementation at this site.

Table 9-41 Keno 200 Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Comstock Adit	Installation of rock pile to plug adit	l.s.	1	$ 15,000.00	$ 15,000.00
Porcupine Adit	Installation of rock pile to plug adit	l.s.	1	$ 15,000.00	$ 15,000.00
Porcupine Shaft	Dry seal shaft	l.s.	1	$ 10,000.00	$ 10,000.00
				Sub-total:	$ 40,000.00
Open Pit					
Open pit	Berm highwall of pit	l.s.	1	$ 10,000.00	$ 10,000.00
				Sub-total:	$ 10,000.00
Waste Rock Dumps and Other Earthworks					
Porcupine WRSA	Recontour dump	l.s.	1	$ 7,500.00	$ 7,500.00
Comstock WRSA	Recontour dump	l.s.	1	$ 4,500.00	$ 4,500.00
				Sub-total:	$ 12,000.00
Loadout and Building Debris Removal					
Porcupine Loadout	Remove loadout and recontour	l.s.	1	$ 7,500.00	$ 7,500.00
Comstock Loadout	Remove loadout and recontour	l.s.	1	$ 7,500.00	$ 7,500.00
				Sub-total:	$15,000.00
Estimated Cost of Common Closure Element for Keno 200 Site					**$ 77,000.00**

9.9 KENO LADUE RIVER

9.9.1 Sadie Ladue 600

Table 9-42 shows the summary closure costs for the Sadie Ladue 600 site for the common elements proposed for implementation at this site. Table 9-43 shows the closure costs for the different closure options being evaluated to address metal loading from the underground workings.

Table 9-42 Sadie Ladue 600 Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
600 Level Adit	Adit upgrades and installation of low pressure hydraulic plug	l.s.	1	$ 231,000.00	$ 231,000.00
				Sub-total:	$462,001.00
Waste Rock Dump and Earthworks					
	Site access upgrades	l.s.	1	$ 7,000.00	$ 7,000.00
	Recontouring of waste rock dump	l.s.	1	$ 10,000.00	$ 10,000.00
	Water diversion channel (including rip-rap and filter fabric)	l.s.	1	$ 3,200.00	$ 3,200.00
				Sub-total:	$20,200.00
Debris Removal					
	Debris removal	l.s.	1	$ 4,000.00	$ 4,000.00
				Sub-total:	$ 4,000.00
Estimated Cost of Common Closure Element for Sadie Ladue 600 Site					**$ 255,200.00**

Table 9-43 Sadie Ladue 600 Closure Options Costs

Site Name:	*Sadie Ladue 600 Adit*			
Water Discharge Rate (lps):	*7.6*			
Work Item	**Description**	**Qnty**	**Unit Cost**	**Total Cost**
	Reclamation-only, No Water Treatment			
CapEx	Initial Installation of Support Facility	1	$ -	$ -
CapEx	Initial Installation of Treatment & Monitoring System	1	$ -	$ -
OpEx	Operation & Maintenance for 30 years	1	$ 79,000.00	$ 79,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ -	$ -
OpEx	Additional Oversight/Taxes/etc.	1	$ 38,000.00	$ 38,000.00
			Sub-total:	**$ 117,000.00**
	Managed natural attenuation			
CapEx	Initial Installation of Injection Facility	1	$ -	$ -
CapEx	Initial Installation of Injection Control & Monitoring System	1	$ 162,000.00	$ 162,000.00
OpEx	Operation & Maintenance for 30 years	1	$ 183,000.00	$ 183,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 234,000.00	$ 234,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 278,000.00	$ 278,000.00
			Sub-total:	**$ 857,000.00**
	Bioreactor			
CapEx	Initial Installation of Support Facility	1	$ 32,000.00	$ 32,000.00
CapEx	Initial Installation of Treatment & Monitoring System	1	$ 307,000.00	$ 307,000.00
CapEx	Capital Replacement Costs after 20 years Operation	1	$ 460,500.00	$ 460,500.00
OpEx	Operation & Maintenance for 30 years	1	$ 180,000.00	$ 180,000.00
OpEx	Reagent Costs for 30 years of Operation	1	$ 339,000.00	$ 339,000.00
OpEx	Additional Oversight/Taxes/etc.	1	$ 411,000.00	$ 411,000.00
			Sub-total:	**$ 1,729,500.00**

9.9.2 Wernecke

Table 9-44 shows the summary closure costs for the Wernecke site for the common elements proposed for implementation at this site. Table 9-45 shows the closure costs for the different closure options being evaluated to remediate the existing tailings. Costing information and background information on the development of the tailings remediation costing is based on Interralogic costing spreadsheets for the Wernecke Tailings which are included with the updated costing memo developed by ERDC which includes costing associated with the dispersed tailings (ERDC 2013b).

Table 9-44 Wernecke Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Waste Rock Storage Area and Earthworks					
	Recontouring of waste rock dumps	l.s.	1	$ 1,500.00	$ 1,500.00
	Construct safety berm	l.s.	1	$ 51,300.00	$ 51,300.00
	Water diversion channel around pit highwall (including rip-rap and filter fabric)	l.s.	1	$ 32,800.00	$ 32,800.00
	Push waste rock into other trenches	l.s.	1	$ 2,500.00	$ 2,500.00
	Revegetation of waste rock dump surface and site	l.s.	1	$ 22,800.00	$ 22,800.00
				Sub-total:	$110,900.00
Debris Removal					
	Debris removal and disposal	l.s.	1	$ 12,400.00	$ 12,400.00
				Sub-total:	$ 12,400.00
Estimated Cost of Common Closure Element for Wernecke Site					**$123,300.00**

The majority of the wooden building debris at the site consists of unpainted wood that can most likely be burned in place. Metal debris is located in a couple of areas below the site and should be collected and disposed of in the Sadie Ladue open pit followed by covering with waste rock. The old Wernecke Mill chimney should be left in place for Heritage purposes. The Wernecke House is being restored for Heritage and has been nominated as a Heritage Site.

Table 9-45 Wernecke Closure Options Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Wernecke Tailings Alternative 1 – Cover In Place					
	Borrow for Cover in Place	l.s.	1	$16,300.00	$16,300.00
	Creek Rehab	l.s.	1	$18,300.00	$18,300.00
	Lime Added	l.s.	1	$9,100.00	$9,100.00
	Organics	l.s.	1	$3,800.00	$3,800.00
	Site Access	l.s.	1	$7,000.00	$7,000.00
	Closure Indirect Costs (45% of Direct Costs)	l.s.	1	$24,800.00	$24,800.00
				Sub-total:	$79,300.00
Wernecke Tailings Alternative 2 – Consolidate and Cover					
	Borrow for Cover in Place	l.s.	1	$16,300.00	$16,300.00
	Creek Rehab	l.s.	1	$18,300.00	$18,300.00
	Lime Added	l.s.	1	$21,100.00	$21,100.00
	Organics	l.s.	1	$3,800.00	$3,800.00
	Relocate Tails at Drainage Creek	l.s.	1	$20,000.00	$20,000.00
	Site Access	l.s.	1	$7,000.00	$7,000.00
	Closure Indirect Costs (45% of Direct Costs)	l.s.	1	$39,300.00	$39,300.00
				Sub-total:	$125,800.00
Wernecke Tailings Alternative 3 – Move and Stabilize					
	Relocate Tailings	l.s.	1	$36,200.00	$36,200.00
	Creek Rehab	l.s.	1	$18,300.00	$18,300.00
	Lime Added	l.s.	1	$21,100.00	$21,100.00
	Relocate Tails at Drainage Creek	l.s.	1	$25,500.00	$25,500.00
	Site Access	l.s.	1	$7,000.00	$7,000.00
	Closure Indirect Costs (45% of Direct Costs)	l.s.	1	$49,100.00	$49,100.00
				Sub-total:	$157,200.00
Dispersed Tailings					
	Total Direct Costs	l.s.	1	$11,000.00	$11,000.00
	Total Indirect Costs (45% of Direct Costs)	l.s.	1	$5,000.00	$5,000.00
				Sub-total:	$16,000.00
Estimated Cost of Closure Alternative 1 for Wernecke Tailings					**$79,300.00**
Estimated Cost of Closure Alternative 2 for Wernecke Tailings					**$125,800.00**
Estimated Cost of Closure Alternative 3 for Wernecke Tailings					**$157,200.00**
Estimated Cost of Dispersed Tailings Remediation for Wernecke Tailings					**$16,000.00**

9.9.3 Wernecke Off-Claim Tailings

Table 9-46 shows the closure costs for the different closure options being evaluated to remediate the Wernecke off claim tailings. Costing information and background information on the development of the tailings remediation costing is based on Interralogic costing spreadsheets for the Wernecke Tailings which are included with their costing memo (Appendix U).

Table 9-46 Wernecke off claim tailings closure options costing

Wernecke Tailings	Alternative 1 - Cover in Place	Alternative 2 - Consolidation	Alternative 3 - Enhance Natural Recovery
Off Claim Wernecke Tailings - Tailings Removal & Consolidation		$ 1,492,974	
Off Claim Wernecke Tailings - Borrow & Placement of Cover	$ 1,888,746	$ 795,354	
Off Claim Wernecke Tailings - Creek Rehab & Reroute	$ 69,285	$ 69,285	$ 22,534
Off Claim Wernecke Tailings - Lime Added	$ 756,338	$ 756,338	$ 277,272
Off Claim Wernecke Tailings - Organics	$ 539,071	$ 324,691	$ 404,303
Off Claim Wernecke Tailings - Site Access	$ 237,578	$ 242,622	$ 45,005
Contingency	$ -	$ -	$ -
Closure Indirect Costs	$ 1,584,922	$ 1,671,294	$ 340,098
Total	**$ 5,075,941**	**$ 5,352,559**	**$ 1,089,212**

9.9.4 Cub and Bunny

The only works proposed for this site involve clean-up of metal debris that is located near to the adit. Table 9-47 shows the estimated cost for this activity.

Table 9-47 Cub and Bunny Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Debris Removal					
	Debris disposal	l.s.	1	$ 2,000.00	$ 2,000.00
				Sub-total:	$4,001.00
Estimated Cost of Common Closure Element for Cub and Bunny Site					**$ 2,000.00**

9.9.5 Fox

No works are proposed for this site.

9.9.6 Highlander

No works are proposed for this site.

9.9.7 Keno No. 9 System

Table 9-48 Keno No. 9 Summary Closure Costs8 shows the estimated cost for remedial activities at the Keno No. 9 site.

Table 9-48 Keno No. 9 Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Shamrock J18 Raise	Dry Seal	l.s.	1	$ 15,000.00	$ 15,000.00
No. 9 Vein Shaft		l.s.	1	$ 15,000.00	$ 15,000.00
				Sub-total:	$ 30,000.00
Site Access and Earthworks					
	Infill drifts with waste rock	l.s.	1	$ 3,500.00	$ 3,500.00
				Sub-total:	$ 3,500.00
Estimated Cost of Common Closure Element for Keno No. 9 Site					**$ 33,500.00**

9.9.8 Lake

Table 9-49 shows the estimated cost for remedial activities at the Lake site. Costing for capping of these shafts requires field verification due to a lack of information concerning the sizing. The costs in the table below are taken from other sites in the area.

Table 9-49 Lake Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Upper Shaft	Dry Seal	l.s.	1	$ 15,000.00	$ 15,000.00
Lower Shaft	Dry Seal	l.s.	1	$ 15,000.00	$ 15,000.00
				Sub-total:	$30,000.00
Site Access					
	Improvements to access to allow for remedial works	l.s.	1	$ 5,000.00	$ 5,000.00
				Sub-total:	$10,001.00
Estimated Cost of Common Closure Element for Lake Site					**$ 35,000.00**

9.9.9 Lucky Queen Shaft

The Lucky Queen shaft is included within the proposed AKHM Production Unit. The Lucky Queen Production Unit includes the shaft house footprint and access road to the site. Costs for remediation of historical liabilities not included within the proposed Production Unit; trenches and minor surface disturbances are shown in Table 9-50.

Table 9-50 Lucky Queen Shaft Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Site Access and Earthworks					
	Infill trenches with waste rock from local piles	l.s.	1	$ 5,00.00	$ 5,000.00
				Sub-total:	$ 5,000.00
Estimated Cost of Common Closure Element for Lucky Queen Shaft Site (non-Production Unit)					**$ 5,000.00**

9.9.10 Monument and Ladue Fraction

No works are proposed for this site.

9.9.11 Silver Basin

The work proposed for this site involves capping of the old shaft. Table 9-51 shows the estimated cost for this activity.

Table 9-51 Silver Basin Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Shaft	Dry seal	l.s.	1	$ 12,500.00	$ 12,500.00
				Sub-total:	$ 12,000.00
Estimated Cost of Common Closure Element for Silver Basin Site					**$ 12,500.00**

9.9.12 Stone

The work proposed for this site involves upgrading the existing rock pile at the adit to ensure access is restricted and removal of debris. Table 9-52 shows the estimated cost for this activity.

Table 9-52 Stone Summary Closure Costs

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
Opening to Underground Workings					
Adit	Additional rock to be added to adit entrance	l.s.	1	$ 5,000.00	$ 5,000.00
				Sub-total:	$ 5,000.00
Debris Removal					
	Debris removal	l.s.	1	$ 10,000.00	$ 10,000.00
				Sub-total:	$ 10,000.00
Estimated Cost of Common Closure Element for Stone Site					**$ 15,000.00**

9.10 MONITORING PROGRAM COSTS

This section describes the estimated monitoring costs (Table 9-53) for the KHSD following implementation of the select closure options. The costs primarily relate to inspections required for geotechnical, water sampling or performance monitoring purposes.

Preliminary monitoring costs have been developed for the different post implementation activities that will be required. These costs are based on current costs to conduct these activities along with estimates for monitoring programs (e.g. metals uptake programs) based on current sample costs and assumptions around the level of effort required. For estimated costs for surface and groundwater water sampling are based on the current level of monitoring required for the District under care and maintenance with some modifications to the costing based on the renewed Care and Maintenance WUL.

9.10.1 Annual Reporting

Annual reporting will be a requirement of the post-implementation period under the Water Use Licence. The annual reporting will include a summary and discussion of all activities and monitoring program results for the specific calendar year. The estimated cost of the annual reporting is $25,000 per year for a total cost of $750,000.

9.10.2 Geotechnical Inspections

Geotechnical inspections are currently required on an annual basis for the dams at the Valley Tailings and the treatment ponds. It is assumed for costing purposes that annual geotechnical inspections will be required throughout the post-implementation monitoring period should the dams at the VTF remain in place under options 1 and 2A. The current annual cost for the geotechnical inspections is

approximately $19,000 which over the 30 year monitoring period would total approximately $570,000.

Should options 2B or 3 be selected then it should be possible to reduce the frequency of geotechnical inspections as has been previously described in Section 8. Based on the need to conduct geotechnical inspections on a bi-annual basis for the first ten years followed by inspections every five years thereafter would result in a total of nine inspections with a total cost of approximately $171,000.

9.10.3 Water Treatment Plant Engineering Inspections

Inspections of the water treatment plants are currently required every year under the renewed Care and Maintenance water use licence. It is currently expected that a permanent treatment plant will be required for the GK300 adit discharge and as such these inspections will be a requirement during the post-implementation period. ERDC proposes for costing purposes that the engineering inspections may be able to only be required every second year based on the rationale that the GK300 treatment site will be a new facility meeting current standards. The current estimated cost of the annual water treatment plant engineering inspection is approximately $16,000. The cost for conducting bi-annual inspections of this type would have a total cost of approximately $144,000.

9.10.4 Surface Water Monitoring

The estimated cost for surface water monitoring during the post implementation period is based on the current sampling requirements for the Care and Maintenance program with a gradual reduction in the number of sampling sites and frequencies over the 30 year post implementation period. Current analytical requirements for the site require a total of 13 sites be monitored on a monthly basis and a further 43 sites be monitored on a quarterly basis. Based on an assumption of 3 days of sampling being required to complete the monthly sampling and 10 days being required to complete the quarterly sampling it is estimated that the surface water monitoring program would cost approximately $380,000 per year.

For calculating the total cost of surface water monitoring over the post-implementation monitoring period it is assumed that the program will be able to be reduced in half every ten years. This would correspond to annual surface water monitoring costs of $190,000 for years 11-20 and $95,000 for years 21-30. Based on these assumptions the total cost of surface water monitoring for the post implementation period is approximately $6,650,000.

9.10.5 Groundwater Monitoring

A total of 24 groundwater wells requiring sampling on a quarterly basis is being used for the purposes of estimating costs associated with groundwater monitoring for the post-implementation period. The monitoring of groundwater is currently assumed to be required for the entire post-implementation period although in a similar manner as used above for the surface water monitoring it is assumed that the program can be reduced in half every ten years.

The estimated cost of this monitoring program which would include summary analytical memos issued following each monitoring trip is approximately $80,000 per year for years 1-10, $40,000 for years 11-20 and $20,000 for years 21-30. Based on these assumptions the total cost of groundwater monitoring for the post implementation period is approximately $1,400,000.

9.10.6 Metal Uptake Monitoring (Soils and Vegetation)

Monitoring for metal uptake and ecological succession in areas where cover systems have been installed onto mineralized wastes is expected to be required every five years as a component of performance monitoring. For the purposes of costing it is assumed that a total of 120 samples of soil and 120 samples of vegetation will be collected during each monitoring program from cover and control areas and analysed for moisture and metal content. Monitoring visits would also be used to identify whether any maintenance seeding or fertilizer applications are required. Based on the number of samples proposed for collection and assumptions around data analysis and reporting the estimated cost for each soil and vegetation monitoring program is approximately $65,000. The total cost for this type of monitoring program would be approximately $390,000 over the post-implementation period.

In addition to the above costing for metals uptake monitoring it is also assumed that there will be a need for annual inspections for a three year period following initial revegetation activities. These annual visits are intended to ensure that revegetation is occurring and to determine whether any maintenance seeding or fertilizer applications are required. The estimated cost of these annual trips is $15,000 per year for a total of $45,000.

9.10.7 Benthic Invertebrates, Sediment and Fish Monitoring

Monitoring of benthic invertebrates and sediment within the KHSD is currently required to be conducted every three years and it is expected that this will also be required during the post-implementation period as a component of performance monitoring. The estimated cost to conduct this monitoring program is approximately $55,000 per monitoring program. Expansion of the program to include fish is expected to be required every ten years during the post-implementation period which would make for three expanded monitoring programs under this category. The addition of fish to this monitoring program would add another approximately $30,000 to the monitoring program.

The total cost for this type of monitoring is approximately $475,000 based on conducting seven monitoring programs for benthic invertebrates and sediment and three monitoring programs that include fish.

Table 9-53 Post Implementation Monitoring Costs

Monitoring Program Cost Summary	Cost
Annual Reporting	$ 750,000
Geotechnical Inspections	$ 171,000 - $570,000
Water Treatment Plant Engineering Inspections	$ 144,000
Surface Water Monitoring	$ 6,650,000
Groundwater Monitoring	$ 1,400,000
Metal Uptake Monitoring (Soils and Vegetation)	$ 435,000
Benthic Invertebrates, Sediment and Fish Monitoring	$ 475,000
Total	**$ 10,025,000 - $10,424,000**

9.11 CLOSURE COST SUMMARY

In order to facilitate the evaluation of the active water treatment plant options, Table 9-54 shows the cost of each water treatment facility in terms of the zinc load that it treats. As a high load, single point source, active water treatment of Galkeno 300 is the most cost effective of the water treatment plant options.

Table 9-54 Comparison of Water Treatment Facility Costs as a Function of Treated Zinc Load

Site	Costs	Zn load (kg/yr)	Treated Zn load over 30 year operation (kg)[a]	Cost per kg treated Zn over 30 year operation	Comments
Husky SW Adit	$1,931,658	14	380	$5,080	
Silver King 100 Adit	$7,453,796	171	4,538	$1,643	
Bermingham Adit	$4,230,638	217	6,327	$669	
Ruby Adit	$2,599,168	41	1,138	$2,284	
Keno 700 Adit	$5,617,796	162	4,538	$1,238	
Galkeno 900 Adit	$5,401,772	502	14,782	$365	
No Cash 500 Adit	$7,306,772	1,746	51,859	$141	
Galkeno 300 Adit	$11,919,102	40,141	1,203,213	$10	
Onek 400 Adit	$4,795,772	5,234	156,820	$31	
New WTF at ST Hwy near Galkeno 900	$22,624,000	45,877	1,374,815	$16	Treat GK300, GK900, Onek 400
New WTF at Elsa	$26,708,400	42,145	1,262,538	$21	Treat GK300, NC500, Bermingham, Ruby

[a] Assumes water treated to 0.1 mg/L zinc and annual discharge and zinc loading values listed in Table 4-1.

A summary of all costs associated with the former UKHM claims by site is listed in Table 9-55. Engineering construction project management (ECPM) consisting of 7% of reclamation costs has been added to the total summary costing of the physical reclamation activities in order to provide an estimate of the cost of implementation oversight.

Table 9-55 Summary Costs by Site

Site	Common Costs	Alternative/Optional Costing
Flat Creek		
Husky SW - Common Elements	$135,000	
Husky SW Adit (Managed Natural Attenuation)		$388,000
Husky SW Adit (Mine Pool Treatment)		$617,000
Husky SW Adit (Bioreactor)		$868,500
Husky SW Adit (Active Water Treatment Facility)		$1,931,658
Husky SW Adit (Reclamation Only)		$215,000
Silver King - Common Elements	$416,900	
Silver King 100 Adit (Managed Natural Attenuation)		$650,000
Silver King 100 Adit (Mine Pool Treatment)		$2,296,000
Silver King 100 Adit (Bioreactor)		$1,851,500
Silver King 100 Adit (Active Water Treatment Facility)		$7,453,796
Valley Tailings - Common Elements		
Valley Tailings Closure Alternative 1		$22,399,500
Valley Tailings Closure Alternative 2A		$24,102,600
Valley Tailings Closure Alternative 2B		$27,973,000
Valley Tailings Closure Alternative 3		$52,828,100
Valley Dispersed Tailings Remediation		$263,800
Coral and Wigwam	$20,000	
Elsa	$197,500	
Elsa - Cover over Mineralized Waste Rock (est. 5 ha covered)		$236,900
Husky	$143,100	
Husky - Optional Cover over Mineralized Waste Rock		$79,300
Sub-total	**$958,800**	**$24,017,500 - $62,793,554**
No Cash Bog		
Bermingham - Common Elements	$469,200	
Bermingham 200 Adit (Managed Natural Attenuation)		$440,000
Bermingham 200 Adit (Mine Pool Treatment)		$1,196,000
Bermingham 200 Adit (Bioreactor)		$1,127,000
Bermingham 200 Adit (Active Water Treatment Facility)		$4,230,638
Bermingham 200 Adit (New WTF at Elsa)		$2,351,624

Site	Common Costs	Alternative/Optional Costing
No Cash 500 - Common Elements	$352,800	
No Cash 500 (Managed Natural Attenuation)		$506,000
No Cash 500 (Mine Pool Treatment)		$1,488,000
No Cash 500 (Bioreactor)		$1,841,500
No Cash 500 (Active Water Treatment Facility)		$7,306,772
No Cash 500 (New WTF at Elsa)		$4,745,874
Ruby - Common Elements	$342,300	
Ruby - Optional Cover over Mineralized Waste		$78,300
Ruby 400 Adit (Managed Natural Attenuation)		$400,000
Ruby 400 Adit (Mine Pool Treatment)		$953,000
Ruby 400 Adit (Bioreactor)		$1,031,000
Ruby 400 Adit (Active Water Treatment)		$2,599,168
Ruby 400 Adit (New WTF at Elsa)		$1,567,330
Betty	$20,000	
Dixie	$66,300	
Dixie - Optional Cover over Mineralized Waste		$39,100
No Cash 100 Level Adit	$205,400	
Townsite	$75,400	
Townsite - Optional Cover over Mineralized Waste		$98,700
Sub-total	**$1,485,100**	**$1,562,100 - $14,352,678**
Christal Creek		
Galkeno (300 level and Slime Pit) - Common Elements	$608,300	
Galkeno 300 Adit (Mine Pool Treatment)		$5,337,000
Galkeno 300 Adit (Upgrade at Galkeno 300)		$11,919,100
Galkeno 300 Adit (New WTF at Elsa)		$18,043,600
Galkeno 300 Adit (New WTF at ST Hwy near Galkeno 900)		$16,571,500
Galkeno 900 - Common Elements	$23,800	
Galkeno 900 Adit (Bioreactor treatment)		$1,613,500
Galkeno 900 Adit (Stand-alone small WTF)		$5,401,772
Galkeno 900 (New WTF at ST Hwy near Galkeno 900)		$3,429,466
Hector-Calumet Site	$424,200	
Hector 400 Adit WRSA Alternative 1		$665,000
Hector 400 Adit WRSA Alternative 2		$1,869,300
Mackeno Tailings Alternative 1		$239,600
Mackeno Tailings Alternative 2		$243,700
Mackeno Dispersed Tailings Remediation		$110,900

Site	Common Costs	Alternative/Optional Costing
Onek - Common Elements	$1,350,200	
Onek 400 Adit (Bioreactor treatment with Natural Attenuation)		$1,090,500
Onek 400 Adit (Stand-alone small WTF)		$4,795,772
Onek 400 Adit (New WTF at ST Hwy Near Galkeno 900)		$2,623,226
Christal (Dorothy)	$50,000	
Dragon (UN) and Miller	$30,000	
Eagle	$8,500	
Klondike Keno	$35,000	
Rico	$18,500	
Shamrock	$64,500	
Tin Can	$37,500	
Sub-total	**$2,650,500**	**$9,056,500 - $30,465,044**
Lightning		
Keno 700 - Common Elements	$13,900	
Keno 700 Adit (Managed Natural Attenuation)		$669,000
Keno 700 Adit (Mine Pool Treatment)		$2,504,000
Keno 700 Adit (Bioreactor)		$1,570,500
Keno 700 Adit (Active Water Treatment Facility)		$5,617,796
5-2	$10,000	
Apex	$12,500	
Divide	$4,000	
Gold Hill No. 2	$2,000	
Keno 200	$35,000	
Sub-total	**$90,400**	**$699,000 - $5,617,796**
Keno Ladue River		
Sadie Ladue 600 - Common Elements	$255,200	
Sadie Ladue 600 Adit (Reclamation-only, No Water Treatment)		$117,000
Sadie Ladue 600 Adit (Managed Natural Attenuation)		$857,000
Sadie Ladue 600 Adit (Bioreactor)		$1,729,500
Wernecke - Common Elements	$123,300	
Wernecke on-claim Tailings Closure Alternative 1		$79,300
Wernecke on-claim Tailings Closure Alternative 2		$125,800
Wernecke on-claim Tailings Closure Alternative 3		$157,200
Wernecke Dispersed Tailings Remediation		$16,000
Wernecke off-claim Tailings Closure Alternative 1		$5,075,941
Wernecke off-claim Tailings Closure Alternative 2		$5,352,559

Site	Common Costs	Alternative/Optional Costing
Wernecke off-claim Tailings Closure Alternative 3		$1,089,212
Cub and Bunny	$2,000	
Keno No. 9 System	$35,000	
Lake	$35,000	
Lucky Queen Shaft	$5,000	
Silver Basin	$12,500	
Stone	$15,000	
Sub-total	**$430,000**	**$1,301,512 - $7,255,259**
Summary Common Element Closure Costing:	**$6,903,800**	
7% ECPM on Common Element Closure Costing:	**$483,300**	
Costing Range for Alternative and Optional Covers:	**$ 36,636,600 - $120,484,300**	
7% ECPM on Alternatives and Optional Covers:	**$ 2,564,600 - $8,433,900**	

10 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 and subsequently renewed and replaced by QZ12-057 in 2013. The current high level closure project master schedule (as of march 2013) is shown in the attached figure.

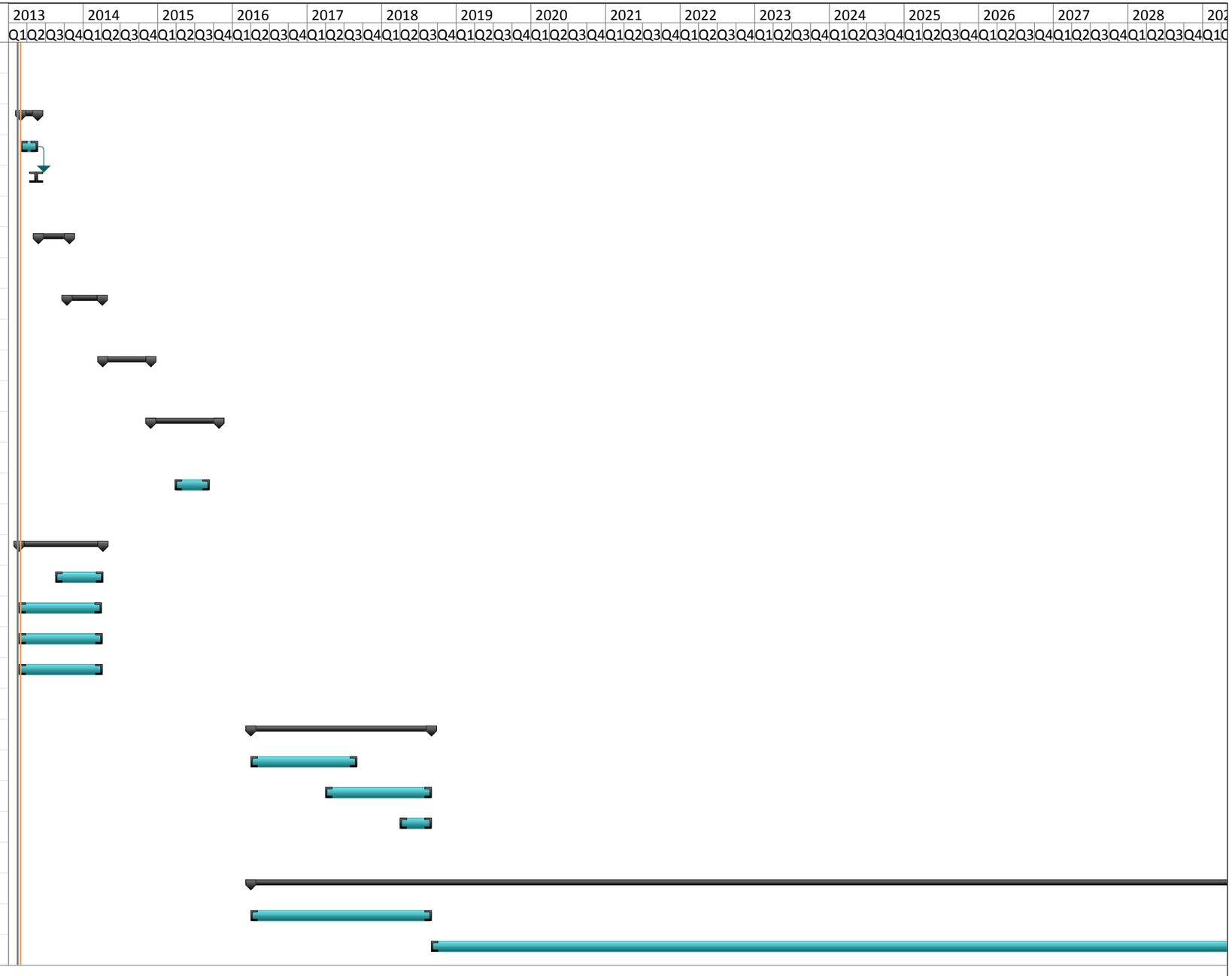
The project schedule is subject to change depending on the actual progress of the indicated project components. To better understand where potential project slippage is occurring, and to ensure that the schedule remains current as a useful planning tool, the project master schedule is revised on approximately 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; and
- Long-term monitoring.

Clause 56 of Water Use Licence QZ12-057 stipulates ERDC develop and submit a decommissioning and reclamation for closure of the Property to the Board by March 31, 2015. ERDC intends to meet and discuss with YESAA the submission of the Closure Plan as the Keno Hill Project is developed over this time frame.

ID	Task Name
1	**Keno Closure Project Schedule**
2	
3	**Completion of Closure Options Report rev 2**
4	Finalize Report with Stakeholders
5	Final Closure Options Report
6	
7	**Preferred Options Selection Process**
18	
19	**ESM Reclamation Plan Preparation**
24	
25	**ESM Reclamation Plan YESAA (DO)**
33	
34	**ESM Reclamation Plan Water Use Licence**
43	
44	**Treasury Board Process**
45	
46	**Project Consultation**
47	Socio-economic Assessment
48	District Heritage Plan
49	Local Community Consultation (Mayo, Keno City)
50	First Nation of Nacho N'yak Dun
51	
52	**Closure Plan Implementation**
53	Remediation of Water Treatment Sites
54	Remediation of Tailings
55	Remediation of Waste Rock
56	
57	**Monitoring Programs**
58	Implementation Monitoring Program
59	Long Term Monitoring



Project: Keno Closure Schedule fo
Date: Fri 3/1/13

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Deadline			
Split	External Tasks	Inactive Summary	Manual Summary	Progress			
Milestone	External Milestone	Manual Task	Start-only				
Summary	Inactive Task	Duration-only	Finish-only				

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