

**BELLEKENO MINE
KENO HILL SILVER DISTRICT
RECLAMATION AND CLOSURE PLAN**



**PREPARED FOR:
ALEXCO KENO HILL MINING CORPORATION
NOVEMBER 2011**



RECLAMATION AND CLOSURE PLAN
BELLEKENO MINE
KENO HILL SILVER DISTRICT

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1. INTRODUCTION

Alexco Resource Corp. (Alexco) through its wholly owned subsidiary Alexco Keno Hill Mining Corp. owns and operates the Bellekeno Mine located in the Keno Hill Silver District. The Bellekeno Mine is licenced under Quartz Mining Licence QML-0009 and Water Use Licence 09-092. A Preliminary Decommissioning & Reclamation Plan was submitted in July 2009 as part of the mine permitting process. Section 9.2 of QML-0009 requires that Alexco submit an updated Reclamation and Closure Plan (RCP) within 12 months of the issuance of that licence. An updated RCP was submitted in January 2011 for regulatory review and this current Bellekeno RCP reflects a further update based on the previous submission and fulfils the requirements set out in Section 9.2 of QML-0009.

In addition to the current mining and milling operations at Bellekeno, Alexco remains active in the Keno Hill Silver District (the District) undertaking the following activities which are scheduled to extend beyond the current life of the Bellekeno Mine:

- Development of the Existing State of Mine Closure Plan. Closure and reclamation planning for the entire District will be developed in accordance with the Subsidiary Agreement with Government of Canada and Government of Yukon and once approved this plan will be implemented;
- Continued care and maintenance, including water treatment, throughout the District until the Existing State of Mine Closure Plan is assessed and permitted for implementation;
- Continued exploration throughout the extensive claim block including potential production at other past producing mine sites. Thus, while 3rd party rates will be used for closure costing purposes, closure activities at Bellekeno would in all likelihood be undertaken by Alexco personnel using Alexco equipment; and
- Continued use of the existing camp located at Flat Creek (including water use and wastewater disposal to the septic system) to support the listed activities.

Figure 1-1 shows the general project location within Yukon, while Figure 1-2 shows the location on a smaller scale proximate to Keno City. The footprint of the Bellekeno Mine occupies previously impacted terrain and watersheds with the exception of the Lightening Creek Bypass road.

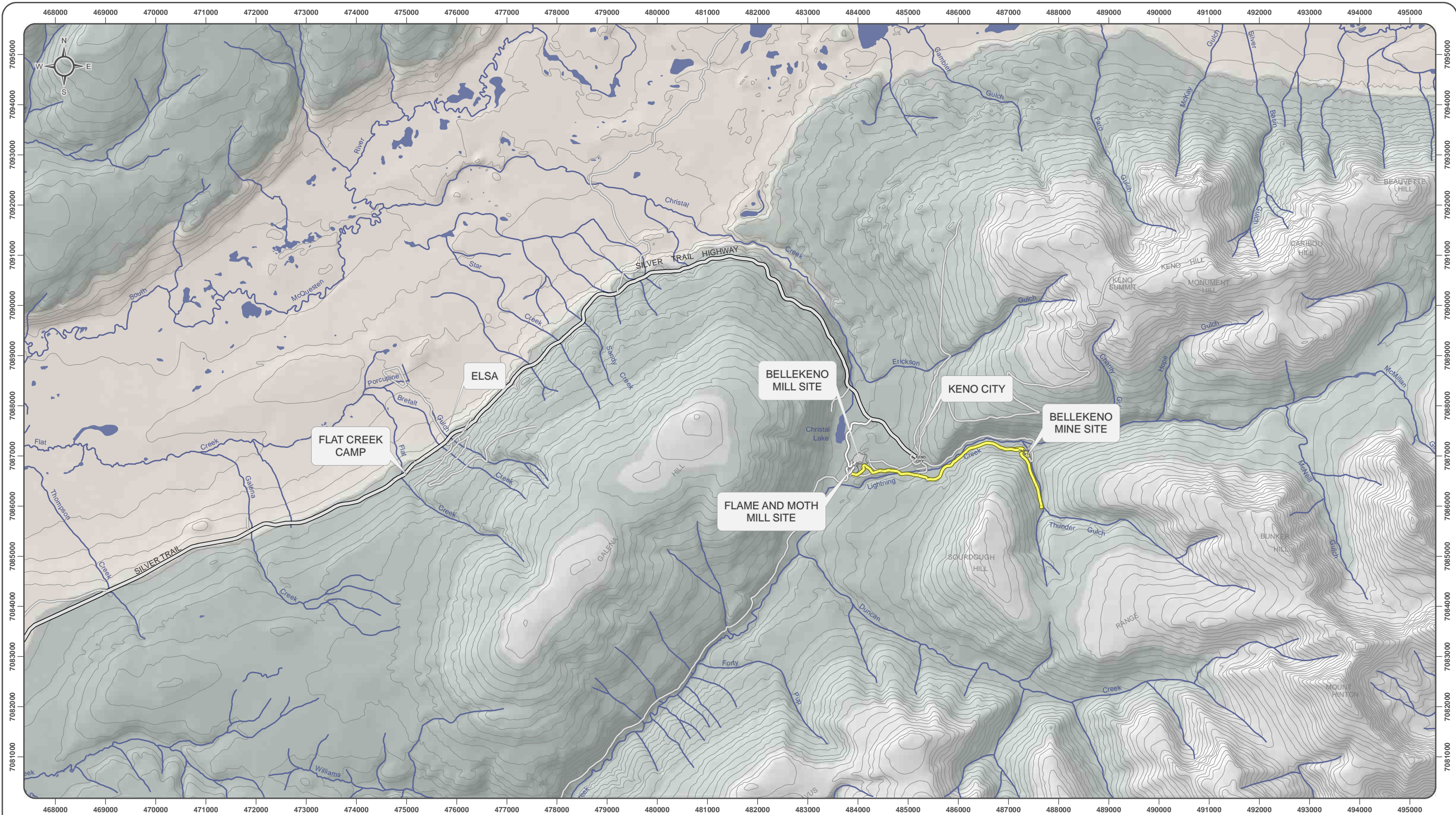
Certain procedures and environmental mitigative measures developed for the advanced exploration program have provided information to support the development of technically sound assumptions for inclusion into the Bellekeno Mine RCP. Components of the advanced exploration program overlap with components comprising the Bellekeno Mine.

The Bellekeno Mine consists of the following main components:

- Underground mining activities at the Bellekeno mine, surface support infrastructure and activities, miners' dry area, offices, trailers and portal;
- Conventional flotation mill & supporting infrastructure, coarse ore stockpile, plant services, fuel storage area, employee dry area, offices, trailers and pond;
- Dry-stack tailings facility (DSTF);
- Bellekeno 625 waste rock storage areas (non-AML WRDA);
- Potentially-AML waste rock storage facilities;
- Bellekeno 625 water treatment facilities;
- Temporary stock pile locations for mill tailings and mineralized rock;
- Haul roads (ore to Mill; waste rock; tailings to underground or DSTF) – upgraded power line haul road and Christal Lake haul road (from Duncan Creek road to the mill); new Keno City bypass road, including new bridge at Lightning Creek;
- Power distribution system (power poles, transformers); and
- Camp accommodations.

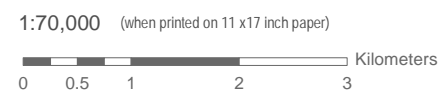
Please refer to Figure 1-3 for the location and summary of reclamation components under this RCP.

The closure measures that are expressed herein are based on the general approach and best management practices used by the mining industry today, which has in recent years developed a great deal of experience in different climates and physical conditions.



Site hydrography and contours provided by Aero Geometrics LTD, derived from aerial photograph.
 Datum: NAD 83; Map Projection: UTM Zone 8N

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- Haul Road
- Mill Access
- Highway
- Local
- Watercourse
- Waterbody
- 100 meter contour



ALEXCO KENO HILL MINING CORP.
BELLEKENO MINE - RECLAMATION AND CLOSURE PLAN

FIGURE 1-2
PROPERTY OVERVIEW

DRAWN BY MD	NOVEMBER 2011	VERIFIED BY BT
I:\ALEX-05-011\Bellekeno\GIS\mxd\Closure\2011\Submitted_Nov2011\Fig1-2_Property_Overview20111107.mxd (Last edited by: jain 11/17/2011 11:58 AM)		

2. SCOPE

2.1 GENERAL PHILOSOPHY

Alexco recognizes the importance of developing an RCP for the Bellekeno Mine that is synchronized and integrated with the district-wide Existing State of Mine Closure Plan (District Plan) that is currently being developed by the company in conjunction with the Governments of Canada, Yukon, and the Nacho Nyak First Nation (NNDFN). Closure objectives, issues, and options are being developed by these four parties in a thorough process that involves field investigations, pilot studies and test work to identify appropriate closure options, supplemented by public consultation, in order to ensure that closure measures with the best potential for success, as viewed by all stakeholders, are selected for implementation.

2.2 INTEGRATION WITH DISTRICT-WIDE CLOSURE PLANNING

The following are draft objectives that are intended to guide the development of the District Plan. These objectives are being developed in conjunction with the local community and will assist with selection of preferred closure options and implementation of the final plan. The intent of the Bellekeno RCP is to ensure that the site-specific objectives are aligned with district objectives. There are 6 primary objectives, which have a number of sub-objectives that are intended to help define how the specific primary objective they relate to will be achieved.

In order for the interested parties and others to have a clearer understanding of the meaning and intent of these objectives and sub-objectives, a glossary to these objectives is attached in **Error! Reference source not found.**

Protect Public and Worker Health and Safety

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

Protect and Restore the Environment

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

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

- i. Minimize access restrictions.
- ii. Reclaim disturbed areas to support future community and traditional land use.

- iii. Preserve identified historical resources.

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

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

Minimize Project Related Liability and Risk

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

Minimize Cost

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

2.3 REGULATORY FRAMEWORK AND OBJECTIVES SPECIFIC TO BELLEKENO CLOSURE

The Bellekeno Mine is subject to approvals received under the provision of the Yukon Waters Act (QZ09-092) and the Yukon Quartz Mining Act (QML-0009). The issuance of Water Use and Quartz Mining Licenses require submission of an RCP with updates to the RCP and associated liability cost estimate every two years. The Yukon Government Mine Site Reclamation and Closure Policy was used to assist in the development of this RCP.

Alexco acknowledges Yukon Government's mandate and specifications for mine site closure and reclamation. As such, the Company has developed this RCP to address regulatory and government policy for the mine closure. In keeping with its high standards for environmental and social responsibility, Alexco intends to implement an environmentally sound and technically feasible decommissioning and reclamation measures for the Bellekeno Mine. Closure planning and implementation will be undertaken with appropriate environmental care while respecting local laws, first nations agreements, and the public interest and ensuring that the Company's high environmental standards are achieved. Necessary environmental protection measures have been adopted in the development of this Plan to ensure that a healthy environment exists after closure.

To ensure that the overall closure philosophy can be achieved, the following primary closure objectives were emphasized during the development of this plan:

Protect Public and Worker Health and Safety

Protect and Restore the Environment by:

- i. incorporating progressive reclamation where possible;

- ii. providing slope stabilization and erosion control on linear and non-linear disturbances;
- iii. ensuring long-term chemical stability of the waste rock storage areas and components constructed from waste rock to minimize effects to downstream aquatic resources;
- iv. ensuring the long term physical stability of materials placed into the dry stack tailings facility;
- v. ensuring the long-term physical stability of key structures such as the dry stack tailings facility, Bellekeno portals, waste rock storage facilities, and access roads;
- vi. conducting post closure monitoring of the site and adaptive management to assess effectiveness of closure measures for the long term;

Ensure Land Use Commensurate with Surrounding Lands

Ensure Meaningful Participation of the NNDFN

Ensure Cost Effectiveness

Realize a Walk-away Closure Scenario

These closure principles and objectives work to ensure both physical stability and chemical stability of the site in the long term and are reflective of the guidelines derived from the YG's Reclamation and Closure Policy. The effectiveness of closure measures implemented at the Bellekeno Mine will be the subject of review by regulatory agencies and under the Yukon Quartz Mining Act, the company would be able to apply for a certificate of closure from the Yukon Government once there is agreement with their effectiveness.

Closure objectives can be considered in terms of the following key areas:

- (a) (geo)chemical stability;
- (b) water quality;
- (c) physical stability; and,
- (d) land use, aesthetics and public health and safety.

At closure the facilities for which physical stability must be addressed will be the Bellekeno portals, waste rock storage areas, any access roads not decommissioned, mill pad, and dry stack tailings facility.

2.4 DOCUMENT ORGANIZATION

This Plan is organized in the following manner:

- Section 3 contains the Project Description;

- Section 4 provides an overview of the environmental setting for the Keno Hill Silver District ;
- Section 5 provides a description of progressive reclamation activities proposed for implementation at the site;
- Section 6 provides a brief description of each mine component and the closure objectives and measures related to reclaiming or closing that component;
- Section 7 contains an overview of closure management strategy and monitoring programs; and
- Section 8 contains a summary of the cost estimate for the reclamation and closure of the Bellekeno Mine.

Yukon Government Energy Mines and Resources (EMR) has laid out requirements to be included in the RCP, as per the November 18th, 2009 letter re: Bellekeno Mine Project QML-0009 – Plan Requirements. These requirements are referenced according to their location in this document in Table 2-1.

EMR has also included a Schedule as part of that letter which details specific objectives for the RCP to achieve in closure. The objectives of that schedule are reproduced here and referenced according to where in the RCP they are adhered to (Table 2-1).

Table 2-1: EMR RCP Requirements Reference List

Closure Plan Requirement	Document Location
(a) A statement of the objectives to be achieved as a result of reclamation and closure of the site;	Section 2.2 and 2.2
(b) an analysis of the measures required to be implemented to ensure the ongoing physical and chemical stability of the site;	Bellekeno Mine (Section 6.1) Waste Rock (Section 6.2) Roads (Section 6.3) Camp (Section 6.4) Mill and Infrastructure (Section 6.5) Dry Stack Tailings Facility (Section 6.6)
(c) a description of how the Licensee will meet the performance standards set out in Schedule 1 (attached to this letter) unless other standards are agreed to in writing by the Chief in advance of submission of the plan;	Table 2-2
(d) target indicators to ensure that reclamation objectives have been met;	Section 13.0, Appendix B (Monitoring and Surveillance Plan)
(e) engineered (stamped or sealed) designs for the closure of all engineered structures, works, and installations associated with the Undertaking, including embankments and other containment structures, dry stack tailings facility, spillways, diversion ditches, waste rock and overburden dumps, the Lightning Creek bypass road and any other roads at the site, and ore stockpiles	Section 6
(f) a program and implementation schedule for the removal of all infrastructure at the site, including the mill and all infrastructure, camp and roads	Section 7.1
(g) a program and implementation schedule for ensuring the long term stability and closure of the dry stack tailings facility and waste rock storage facilities	Dry Stack Tailings Facility (Section 5.6) Waste Rock Storage Areas (Section 5.2)
(h) a program and implementation schedule for progressive reclamation to be carried out during development and production	Section 5
(i) a program for revegetation of disturbed areas, including a description of how soils will be tested for quality and quantity of nutrients and organic matter to support plant growth and a description of the seed mix to be utilized;	Section 6.7
j) details of the covers (if any) to be placed over the non acid generating or metal leaching and the potentially acid generating or metal leaching waste rock storage facilities and dry stack tailings facility;	Section 6.7
(k) a monitoring and maintenance program and implementation schedule to obtain surface and hydrogeological information adequate to verify that the reclamation objectives and discharge requirements applicable for all engineered structures, works and installations are met at closure and post-closure;	Closure Monitoring and Maintenance (Section 7.2) Adaptive Management(Section 7.3)
(l) a cost estimate to implement the plan, including a cost estimate for post closure monitoring, inspections, interim care and maintenance;	Section 8
(m) details respecting maintenance of security at the site, including any requirements for continuous care by an on-site caretaker, during reclamation and closure and post-closure;	Section 7.2.1
(n) updates on the collection and interpretation of hydrogeological information, related geochemical effects and water discharge from the mine;	Section 6.1.2 (pg.33)
(o) a program and implementation schedule for determining the effects on the receiving environment during closure and post-closure, including details of monitoring of geochemical and physical stability of all facilities at the Site and other matters as appropriate;	Section 7.2
(p) description of the quantity and quality of available organic material and borrow material stockpiles for use in reclamation;	Section 6.7.1
(q) list of equipment required to be on-site to ensure that the Licensee can provide an adequate response to an unexpected water flow or level, a spill or a release of a hazardous substance;	Section 8
(r) details of how technological developments and best management practices will be incorporated into the plan over time;	
(s) details respecting management of a temporary closure, including the following:	Section 7.4
(i) how the Licensee will secure the site during a temporary closure and ensure that all engineered structures, works and installations remain stable;	Section 7.4.2
(ii) how all engineered structures, works, and installations required to resume mining, milling, hauling and waste treatment will be maintained in good order on the site during a temporary closure;	Section 7.4.1
(iii) how the various roads under the control of the Licensee at the site will be monitored and controlled to prevent public use where appropriate and ensure public safety;	Section 6.3
(iv) a list equipment required to be on-site ensure that any unexpected water flows or levels or other contingencies are properly managed by the Licensee to protect the environment and human safety;	Section 8
(vi) monitoring and reporting schedules for ensuring the geochemical and physical stability of all engineered structures, works, and installations associated with the Undertaking, and	Sections 2.0; 3.0; 5.0 and 9.0, Appendix B (Monitoring and Surveillance Plan)
(vii) a cost estimate to implement (i) to (vi), as well as any other activities to be undertaken for a temporary closure of five years.	Section 8

Table 2-2: Schedule 1 Requirements for Terrestrial Performance Standards

Technical Guideline #	Theme	Closure Objective	Document Reference
T-01	Water Retention and Sediment Control Structures	Ensure decommissioning of water retention and sediment control structures, and their appurtenances, in such a way that drainage at, and adjacent to the site, is stable in the long term.	Existing water treatment ponds will be decommissioned and reclaimed (see Section 6.1.2 pgs. 29-35 for the Bellekeno Mine water treatment facility; Section 6.5.2 (pg. 54) for the Mill Pond)
T-02	Watercourses	Restore watercourses to meet current water management objectives (in accordance with the approved reclamation and closure plan).	Watercourses have not been physically altered by mining activities
T-03	Water Quality	Prevent contamination of receiving environments. Following decommissioning, water quality must consistently meet the requirements of applicable territorial and federal legislation. Recognition will be given to background levels of substances occurring prior to start of operations	A bioreactor will be installed in the current water treatment ponds at the Bellekeno Mine for treatment of mine discharge (see Section 6.1.2 pgs. 29-35)
T-04	Site Contamination	Prevent exposure to and mobilization of substances that pose a risk to human health and the environment through physical and chemical stability	Section 6
T-05	Potential Acid Rock Drainage	Walk-away solution	P-AML and AML waste rock is being stored in a temporary lined facility during operations, and will be rehandled back to the underground below the long-term static water level of the mine at closure. Additional permanent P-AML storage facilities will be constructed according to approved engineering designs, if necessary (see Section 6.2.2 pgs. 39-40)
T-06	Tailings Management	Ensure physical and chemical stability in the long term and eliminate the need for active treatment	The DSTF will be constructed in a manner that is physically stable and covered with an evapotranspirative cover at closure to prevent infiltration and promote vegetation (see Section 6.5.5 pgs. 64-66)
T-07	Underground Workings and Openings to Surface	Meet water quality objectives Except for authorized access, prevent inadvertent or intentional underground access that may be a hazard to humans and wildlife Prevent subsidence or changes in the topography that may result in a hazard to humans or wildlife	A rock pile will be constructed to close access to the Bellekeno East Adit (Section 6.1.2 pgs. 24-26); an adit bulkhead will be installed at the Bellekeno 625 Adit to prevent access and provide the ability to manage water discharge (Section 6.1.2 pgs. 31-32); an engineered cap will be placed at the 200 Level Vent Raise (Section 6.1.2 pgs. 36-37)
T-08	Terrain Hazards	Terrain hazards at the site should be no more significant hazard to people and wildlife than is present in the surrounding vicinity	Section 6
T-09	Mine Rock Piles	Rock piles and dumps must be physically and chemically stable in the long term to prevent erosion, subsidence or collapse, and such that dump runoff and surface drainage meet legal requirements	Waste Rock will be stored in approved, engineered facilities and covered and revegetated at closure (see Section 6.2.2 pgs. 39-40)
T-10	Roads and Other Access	Protect public safety. In decommissioning linear infrastructure, enable pre-mining human and wildlife utilization of the area. If however, an alternative future land use is identified, alternative objectives may be identified	Road decommissioning will occur in a manner commensurate with EMR's Yukon Mine Site and Reclamation Closure Policy (see Section 6.3.2 pgs. 42-44)
T-11	Erosion Control	Physical stability such that upon closure, slopes, excavations and other disturbed lands are in a condition that will limit the incidence of soil erosion, slumping and other instabilities that are likely to impede revegetation of a reclaimed site, pose a threat to public safety, lead to wildlife mortality or cause excessive sediment loads to enter nearby water bodies	Slopes will be regraded to at least 2.5H:1V or better, for physical stability
T-12	Re-vegetation	Ensure physical stability and prevent a temporary loss of wildlife habitat utilization from becoming permanent by re-establishing a vegetative mat (food source, hide, etc.) leading to self-sustaining natural revegetation	Revegetation will occur in a manner that meets or exceeds EMR's Yukon Mine Site and Reclamation Closure Policy (see Section 6.6 pgs. 66-67)
T-13	Mine Infrastructure	Ensure physical stability and to remove potential threats to public health and safety, including identification and removal of hazards and hazardous materials	All infrastructural buildings and equipment will be removed and transported offsite for salvage at the end of mine life (see Section 6.1.2 pgs. 27-29 for Bellekeno Mine facilities; see Section 6.5.2 pgs. 46-62 for the Mill area facilities)
T-15	Temporary Closure Site Conditions	Ensure public health and safety and protection of the environment in the event of a temporary closure and to manage risks associated with potential abandonment of the site	Section 7.4 pgs. 74-78
T-16	Geological Values and Heritage	Ensure post-closure access to geological information obtained both leading up to and during mineral development and production at a mine site	Not applicable

3. PROJECT DESCRIPTION

3.1 PROJECT LOCATION AND OVERVIEW

The Bellekeno Mine Project principal mine activities and infrastructure include underground mining and development operations at Bellekeno, (located within the Keno Hill Silver District) and a conventional flotation mill and dry stack tailings facility at the Keno District mill site for the processing and production of minerals from the Bellekeno Mine. The project is located in the vicinity of Keno City in central Yukon, 354 km (by air) due north of Whitehorse (see previous Figure 1-1). Access to the property is via a paved, two-lane highway from Whitehorse to Mayo (407 km) and an all-weather gravel road northeast from Mayo to Elsa (45 km); a total distance of 452 km. The property lies along the broad McQuesten River valley with three prominent hills to the south of the valley (see Figure 1-2). The Bellekeno mine area is located about 3 km east of Keno City, while the mill site is about 1.2 km to the west.

The following Table 3-1 presents an overview of the Bellekeno Mine Project:

Table 3-1: Bellekeno Mine Project Overview	
Location	3 km east of Keno City, 45 km northeast of Mayo, 354 km north of Whitehorse, YT. Located in the Traditional Territory of the First Nation of Nacho Nyak Dun within the McQuesten River Valley
Land Position	Alexco Resource Corp. and its wholly owned subsidiary Elsa Reclamation and Development Corp. owns 1,563 claims and leases covering an area of approximately 24,262 ha within the Keno Hill Silver District including the Bellekeno Mine project area. Two Fee Simple lots within the Bellekeno Mine project area total 59 ha (Lot 960 and Lot 956)
Mining Method	Year round underground narrow vein cut and fill mining
Current Mine Life	5 years
Current Total Project Life	15 years (0 – 5 years construction and mine operation; 6 – 15 years decommissioning and reclamation and closure monitoring).
Annual Production	Average annual production of 3,300,000 oz silver, 30,000,000 lb lead, and 24,500,000 lb zinc (based on current Preliminary Economic Assessment).
Total Metal Production	Current Life of Mine production of 16,500,000 oz silver, 150,700,000 lb lead, and 122,400,000 lb zinc (based on current Preliminary Economic Assessment).

Table 3-1: Bellekeno Mine Project Overview

Ore Production Rate	250 tonnes/day for Years 1-2 and 400 tonnes/day for Years 3-5 (annual average). Maximum of 613,000 tonnes of ore mined from Bellekeno
Mine Waste Rock	500,000 tonnes of waste rock produced from underground development
Ore Mining and Placement Schedule	Ore mining for 360 days/year Mill Operation 360 day/year 100,000 tonnes of waste material placed on surface each year
Mill Recovery Process	Conventional flotation process producing separate lead/silver concentrate and zinc concentrate shipped off site for smelting. Mill location at historic Flame and Moth pit area. Dry stack tailings technology, ~50% of dry tailings placed on surface and ~50% placed underground as paste backfill. Two tailings streams to allow for separation of high pyrite tailings if required for placement underground as paste backfill.
Effluent Testing	Metal Mining Effluent Regulations
Work Force	~ 165 production and ongoing exploration;
Airstrip	Mayo, YT
Power	Hydro grid power Yukon Energy, diesel power backup
Water Supply and Use	Water use and discharge within 2 drainages, Lightning Creek and Christal Creek. 245 m ³ /day water use, 385 m ³ /day water discharge Lightning Creek drainage 68 m ³ /day fresh water use, 17 m ³ /day water discharge Christal Lake drainage Conventional lime precipitation water treatment
Climate Setting	945 m above sea level Annual Precipitation 413 mm Annual Lake Evaporation 460 mm
Environmental Baseline	Site Characterization Report 1996, ongoing data collection programs through current Type A Water Licence QZ09-092, Type B Water Licenses QZ06-074 and QZ07-078, Class IV Mining Land Use Approval LQ00240 and QML-0009.
First Nations	First Nation of Nacho Nyak Dun

3.2 CURRENT STATUS

In 2006, Alexco initiated a broad surface exploration program (Class 3 Mining Land Use Approval LQ00186) in the historic Keno Hill Silver District with surface diamond drilling focused primarily toward systematic testing of numerous targets, validating and expanding historic mineral resources and acquiring a better understanding of the local geology and ore controls. Based on broadly successful 2006 results, in 2007 Alexco expanded its exploration to a two phase district exploration program; the first phase focused on following up prior results in the area of the historic Bellekeno mine and the second phase continuing the broad information gathering drill program elsewhere across the district. In 2008 Alexco conducted surface exploration at a number of targets throughout the district and proceeded with advanced underground exploration and development at Bellekeno (Mining Land Use Approval LQ-00240, and Yukon Water Board Licence QZ07-078). On July 9, 2008, Alexco released a Preliminary Economic Assessment (PEA) of Bellekeno prepared by SRK Consulting.

On July 10, 2009 a YG Decision Document recommended the project proceed subject to recommended terms and conditions of mitigation measures. Quartz Mining Licence QML-0009 was issued for the project on November 17, 2009 which allowed for the commencement of non-water related construction activities. Underground development at Bellekeno re-commenced in January 2010. Initial development consisted of excavating central remucks in the Bellekeno East Decline and the widening and heightening of the existing ramps down to the Southwest Zone. By March 2010 the majority of this work was completed and a new incline and decline were driven from a central location in the Southwest portion of the mine. Various ore accesses off of these ramps were also driven. At the bottom of the mine the existing 850 Decline was extended and an exploration drilling platform was excavated. During this time, minor ore access development in the 99 Zone was on-going. Pre-production mining of mineralized vein material commenced in September 2010 and continued through till December 2010 in various stopes located throughout the mine.

The Type A Water Licence QZ09-092 with additional conditions and monitoring requirements was issued for the project on August 19, 2010 which allowed for water related construction activities to commence. Construction activities were substantially completed in December 2010 and the mill and mine commissioning continued through December 2010. Finalization of ancillary construction tasks was ongoing through 2011 and commercial production for the Bellekeno Mine was declared in early January 2011.

4. ENVIRONMENTAL SETTING

Table 4-1 provides an overview of the project area and environmental setting information for the area. This information was compiled from various published and unpublished reports and is not intended to provide a thorough reflection of the environmental setting, but rather a succinct overview of the key environmental parameters.

Table 4-1: Keno Hill Silver District Setting Summary	
Region:	Yukon
Topographic Map Sheets:	NTS 105M/14 & 105M/13
Geographic Location Name Code:	Keno City
Latitude:	63° 54' 32" N
Longitude:	135° 19' 18" W
Drainage Region:	Stewart River drainage region
Significant Watersheds:	McQuesten River, Lightning Creek and Stewart River Watershed, Mayo River
Nearest Communities:	Mayo, Keno City
Road Access:	Silver Trail Highway
First Nations Traditional Territory:	Nacho Nyak Dun
Surrounding Land Status:	YG Land
Special Designations:	None
Ecoregion:	Yukon Plateau (North)
Study Area Elevation:	945 m asl (Above Sea Level)

<p>Vegetation Communities:</p>	<p>Northern boreal forests occupy lower slopes and valley bottoms, spruce, pine and alder</p> <p>Grasses and sedges, mosses occupy forest floor</p> <p>Heavy moss and lichen growth resident as ground cover understory of shrub willow</p> <p>Open and forest fringe areas of willow and scrub birch, and various flowering plant species</p>
<p>Wildlife Species:</p>	<p>Moose, dall sheep, grizzly and black bear, caribou, furbearers, small mammals</p> <p>Various terrestrial bird species including ptarmigan, birds of prey, and migratory species, including waterfowl (snow geese, eagles, peregrine falcon, gyrfalcon)</p>
<p>Fish Species:</p>	<p>Bering and Beaufort Sea salmonids and freshwater species, including: Arctic grayling, Arctic char, lake trout, trout perch, lake whitefish, broad whitefish, burbot, inconnu, Arctic Cisco, Northern pike</p>
<p>Valued Environmental and Socio-economic Components:</p>	<p>Water quality, Arctic grayling, Chinook salmon, moose, public health and safety, trapping, traditional harvesting, tourism.</p>

5. PROGRESSIVE RECLAMATION

Progressive reclamation efforts will help reduce slope erosion through physical slope stabilization by means of revegetation efforts, enhancing ultimate reclamation success. Progressive reclamation will be undertaken in a manner to ensure that the amount of work required at the end of the mine life to achieve the closure objectives are minimized.

Progressive reclamation limits the environmental liability and thus reduces the ongoing risk carried by the company through:

- providing remediation to reduce or eliminate chemically hazardous material and sources of chemical contamination and other wastes;
- stabilizing potential sources of erosion and sediment release;
- initiating slope stability measures to enable reclamation;
- replanting and reseedling of disturbed areas no longer required for mine operations;
- reducing the total area requiring reclamation at the end of mining; and
- reducing closure security requirements as closure liability is reduced progressively.

Progressive reclamation activities will take place at every possible opportunity. Initially these activities are limited to stockpiling surface overburden and soil materials for future use in stabilization and revegetation of disturbed areas resulting from mine construction.

Initial progressive reclamation associated with the Bellekeno Mine Project has occurred in 2011 and in previous years and consists of the following activities:

- Recontouring and revegetation of the slopes surrounding the Bellekeno mine portal;
- Recontouring the organic growth media stockpiles located at the mill area;
- Recontouring disturbed areas adjacent to the Dry Stack Tailing Facility.
- Reclamation of the power line corridor from the Silver Trail Highway to the mill site.

5.1 REVEGETATION

Progressive revegetation is an important aspect of progressive reclamation. In general, revegetation measures can be grouped into two categories:

- Linear disturbances (roads, cut lines, power lines, etc.) that by their nature are within close proximity to natural seed sources are best prepared by decompacting the surface but allowing the surrounding flora to volunteer seed for the clearing. This has been shown to promote the development of vegetative covers comprised of native species which tend to require little fertilization and have the best chance of becoming self-sustaining. Natural revegetation observed on the historic haul roads at Keno Hill probably took many years to become revegetated on a strictly volunteer basis because the road surfaces were compacted from truck traffic, and therefore

water and seed had difficulty penetrating the surface. Therefore, scarification and decompaction have been shown to produce excellent natural revegetation results and will normally suffice as a reclamation measure for these type of linear features. In certain circumstances, areas of access roads which may require drainage/erosion control will be assisted with reseeding. Each linear area to be reclaimed will be inspected prior to the implementation of reclamation activities in order to ensure that the most appropriate reclamation prescription has been developed for implementation.

- Areal disturbances (tailings area, mill pad clearing, etc.) tend to require assisted revegetation to promote self-sustaining revegetation in a timely manner. Areas that have been compacted (mill pad and other areas subject to truck traffic) will be scarified/decompacted and reseeded. Experience at other sites has shown that simple grass seeding may create large open areas of grass species that have the tendency to out-compete woody stemmed vegetation, thereby creating an unnatural 'pasture' in the boreal forest. Therefore, revegetation of these sites is focused on stabilizing the surface from erosion but allowing natural succession (willows, etc). The incorporation of commercially available native species known to occur in the District and in the Yukon will be evaluated for inclusion into the final reclamation seed mixture in order to reduce the introduction of agronomic species into reclaimed areas.

5.2 RECLAMATION RESEARCH

Reclamation research programs are used to support the site specific refinement of closure measure designs implemented at sites during final closure. There are currently a number of reclamation research programs underway as part of the District Closure Plan. These current programs have direct application to the reclamation and closure of the Bellekeno Mine and Alexco will continue to utilize the research programs underway within the District Closure Plan for planning and optimization of the Bellekeno RCP. The following reclamation research programs are currently in progress and the results utilized for the Bellekeno mine:

- cover system design and field trials;
- site revegetation field trials;
- bioreactor trials;
- natural attenuation studies

Alexco will initiate additional reclamation research programs during the Bellekeno Mine operational in order to infill any gaps in closure programs for the District Closure Plan. Details on any reclamation research programs will be included in subsequent revisions to this RCP.

6. CLOSURE MEASURES

This section presents a discussion of the closure objectives and measures associated with the various components slated for reclamation (reclamation components) at the Bellekeno Mine. It is worth noting that some elements of this plan have already been developed, reviewed and approved under Mining Land Use Approval LQ-00240 (such as closure measures for the Bellekeno East portal reclamation, mine access road, waste rock storage area), and security has been provided to cover the anticipated costs. These measures are repeated here with up-to-date information and costs (Section 8).

Decommissioning and reclamation measures will be reviewed regularly to ensure conformity with site wide objectives, issues and closure measures that are developed during the District Closure Plan discussed above. As the Reclamation and Closure Plan is updated in the future, site conditions will be updated based on as-built information and survey pick-ups of constructed facilities.

The approach to each subsection is to present a brief description of each component and related facilities with potential closure objectives and planned closure measures to ensure long term physical and chemical stability.

Summaries of the various closure measures are provided for features or groups of features shown in Figure 1-3 and discussed below.

The Bellekeno Mine Project reclamation components are segregated as follows:

- 1) Bellekeno Mine
- 2) Waste Rock Storage Facilities
- 3) Roads
- 4) Camp Downsizing
- 5) Mill and Ancillary Facilities
- 6) Dry Stack Tailings Facility

In addition to the closure measures proposed in the following sections, the *Yukon Mine Site and Reclamation Closure Policy* Technical Guidelines also provide direction on reclamation and closure objectives for key features of a mine. These Guidelines are repeated in the November 18, 2009 letter to AKHM regarding QML-0009 Plan Requirements, and are references herein in Table 2-2. The Guidelines themselves may be referenced for principal legal requirements, policy detail pursuant to the Yukon Mine Site Reclamation and Closure Policy, as well as possible strategies for achieving the desired objectives, which have been considered in the development of this RCP.

6.1 BELLEKENO MINE

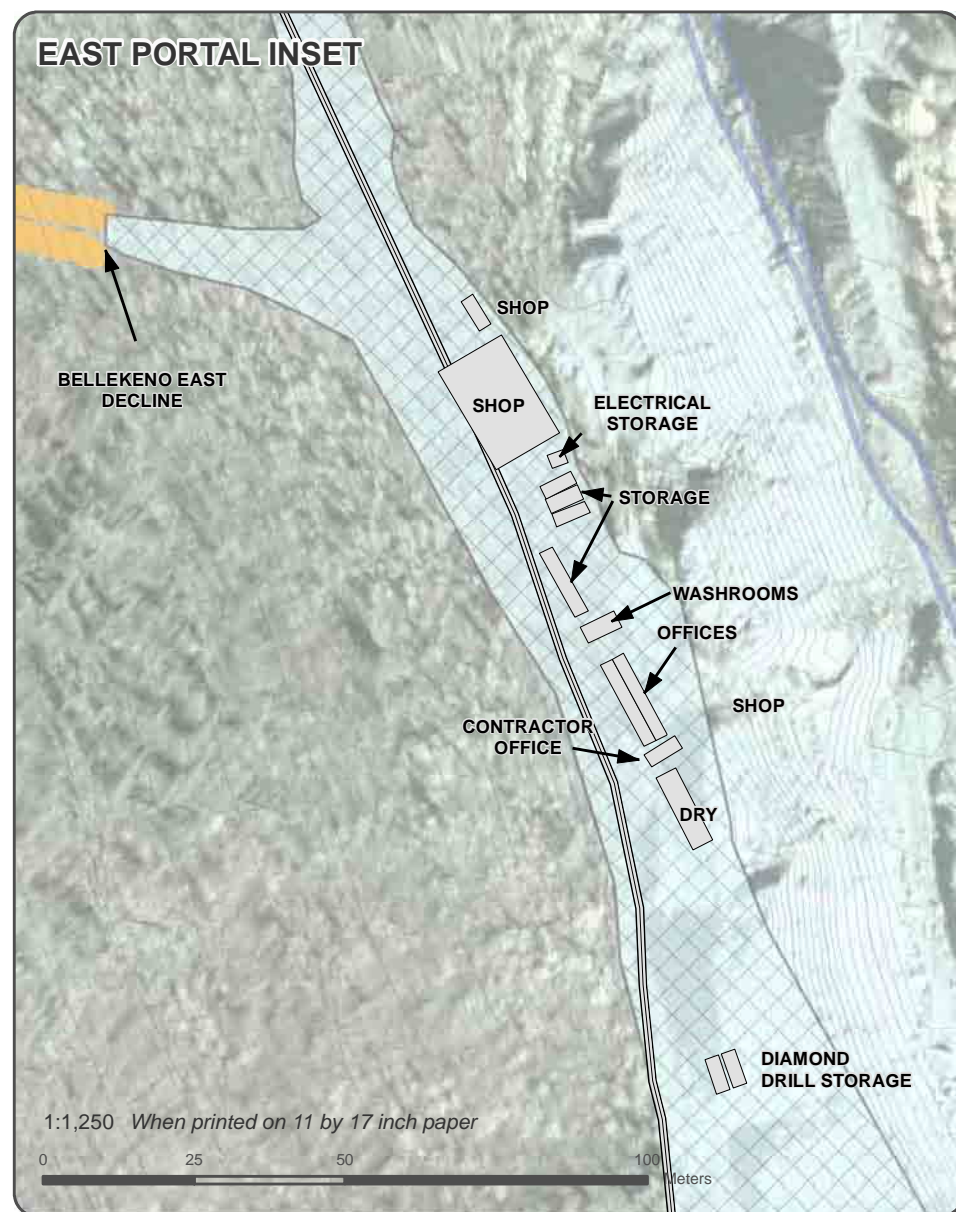
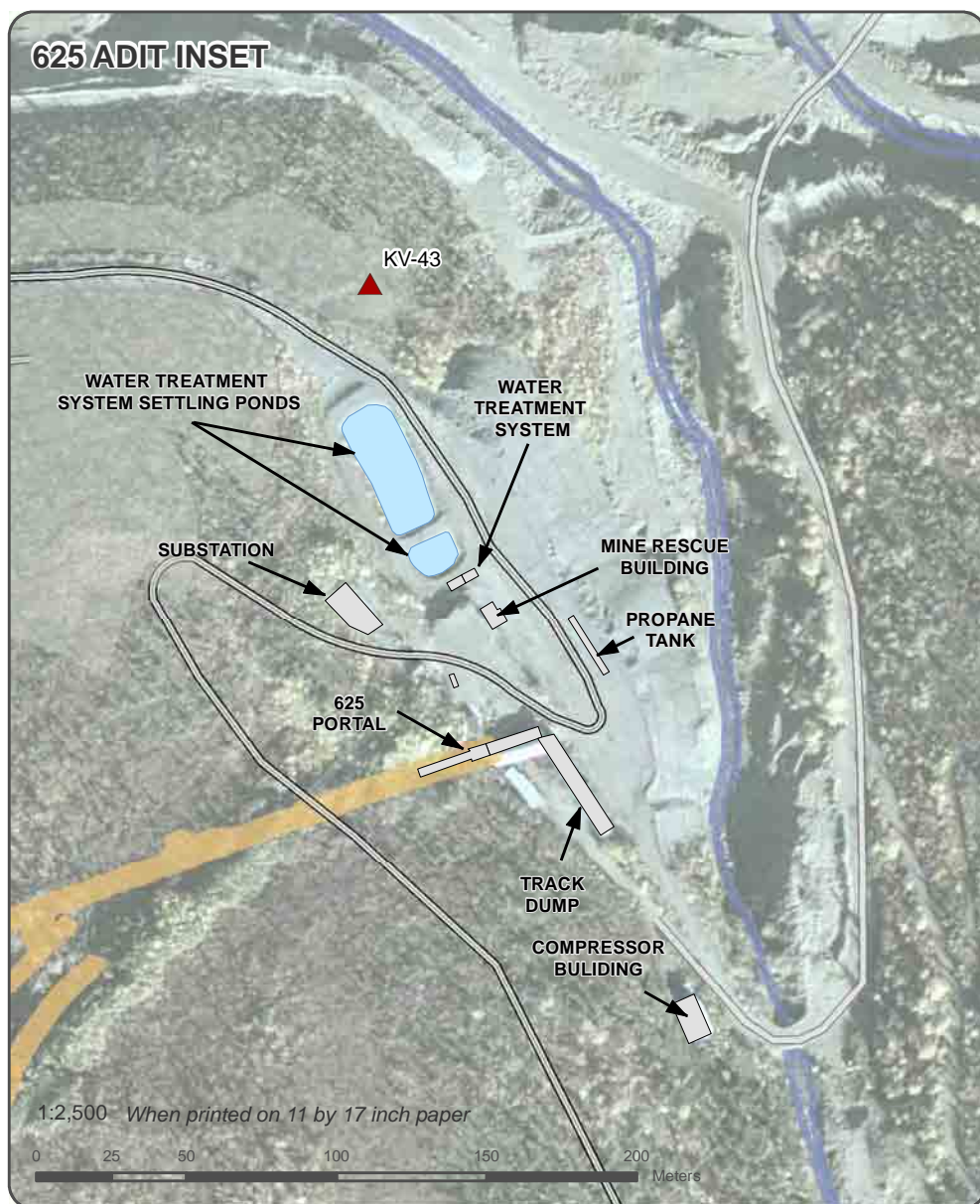
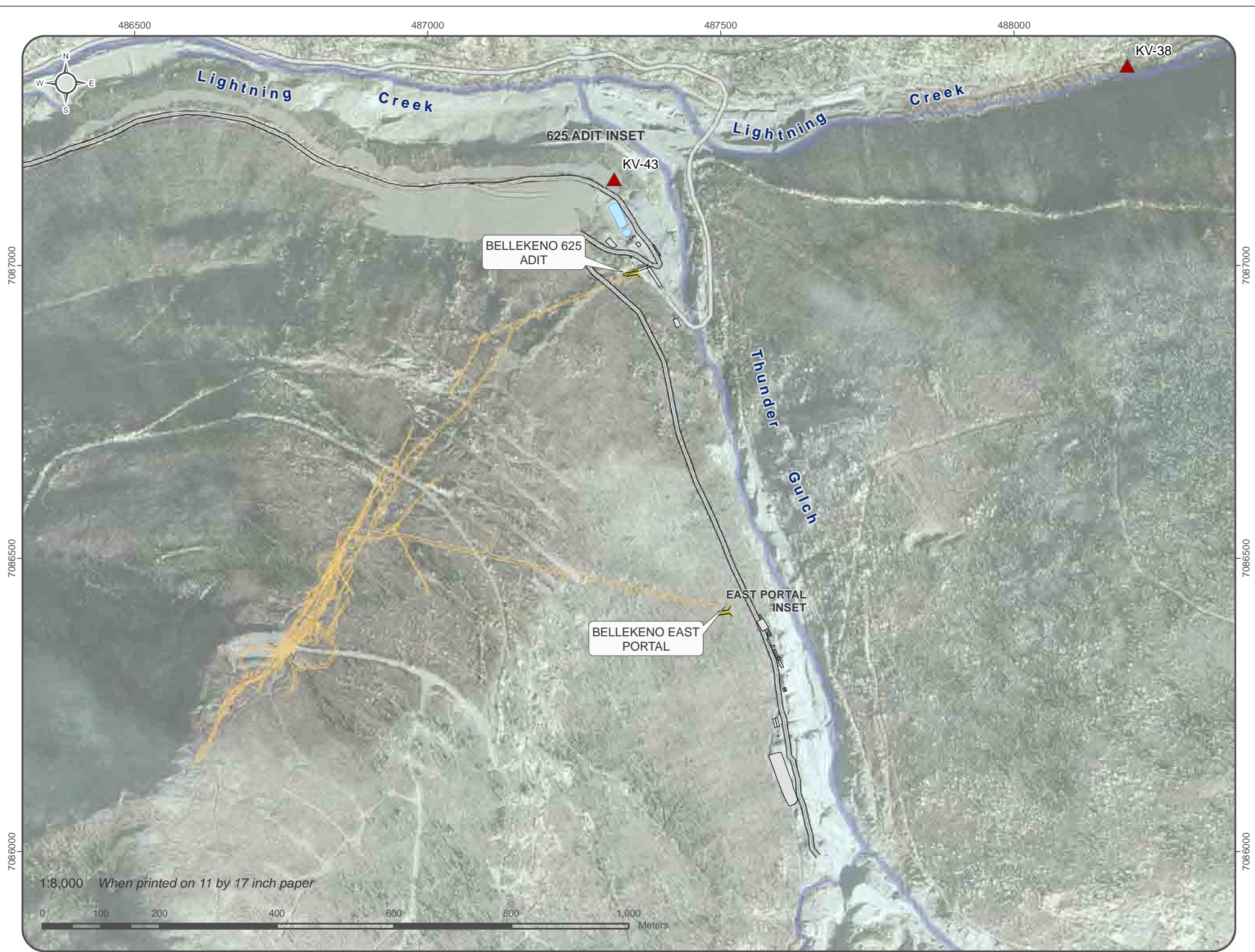
The Bellekeno Mine consists of the underground workings, surface adit entrances, the current Bellekeno 625 treatment facility and associated buildings and infrastructure. There are three access points to the underground workings including the Bellekeno East underground and portal site, the Bellekeno 625 adit site and treatment facility and the 200-level vent raise (Figure 6-1). The 200-level vent raise is not a component of the Bellekeno mine operations (historic liability not used in Bellekeno operations) but is included in the RCP given its proximity to the Bellekeno mine. The Bellekeno East portal is the primary ingress/egress point for the Bellekeno Mine. The Bellekeno 625 portal provides secondary escape and ventilation intake for the mine and discharges metals-laden water which requires treatment on a continuous basis. The current treatment facility is a lime-addition circuit and multi-media filtration system. The system formerly consisted of a simple lime-addition circuit to deal with the natural leaching of metals from the exposed workings, but was upgraded to deal with an increase in TSS and ammonia levels associated with underground mining activities.

6.1.1 Closure Objectives

The objective for decommissioning the Bellekeno mine infrastructure is to ensure: (1) physical stability and management of the mine pool, (2) chemical stability of the mine pool discharge (3) that there are no threats to public health and safety, and (4) that the mine area is reclaimed such that it is aesthetically acceptable.

6.1.2 Closure Measures

Closure of the mine area will include restricting access and identifying and removing hazards and hazardous materials. Concern regarding physical stability of infrastructure at closure will be mitigated for the most part through disassembly and removal from the site and by eliminating underground access. The mine pool will be managed by transitioning from actively treating adit discharge to sealing the adit, implementing in situ mine pool treatment and installing a passive treatment system (bioreactor). Additional chemical stability objectives will be associated with any soil contamination by fuel, chemicals or other wastes in the areas around the portal and treatment system.



	Adit		Building		Portal Area		Haul Road
	Surface Water Quality Station of Interest		Pond		Conceptual design of waste rock disposal Area		Local Road
	Underground Workings						

Aerial photograph obtained from Geodesy Remote Sensing Inc., Calgary Alberta. Imagery acquired September 13th and 14th 2006. Site hydrography and contours derived from 2006 aerial imagery obtained from Aero Geometrics, Calgary Alberta.

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Datum: NAD 83; Projection: UTM Zone 8N

AKHM

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ALEXCO KENO HILL MINING CORP.
BELLEKENO MINE - RECLAMATION AND CLOSURE PLAN

FIGURE 6-1
BELLEKENO MINE SITE LAYOUT
SPECIFIC MINE COMPONENTS FOR CLOSURE

DRAWN BY MD	NOVEMBER 2011	VERIFIED BY BT
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I:\ALEX-05-01\Bellekeno\GIS\mxd\Closure\2011\Submitted_Nov2011\Fig-1_Bellekeno_Mine_Site_Layout20111116.mxd (Last edited by: jjan 11/17/2011 12:06 PM)

Bellekeno East

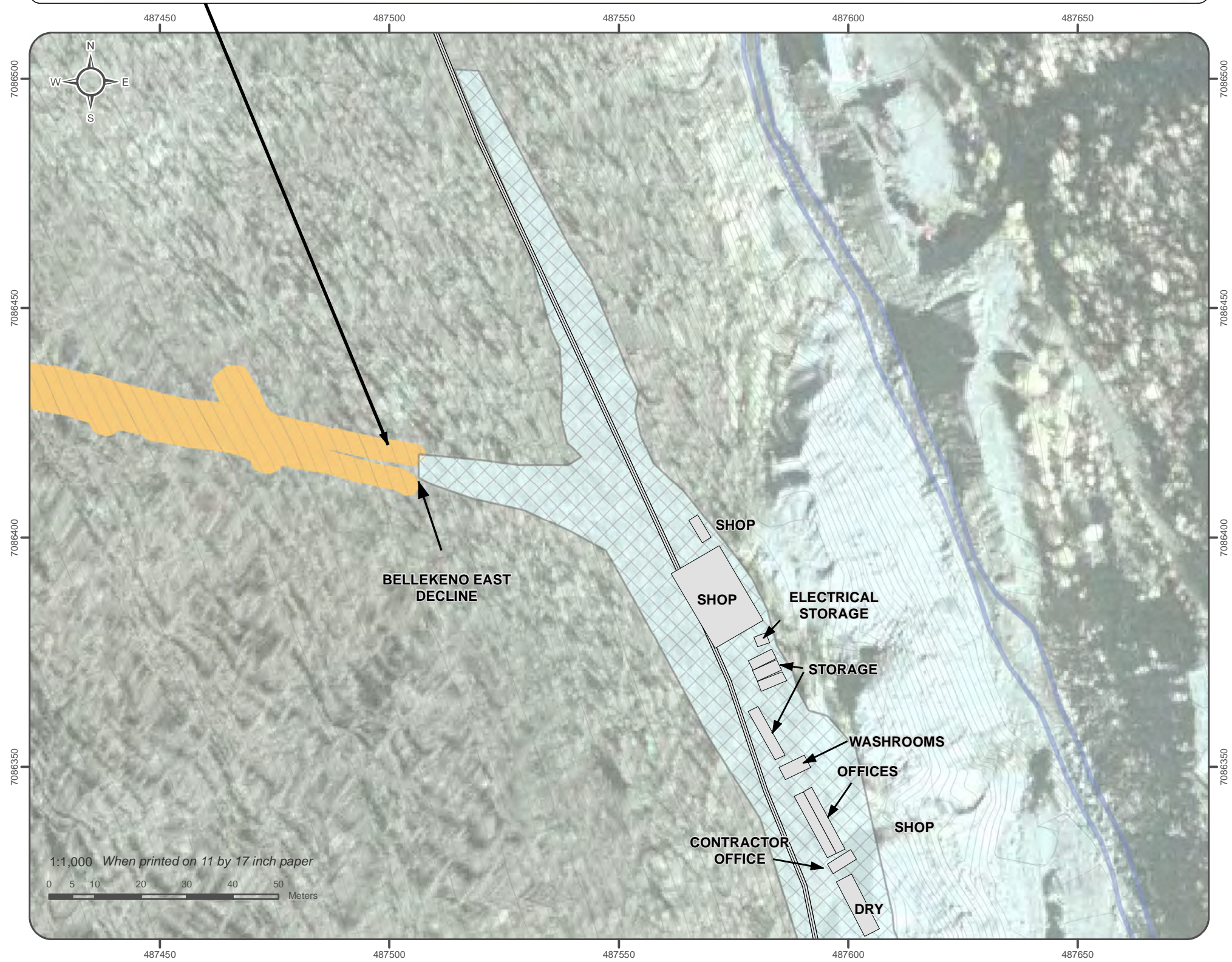
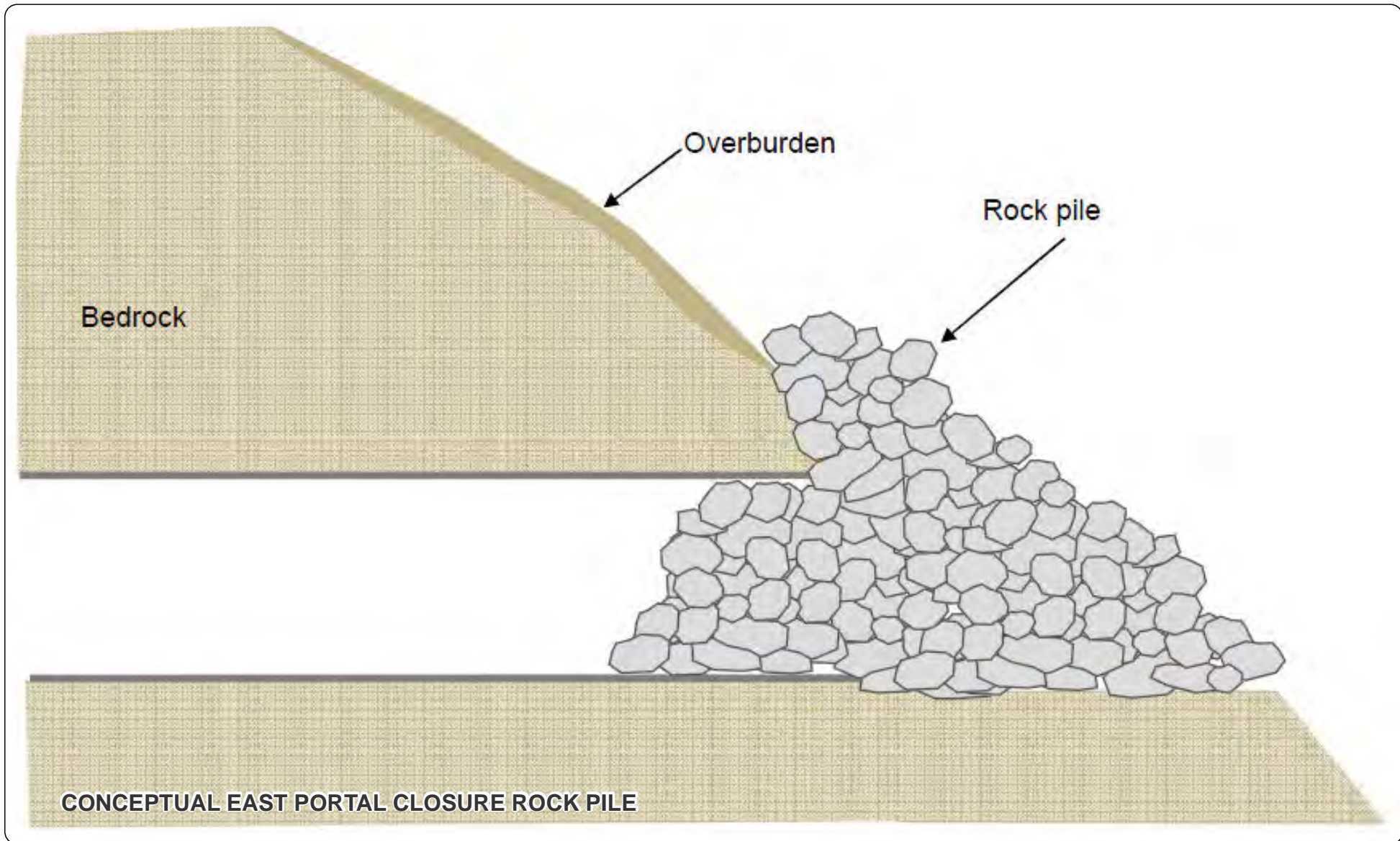
Plate 6-1 shows the current state of the Bellekeno East decline. The decline collar is a multi-plate culvert 4 meters in diameter extending from the surface into the competent bedrock.

At closure, underground equipment will be removed from the underground mine through Bellekeno East. The portal will remain temporarily accessible at closure for the rehandling of P-AML waste rock back into the underground (see Section 6.2). The Bellekeno East adit opening will then be blocked by inserting rock fill to protect human health and safety and prevent wildlife access (Figure 6-2). This method, in use at other northern Canadian mines, allows for movement of water and air through the opening, as well as allowing for any movement of rock walls, to prevent failure as would occur with a concrete plug for example. An adit decant channel will not be constructed as any water leaving the mine workings will flow via the Bellekeno 625 adit which is connected to the Bellekeno East decline. Reclamation measures for the Bellekeno Mine are predicated on the fact that the static water elevation will not reach the elevation of the Bellekeno East portal and therefore this portal will not discharge water. As such the sediment ponds constructed at Bellekeno East for development of the decline will be progressively reclaimed prior to mine closure.



Plate 6-1: Bellekeno East Portal

Reclamation of the Bellekeno East portal site will include removal of the shop and other buildings (e.g. explosives and cap magazine). Fuel tanks will be cleaned and removed along with liners for reuse or landfilling. Any additional debris will also be removed for reuse or proper disposal. All solid waste will be disposed of in accordance with the Yukon Environmental Act Solid Waste Regulations. Alexco has a permitted commercial solid waste facility located in Elsa. All waste petroleum products and any other special waste, as defined in the Special Waste Regulations will be disposed of in accordance with the Regulations. Any soils contamination will be documented through a final site contamination assessment. Contaminated soil will be removed and/or remediated in an approved manner. A land treatment facility has been constructed near the Elsa Valley Tailings Facility for remediation of such soils for district closure, and can be used for remediation of any hydrocarbon contamination at the Bellekeno Mine. The portal site would then be recontoured and scarified to facilitate revegetation and establish drainage (revegetation at the Bellekeno East portal site has already been undertaken). Signage will be installed to indicate the portal presence.



- Underground Workings
- Building; Unknown
- Haul Road
- Portal Area
- Local



ALEXCO KENO HILL MINING CORP.
 BELLEKENO MINE - RECLAMATION AND CLOSURE PLAN
FIGURE 6-2
BELLEKENO MINE SITE LAYOUT
EAST PORTAL CLOSURE ROCK PILE

DRAWN BY MD NOVEMBER 2011 VERIFIED BY BT

Aerial photograph obtained from Geodesy Remote Sensing Inc., Calgary Alberta. Imagery acquired September 13th and 14th 2006. Site hydrography and contours derived from 2006 aerial imagery obtained from Aero Geometrics, Calgary Alberta.

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Datum: NAD 83; Projection: UTM Zone 8N

Bellekeno East Surface Facilities

Various surface support buildings and facilities (Plate 6-2; Plate 6-3) are in place near the entrance to the Bellekeno mine and include:

- Surface maintenance shop
- Sea container storage units
- Wash / restroom building
- Contractor offices
- Technical services offices

All of the surface buildings at Bellekeno East are portable structures that will be removed and transported offsite for salvage at the end of the mine life.



Plate 6-2: Bellekeno East Surface Facilities



Plate 6-3: Bellekeno East Office Facility

Bellekeno 625

As with Bellekeno East, reclamation of the Bellekeno 625 adit site will include removal of buildings and infrastructure but also includes the conversion of the water treatment ponds into passive bioreactors. The primary facilities in place at the Bellekeno 625 location include:

- Historic loadout and snow shed facility
- Compressor shack
- Ventilation fan and propane tank
- Water treatment buildings
- Sea container storage units
- Electrical substation

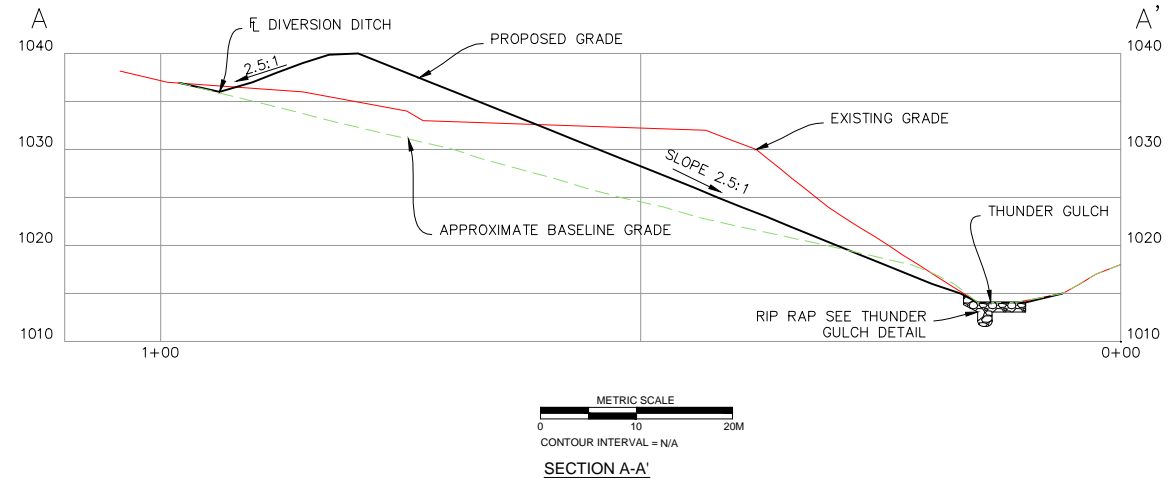
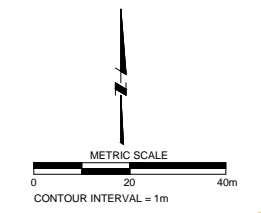
Reclamation and closure of historic terrestrial liabilities are addressed under the District Plan and in discussion with INAC and YG respecting terrestrial liability. Any additional debris will also be removed for reuse or proper disposal. All solid waste will be disposed of in accordance with the Solid Waste Regulations. All waste petroleum products and any other special waste, as defined in the Special Waste Regulations will be disposed of in accordance with the Regulations. Any soils contamination will be documented through a final site contamination assessment. Contaminated soil would be removed and/or remediated in an approved manner (i.e. land treatment facility in Mayo or Elsa). The adit site would be recontoured and scarified to facilitate natural revegetation and establish drainage. Signage will be posted to indicate the presence of an adit.

Terrestrial reclamation of historic liabilities at Bellekeno is currently under the scope of the District Closure Plan. Preliminary designs for recontouring the historic Bellekeno 625 waste dump have been developed under the District Closure planning process and are included in this RCP to ensure all areas of disturbance are included in the RCP. The preliminary Bellekeno 625 waste rock dump recontouring design is shown in Figure 6-3.

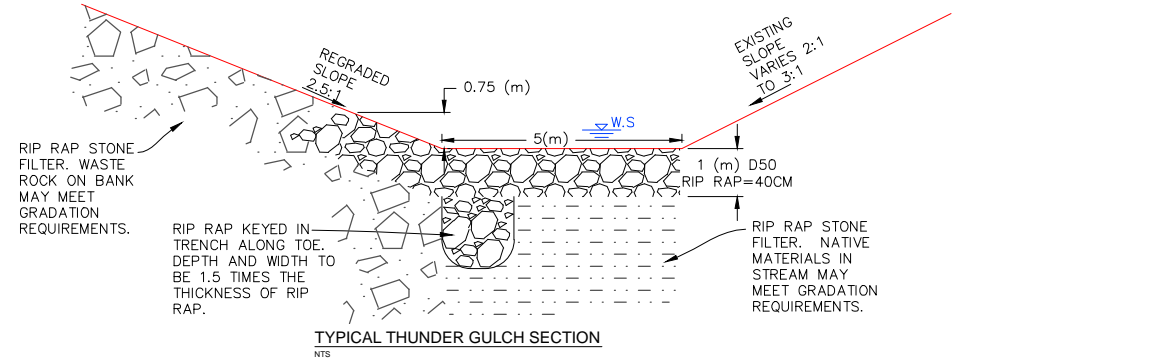
An overview of the Bellekeno 625 area and facilities is shown in Plate 6-4



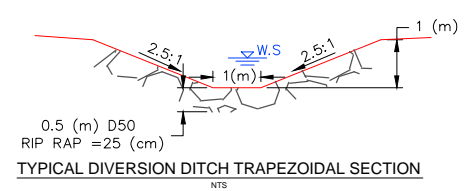
Plate 6-4: Bellekeno 625 Area Overview



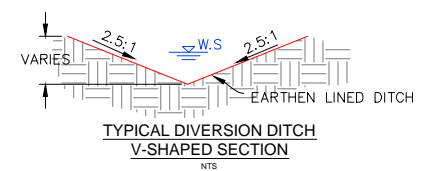
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0 10 20M
CONTOUR INTERVAL = N/A
SECTION A-A'



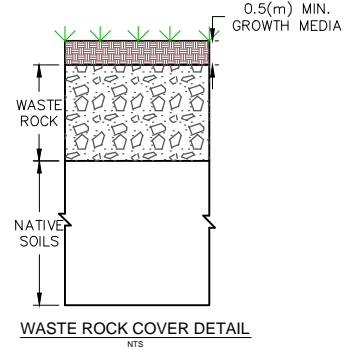
TYPICAL THUNDER GULCH SECTION
NTS



TYPICAL DIVERSION DITCH TRAPEZOIDAL SECTION
NTS

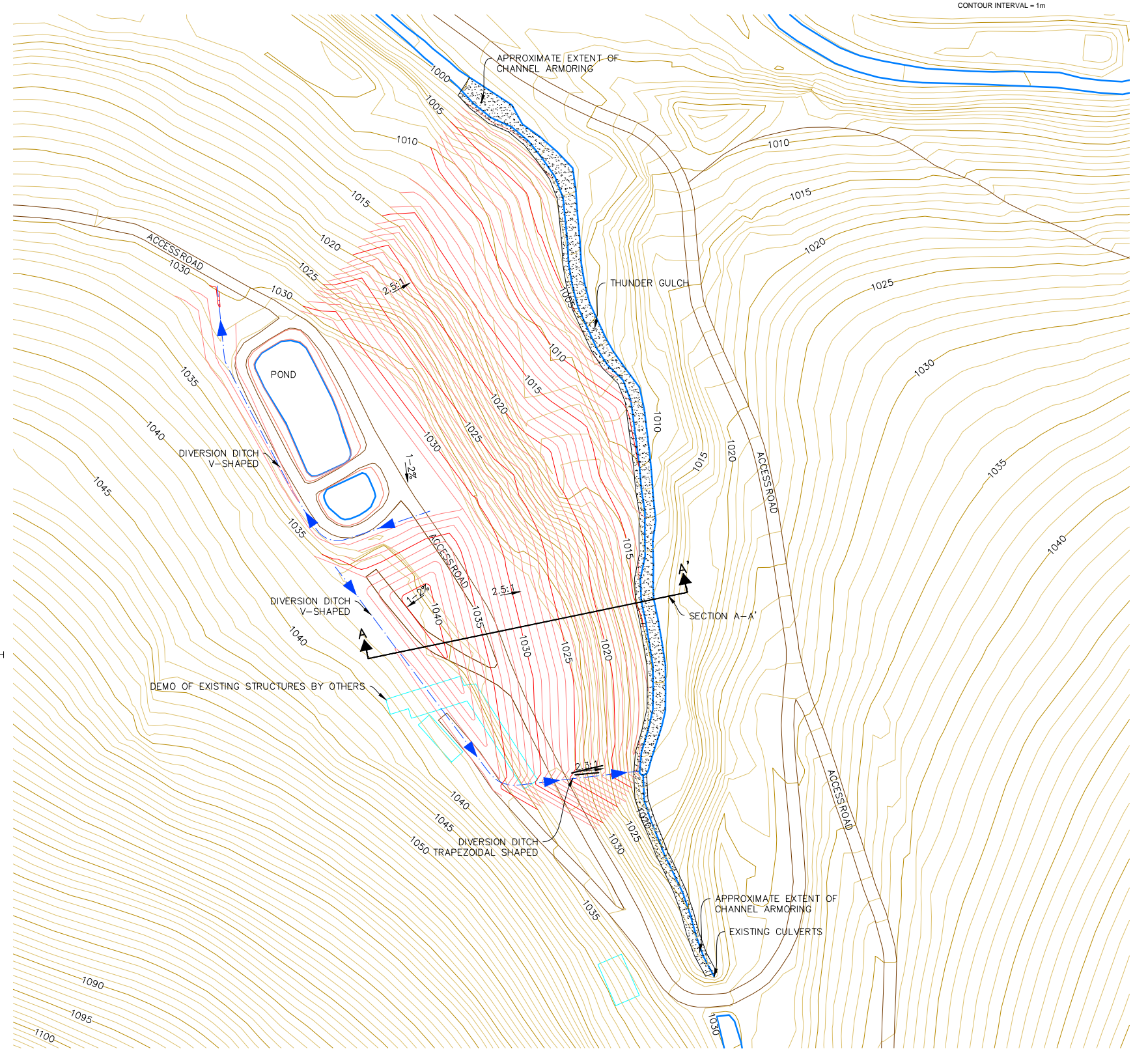


TYPICAL DIVERSION DITCH V-SHAPED SECTION
NTS



WASTE ROCK COVER DETAIL
NTS

- NOTES:**
1. EXISTING CONTOURS PRESENTED MAY NOT REPRESENT CURRENT CONDITIONS. PLACER MINER CURRENTLY EXCAVATING AND MINING EAST OF THUNDER GULCH.
 2. CHANNEL SECTION MAY VARY DUE TO CURRENT PLACER MINING DISTURBANCE IN THUNDER GULCH.
 3. DIVERSION DITCHES SHALL BE EARTHEN WHEN SLOPES < 5% AND RIP RAP LINED WHEN SLOPES ARE GREATER.
 4. BELLEKENO EAST "HIGH ROAD" NOT PRESENTED ON THIS DRAWING.

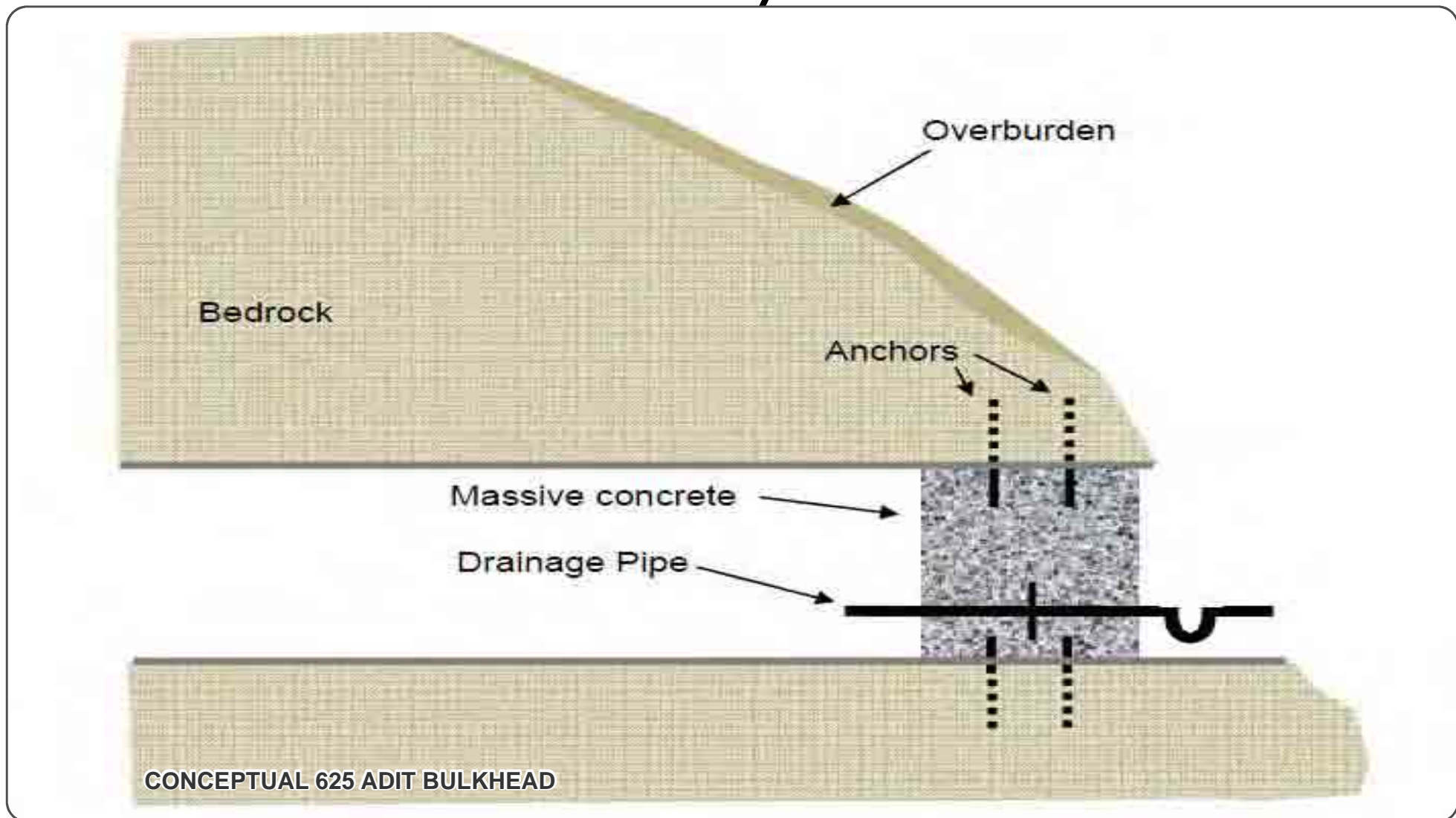
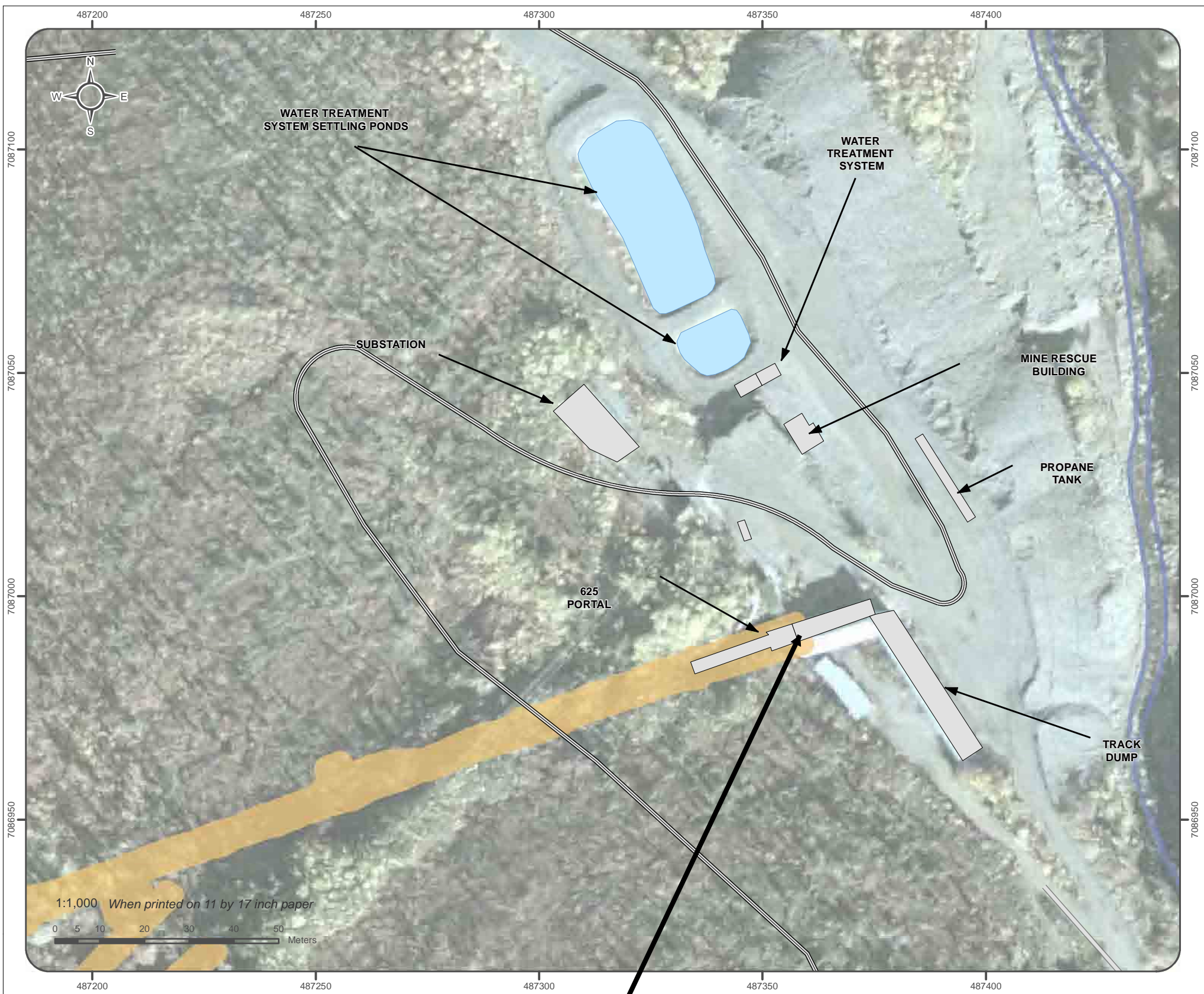


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4	---	---	---	---	DATUM: NAD83	DRAWN BY CJG 11-16-2011	PROJECT BELLEKENO MINE CLOSURE	DRAWING FIGURE 6-3	
3	---	---	---	---	SCALE: 1"=100'	CHECKED BY B. JOHNSON 11-16-2011	TITLE FIGURE 6-3 WASTE ROCK DUMP REGRAIDING AND DETAILS	REVISION	
2	---	---	---	---		APPROVED BY B. JOHNSON 11-16-2011		FILE NAME Grading (11-16-2011)	
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ISSUE/REV	DESCRIPTION	TECH	ENG	DATE		CLIENT REFERENCE NO. ---			

Water Treatment

Without continued dewatering and pumping after closure, the static water elevation of the Bellekeno Mine will rise to and discharge from the Bellekeno 625 adit. A concrete adit bulkhead will be constructed to allow management of the mine pool long term. The bulkhead is not designed as a high head pressurized structure that will allow increased flooding above the 625 elevation but rather as a water management tool and feature that will allow consistent flow to the secondary bioreactor treatment system. A conceptual design for the Bellekeno 625 adit bulkhead is shown in Figure 6-4. The size of this opening is approximately 2.5 m x 2.5 m.

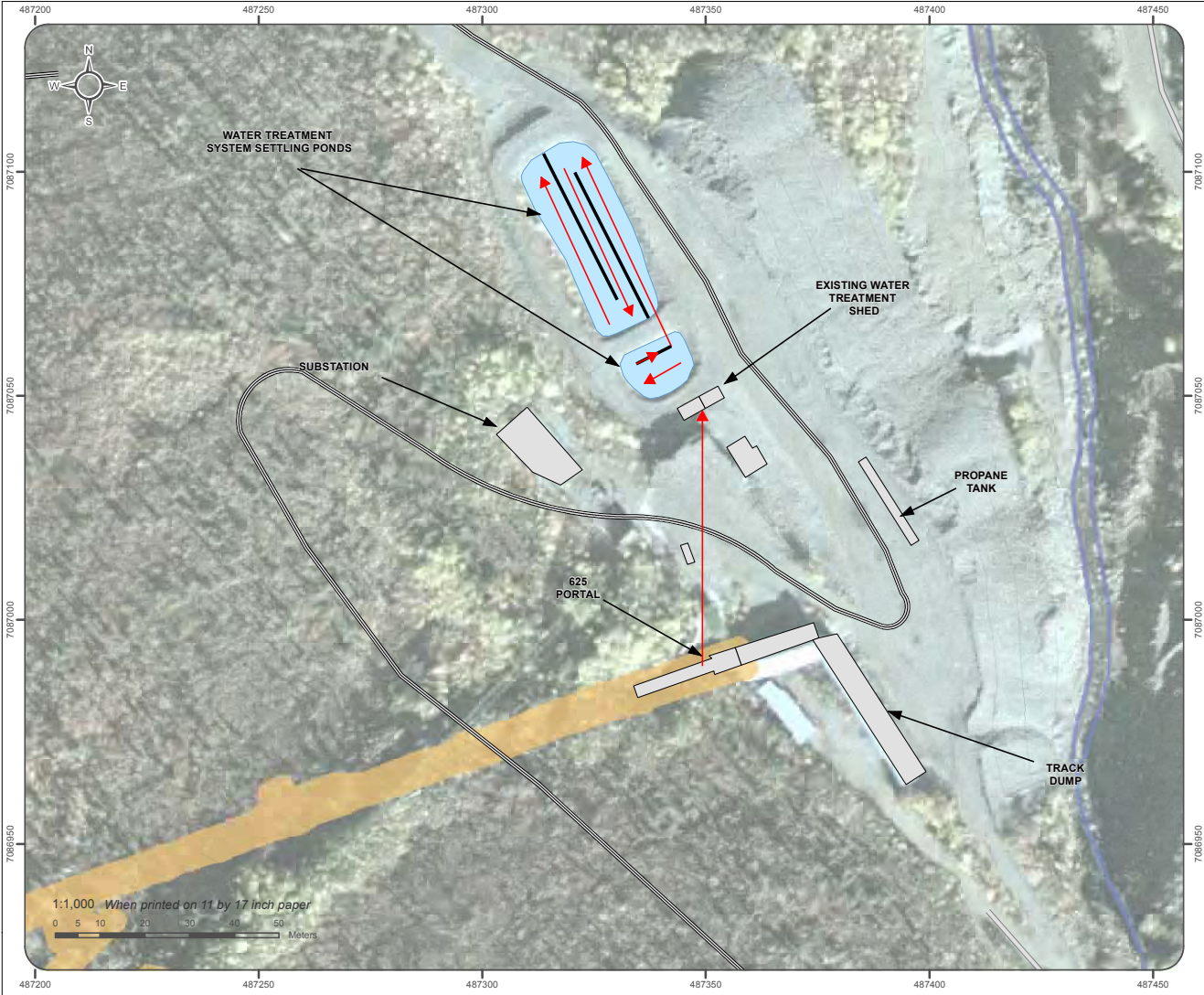


	<p>ALEXCO KENO HILL MINING CORP. BELLEKENO MINE - RECLAMATION AND CLOSURE PLAN</p> <p>FIGURE 6-4 BELLEKENO MINE SITE LAYOUT 625 ADIT BULKHEAD</p>
<p>Datum: NAD 83; Projection: UTM Zone 8N</p> <p><small>This drawing has been prepared for the use of Access Mining Consultants Ltd's client and may not be used, reproduced or relied upon by third parties, except as agreed by Access Mining Consultants Ltd. and its client, as required by law or for use of governmental reviewing agencies. Access Mining Consultants Ltd. accepts no responsibility, and denies any liability whatsoever, to any party that modifies this drawing without Access Mining Consultants Ltd's express written consent.</small></p>	<p>AKHM</p> <p>ACCESS</p> <p>DRAWN BY MD NOVEMBER 2011 VERIFIED BY BT</p> <p><small>I:\ALEX-05-01\Bellekeno\GIS\mxd\Closure\2011\Submitted_Nov2011\Fig6-4_625ADIT_20111115.mxd (Last edited by: jjan 11/17/2011 12:07 PM)</small></p>

The long-term water management and treatment approach for the Bellekeno mine is summarized as follows:

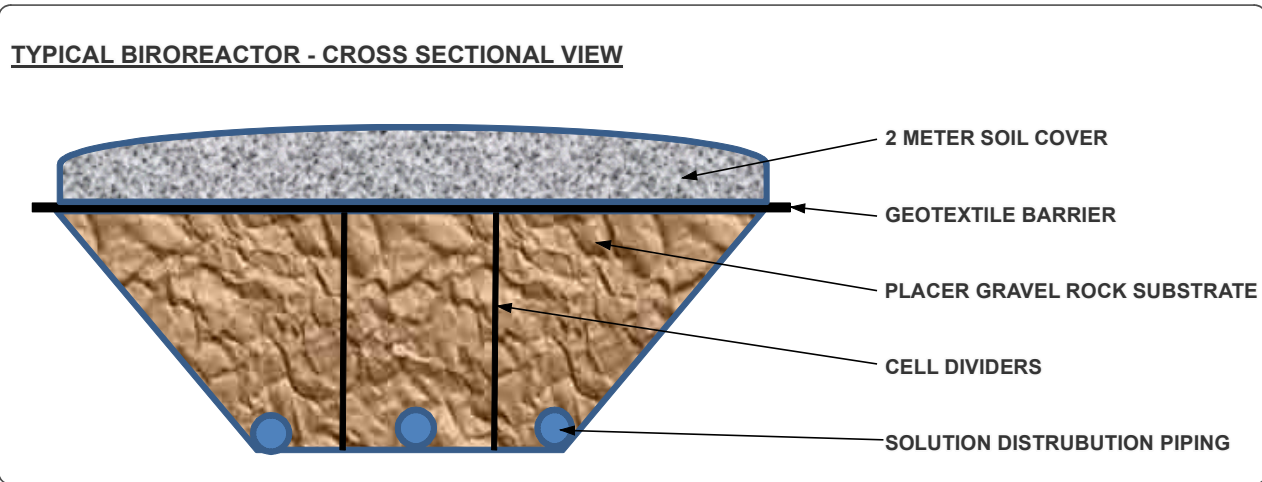
- A detailed hydrogeologic study of the Bellekeno Mine will be required to determine the final elevation of the static water. This study will be based on information collected as part of the Bellekeno Hydrogeology Plan which was submitted in November 2010 as a requirement under Water Licence QZ09-092.
- Final detailed design engineering will be required to construct a bulkhead at Bellekeno 625. The bulkhead would be put into place as the mine pool is allowed to flood (estimated to take ~12 months if not longer). Instrumentation in the form of a pressure gauge would be installed to assist with monitoring of the mine pool.
- In mine pool treatment to reduce soluble metals (zinc) loads using a carbon source such as molasses will be implemented immediately upon commencing Bellekeno mine pool flooding. Alexco has implemented this technology at several minesites throughout North America and it has proven highly successful in reducing soluble metal loading. The mine pool would be accessed through the Bellekeno East decline, which would not be blocked until Bellekeno 625 has been adequately decommissioned. In-situ treatment of the mine pool for at least 12 months prior to the mine pool discharging at 625 is expected to produce acceptable water quality discharge criteria.
- Once active treatment and pumping of the mine pool ceases and in situ treatment begins, conversion of the current water treatment ponds at Bellekeno 625 into bioreactors would take place. Water from the flooding mine pool would be pumped to the bioreactor constructed at 625 and commissioning and optimization of the bioreactor would take place. Once the treated mine pool reaches the static elevation of the 625 adit and begins to gravity flow out of the adit, pumping to the bioreactor for commissioning would cease and passive flow and treatment through the bioreactor would continue. A bioreactor was constructed and continues to operate at Galkeno 900 as part of the District Closure Plan. A report on the performance of the Galkeno 900 bioreactor is included in Appendix A.
- The overall water management approach for Bellekeno is to have the bioreactor constructed and commissioned prior to when the mine pool is fully flooded and discharging out 625. In addition it is expected that the mine pool treatment will obtain acceptable discharge water quality but in the event it does not then the bio reactor will already be fully commissioned by the time the mine pool reaches the elevation of the 625 level.

A preliminary design of the bioreactor at 625 is shown in Figure 6-5. A water treatment and management schedule for Bellekeno 625 is included in Table 6-1.



Conceptual Design Assumptions

Divide Pond 1 into 2 zones with a HDPE liner divider. 2 cells @ 6m x 15m	Porosity = 40%
Divide Pond 2 into 3 zones with a HDPE liner divider, 3 cells @ 5.3m x 42m	Flowrate = 4 lps
Total Volume = 2,700 m ³	Retention Time = (2700 m ³ x 0.40)/4 lps = 3.1 days



Underground Workings	Haul Road	Flowpath of Adit Water
Building	Local Road	Cell Divider
Pond		

Datum: NAD 83; Projection: UTM Zone 8N

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BELLEKENO MINE - RECLAMATION AND CLOSURE PLAN

FIGURE 6-5
BELLEKENO 625 BIOREACTOR
PRELIMINARY DESIGN

DRAWN BY JP	NOVEMBER 2011	VERIFIED BY TL
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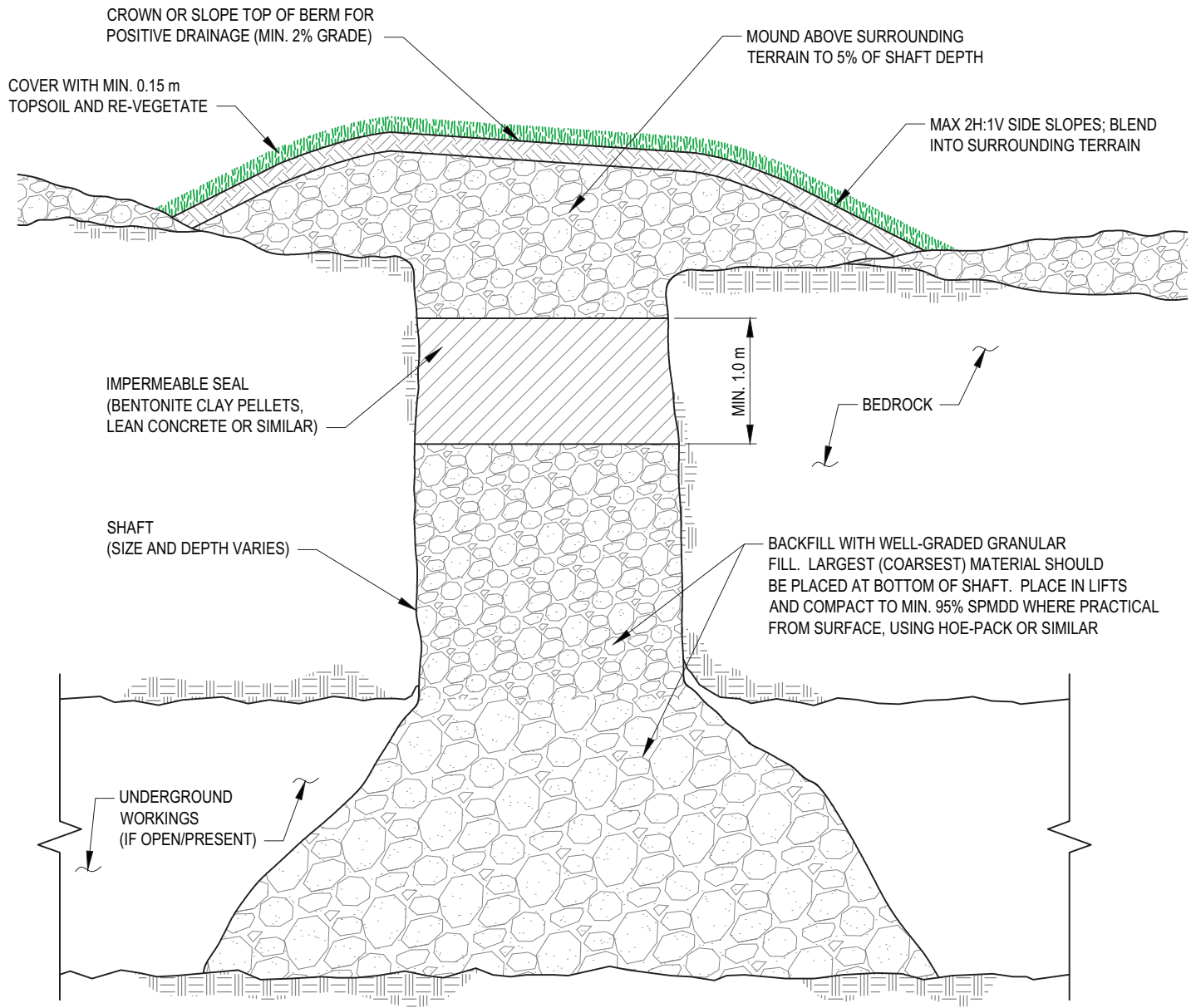
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Table 6-1: Bellekeno Mine Water Management Schedule

Task	Months following cessation of mining activities												
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	
Cessation of mining	█												
Pump shutdown and mine workings flooding	█	█	█	█	█	█	█	█	█	█	█	█	█
Construct bioreactor		█	█	█									
Commission bioreactor with mine pool water				█	█	█	█	█	█	█	█	█	█
Passive feed of bioreactor from mine pool													→

200 Level Vent Raise

The 200 level vent raise will be capped with an engineered concrete cap similar to what is used at mines elsewhere in Canada. This cement plug will restrict physical entry and prevent air movement and possible ice plug formation at the Bellekeno 625 adit. A preliminary design for a concrete cap is included in Figure 6-6.



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

**KENO HILL SHAFT CLOSURES
KENO HILL, YT**

**CONCEPT A
DRY SEAL**

SCALE 1:50



CLIENT



PROJECT NO.
V15101043

DWN
SF

CKD
JP

REV
0

OFFICE
VANC

DATE
April 4, 2011

Figure 6-6

Treatment Sludge

Sludge from the 625 treatment system is currently disposed of into a cell on the surface of the Valley Tailings as per the current Sludge Management Plan and as authorized under QML-0009. Bellekeno water treatment sludge is also authorized for disposal in the DSTF. The sludge from Bellekeno 625 that is stored in the valley tailings cell is kept separate from the sludge generated at the other treatment facilities. The sludge containment cells are not lined in order to allow water to exfiltrate from the cells. Closure activities related to the 625 operations sludge involve the excavation and rehandling of the 625 treatment sludge solids from the current holding location to the underground workings.

6.2 WASTE ROCK STORAGE

Waste Rock extracted from the mine is characterized according to industry standards laid out in the Bellekeno Waste Rock Characterization Plan. Waste rock is identified as being one of the following types: (a) acid-generating (AML), (b) potentially acid-generating (P-AML) or (c) non-acid-generating (non-AML). Waste rock is separated according to its acid-generation potential and stored in a manner protective of the environment.

6.2.1 Closure Objectives

During operations and at closure, the physical and chemical objectives for the waste rock storage facilities and disposal areas are erosion control, geotechnical stability and geochemical stability.

6.2.2 Closure Measures

Both AML and P-AML waste rock from mine development activities is currently being placed in a lined temporary waste rock storage facility (WRSF) which exists south of the Bellekeno East portal (Figure 6-7). The facility design ensures containment of waste rock, runoff and infiltration.

Additional permanent P-AML waste rock storage facilities will be constructed if necessary on the top of the Bellekeno WRD areas. Rock that is not potentially acidic or metals-leaching (non-AML), will be deposited in a waste rock disposal area (WRDA) along the northeast flank of Sourdough Hill, northwest of the current Bellekeno 625 waste rock storage areas. The Bellekeno WRDA has not yet been constructed since all of the non-AML waste currently generated from the Bellekeno mine is being consumed as road construction material and cemented rock fill (CRF) for underground backfill. Final engineering design of the P-AML facilities by EBA Engineering Consultants has been approved by YG, Energy Mines and Resources as per Mining Land Use Approval LQ00240.

Temporary P-AML WRSF – Bellekeno East

A temporary P-AML facility is currently in use south of the Bellekeno East portal. At closure, P-AML rock stored in the lined facility will be rehandled back into the underground mine below the long-term static water level of the mine. The liner will be removed and the area recontoured and revegetated to be commensurate with the surrounding natural terrain. Revegetation will take place with appropriate growth media and seed mixes.

Permanent P-AML WRSF

Additional permanent WRSFs for potential AML waste rock will be constructed at alternative sites in accordance with the approved engineered designs. Excavation of overburden will occur before placement, with the material being stored in close proximity to the facility. Waste rock placement protocols will be developed with closure measures in

mind to ensure that at closure, when all waste rock is in place, that minimal recontouring will be necessary. The final facilities will be recontoured as necessary to ensure its long-term stability.

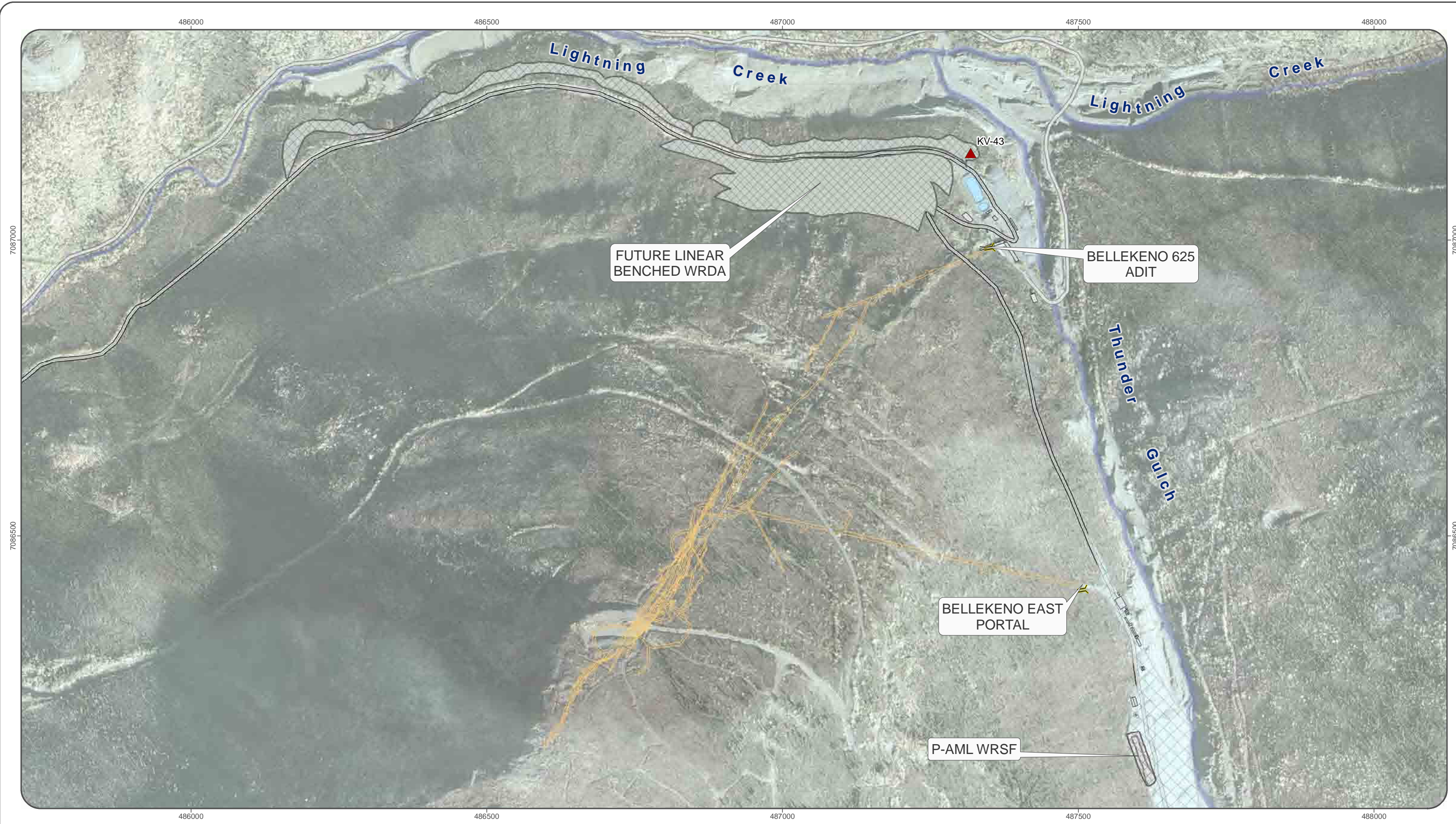
The facilities will be covered with a total 0.5m depth cover consisting in the bottom portion of low-permeability borrow material to minimize infiltration of meteoric water. The top portion of the cover shall consist of growth medium that will be seeded to promote vegetative growth.

In the event that water accumulates in the bottom of the P-AML before cover placement, it will be educted using a vacuum truck and transported to either the Bellekeno 625 treatment facility or the mill site for discharge, and treatment if needed.

Non-AML WRDA - Bellekeno 625

Preliminary engineering design by EBA Engineering Consultants Ltd. of the linear benched waste rock disposal area (WRDA) to be developed adjacent to and to the east of the Bellekeno 625 adit (Figure 6-7) has concluded that no additional contouring is required upon closure with regard to stability. However, in order to further increase stability and improve aesthetics, Alexco will recontour the WRDA by pulling the crests back with an excavator followed by scarification and revegetation of the flat surface of the WRDA. The final overall (crest to crest) slope of the WRDA will be 3H:1V.

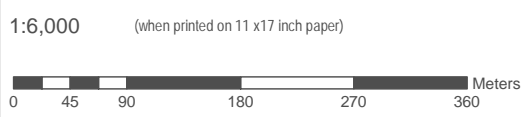
A toe buttress may be required along the alluvial terrace below the toe of the WRDA which was previously placer mined. This contingency may be necessary to improve the overall stability of the embankment in the event of an earthquake, or other seismic event. Adequate backfilling or re-contouring by the placer miner may alleviate this concern, but this should be re-examined at closure.








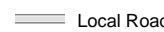


Aerial photograph obtained from Geodesy Remote Sensing Inc., Calgary Alberta. Imagery acquired September 13 and 14 2006. Site hydrography and contours provided by Aero Geometrics LTD, derived from aerial photograph.

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

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-  Adit
-  Surface Water Quality Station of Interest
-  Underground Workings
-  Building
-  Pond
-  Portal Area
-  Haul Road
-  Local Road



ALEXCO KENO HILL MINING CORP.
BELLEKENO MINE - RECLAMATION AND CLOSURE PLAN
FIGURE 6-7
LOCATION OF EXISTING WASTE ROCK STORAGE FACILITY AND PROPOSED WASTE ROCK DISPOSAL

DRAWN BY JP	NOVEMBER 2011	VERIFIED BY TL
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6.3 ROADS

All roads either developed new or reconstructed/upgraded from existing roads will be subject to standard road decommissioning and reclamation measures at closure (Figure 6-8). These roads include:

- the newly constructed haul road between BK East Portal and BK 625 Adit;
- the upgraded power line haul road;
- the new Keno City bypass including a new bridge at Lightning Creek; and
- Christal Lake road (from Silver Trail Highway to the mill).

These roads will be resloped and scarified, culverts and bridge removed and seeded in areas where erosion control is necessary. Plate 6-5 illustrates a typical section of the haul road between the mine and mill, and shows the bridge crossing at Lightning Creek.

6.3.1 Closure Objectives

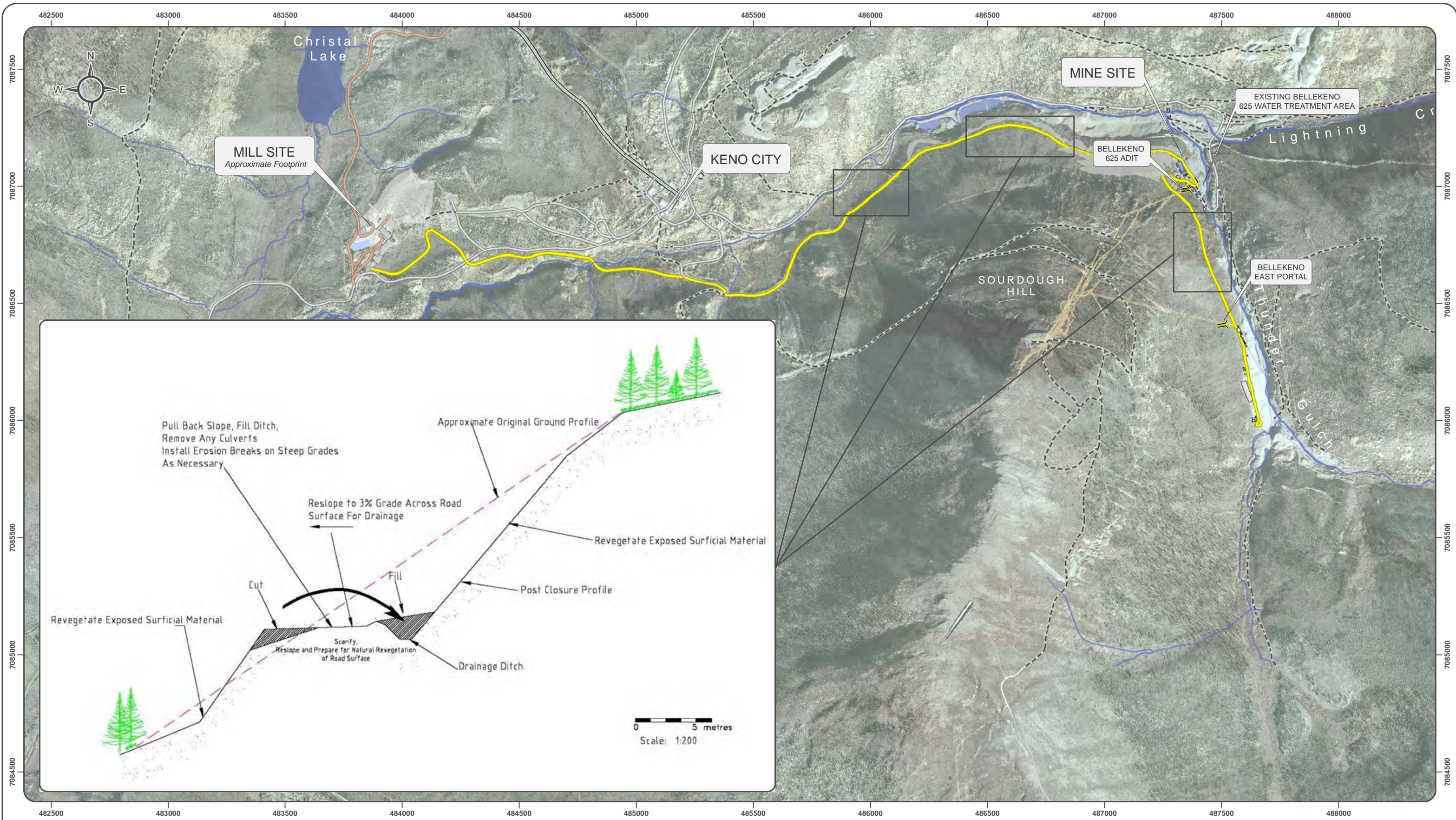
The primary consideration for the physical stability of roads at closure will be slope stability where culverts have been removed and intermittent drainage channels have been established through the road alignments which could lead to localized erosion.

6.3.2 Closure Measures

Standard road decommissioning and reclamation measures at closure include culvert removal, resloping banks and removal of the safety berm to reflect the natural topography as well as provide stability, and surface scarification to encourage natural revegetation (Figure 6-8). Regrading/contouring the roads will ensure that runoff sheds off the road surface. Localized seeding will take place where erosion control is necessary.



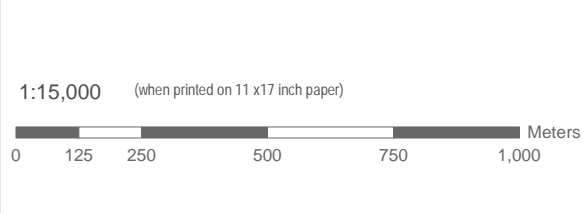
Plate 6-5: Lightning Creek Bridge and Typical Haul Road Section



Aerial photograph obtained from Geodesy Remote Sensing Inc., Calgary Alberta. Imagery acquired September 13 and 14 2006. Site hydrography and contours provided by Aero Geometrics LTD, derived from aerial photograph.

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

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- Silver Trail Highway
- Haul Road
- Mill Access
- Local
- Track
- Underground workings



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BELLEKENO MINE - RECLAMATION AND CLOSURE PLAN
FIGURE 6-8
HAUL ROAD AND SITE ROAD
TYPICAL RECLAMATION CROSS SECTION

DRAWN BY JP NOVEMBER 2011 VERIFIED BY BT

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6.4 CAMP

Employees and contractors directly related to Bellekeno mine operations are housed in the Flat Creek camp as well as in 4 staff houses that are located in Elsa. Additional personnel and camp accommodation requirements are ongoing beyond Bellekeno mine operations including exploration, care and maintenance and district closure planning and implementation. Given these ongoing activities, removal and closure of the entire camp facility is not envisioned as part of the Bellekeno mine closure plan and requirement.

6.4.1 Closure Measures

Closure objectives and measures include dismantling and removal of the excess trailer units to Lot 960. The expanded septic system, along with the increased freshwater supply will remain in place for continued use by the downsized camp.

6.5 MILL PAD AREA AND ANCILLARY FACILITIES

The mill is located at the Flame and Moth mill site. An as-built layout of the mill facilities is shown in Figure: 6-9. The Keno District Mill is a conventional differential flotation facility producing two separate metal concentrates that are shipped offsite for final processing.

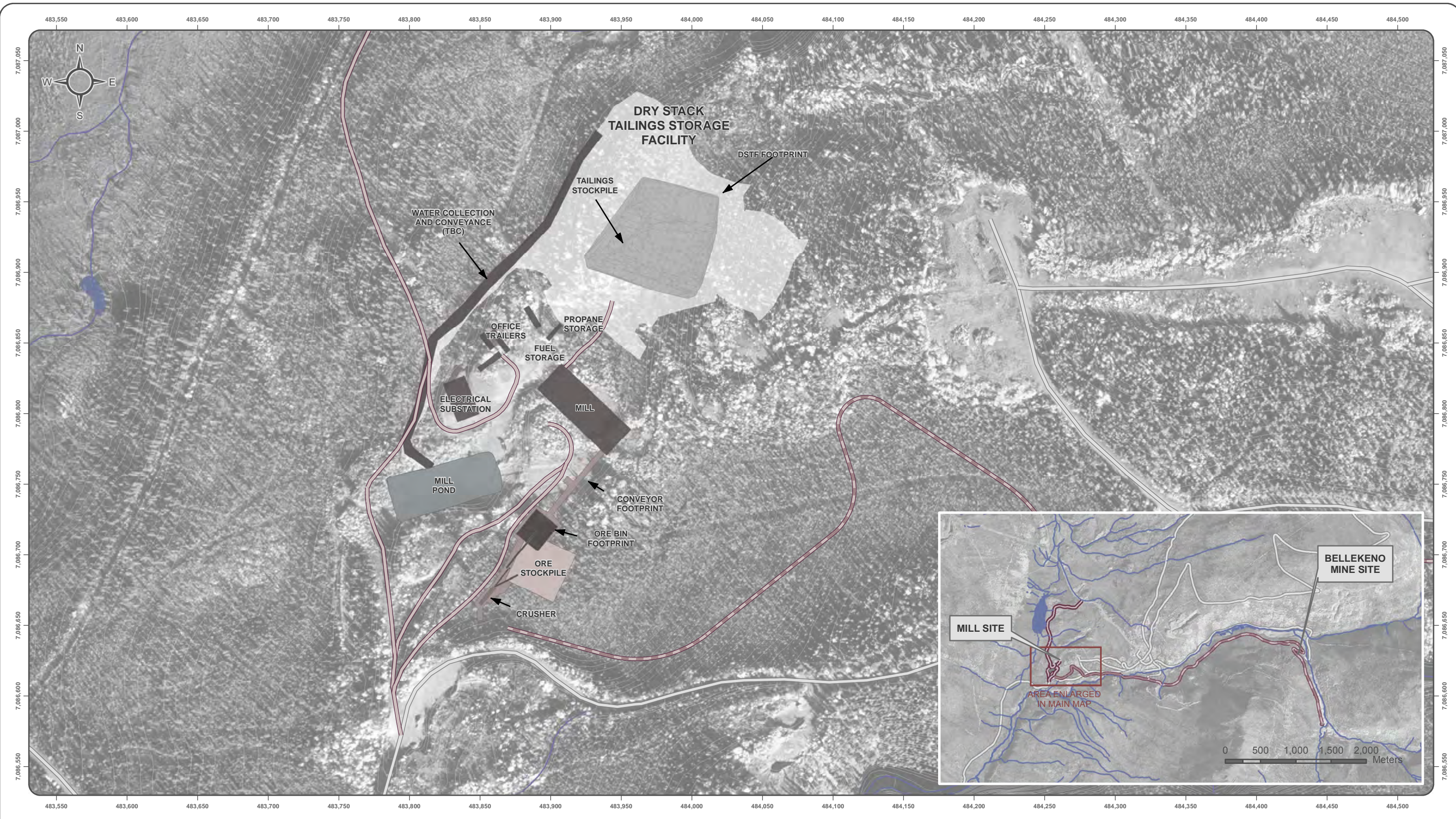
6.5.1 Closure Objectives

The objective for decommissioning the mill and ancillary facilities is to ensure physical stability and management of run-off. Potential threats to public health and safety will be removed, including identification and removal of hazards and hazardous materials. Concern regarding physical stability of these structures at closure will be mitigated for the most part by their disassembly and removal from the site. Additional chemical stability objectives would arise primarily from contamination of surrounding soils by metals, fuel and reagents.

6.5.2 Closure Measures

The following mill infrastructure and facilities comprise the main facilities constructed over the 2010/2011 mill construction and commissioning period and comprise the facilities that require removal under the closure plan (Plate 6-6):

- Mill building
- Mill office and dry
- Electrical substation
- Mill process pond
- Crusher plant
- Crusher MCC
- Fine ore stockpile
- Mill feed conveyor
- Mill MCC
- Assay lab
- Process water tank
- Diesel storage tank
- Propane tank
- DSTF
- Lightning Creek bridge



Aerial photography flight date: July 13th 2006. Ortho-rectification produced by Challenger Geomatics Ltd. Data obtained from EBA: "As built" spatial data: Mill pond (Y.E.S.), Mill structure, and current DSTF footprints, Roads (In House survey December 11th 2011). Design spatial data: Conveyance and water collection, diversion ditches and berm.

Datum: NAD 83; Projection: UTM Zone 8N

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Main Map: 1:2,500 Inset Map: 1:50,000
 (when printed on 11 x17 inch paper)

0 50 100 150 200 Meters

- Mill Access Road
- Haul Road
- Local Road



ALEXCO KENO HILL MINING CORP.
BELLEKENO MINE - RECLAMATION AND CLOSURE PLAN
FIGURE 6-9
MILL SITE LAYOUT

Drawn By JP	NOVEMBER 2011	Verified by BT
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6.5.3 Mill Buildings and Infrastructure

The buildings at the Keno District Mill site can be broken into three categories for dismantling and salvage purposes:

- modular, prefabricated trailer style buildings, such as the offices and dry;
- rigid, steel frame construction buildings with steel wall sheeting, such as the mill building;
- non-rigid prefabricated steel frame "fold-away" or containerized buildings;

The modular prefabricated trailer style buildings will, wherever economically feasible, be removed from the site and sold for their salvage value. Generally disassembly involves removing the underlying wood skirting, water, electrical and septic piping and cabling and then breaking the units into their respective prefabricated units. The individual units are then placed on axle dollies and removed from the site to be reused elsewhere following refurbishing. The remaining service piping, cabling and skirting lumber is removed and disposed of as either scrap or as salvageable material. The gravel pad beneath the trailer units will be scarified with a grader to enhance the re-establishment of natural vegetation.

In the event that it is found at the time of decommissioning that any such unit(s) cannot be removed or sold for their salvage value, then the unit(s) will be inspected for hazardous materials, the hazardous materials removed and units demolished on site. The materials with salvage value will be removed and sold for their respective value. Non-hazardous materials that have no salvage value will be disposed of in an approved landfill site on the mine site. Combustible wastes such as lumber-based building materials will be burned and the residue buried in the landfill site.

The rigid steel frame buildings will be dismantled on site with the support steel being sold for salvage value wherever economically feasible. Prior to disassembly, the buildings will be stripped of all non-attached equipment and materials such as shelving units, office furniture, equipment, etc. Wherever feasible, materials with salvage value will be sold for its value. Non-hazardous materials that have no salvage value will be disposed of in the approved on-site landfill area. As indicated earlier, all buildings will be inspected for hazardous materials, such as hydrocarbons, reagents, etc. Any such material will be removed and disposed of in a manner approved by regulatory authorities for the Yukon Territory. Generally disassembly of these buildings involves removing all of the steel sheet roof and wall panels and internal insulation. The steel support structure is then disassembled and where feasible sold for its salvage value either as an intact building or as high quality steel scrap. Internal steel structures would then be removed and treated in a similar fashion.

Above grade concrete footings, foundations concrete floor slabs and below grade concrete foundations will be covered by a minimum thickness of 1 m of overburden and scarified.

These covered slabs will be seeded with an appropriate vegetation mix to establish vegetative growth over these areas. The specific details of each of the mill area buildings are further described in the following sections and closure measures identified.

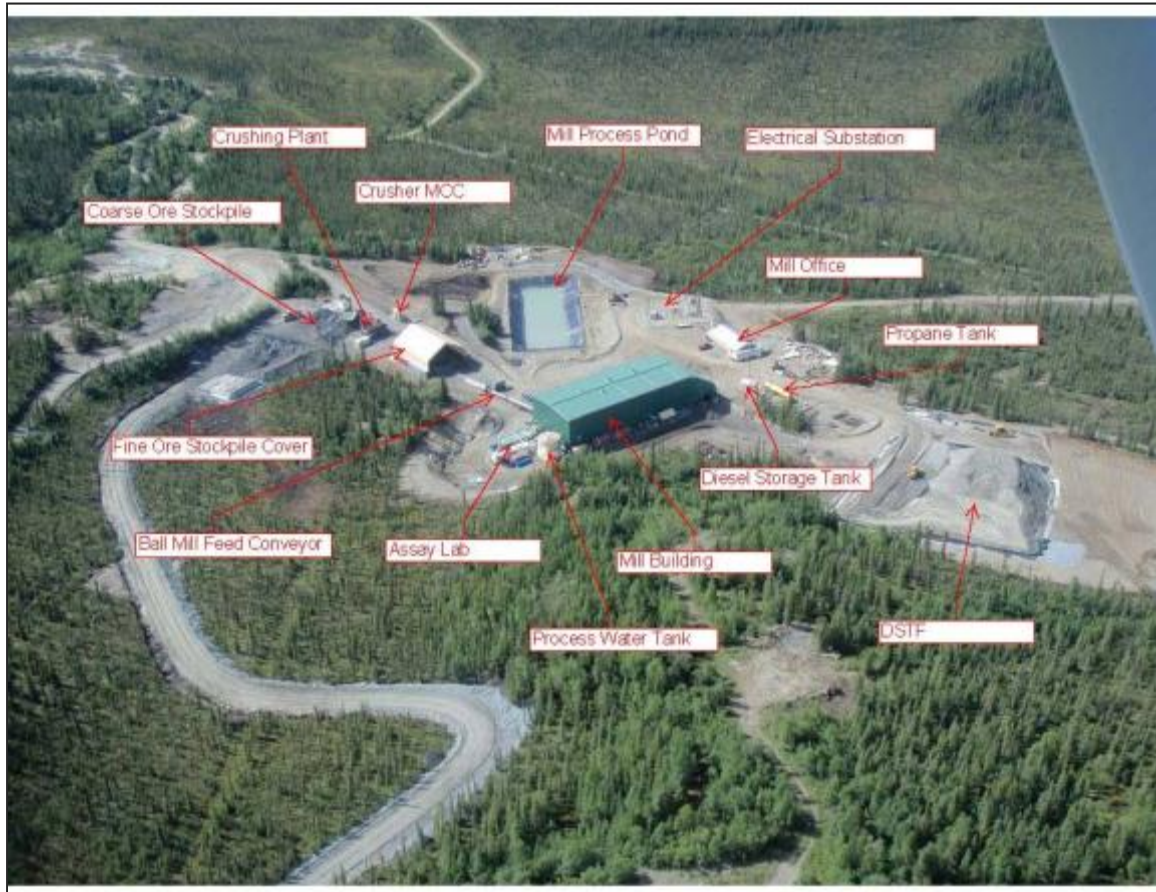


Plate 6-6: Aerial View of Mill Site Infrastructure and Layout

Mill Building

The mill building is a pre-engineered steel building containing all of the processing equipment used for the milling, flotation and recovery of Ag, Pb and Zn from the Bellekeno mine underground ore. The mill building is 22.5 meters 54 meters in dimension (Plate 6-7).

Closure measures for the mill building include salvage and removal of the process equipment, dismantling of the engineered building, breaking the concrete slab to allow percolation of water and covering of the footprint with growth media.



Plate 6-7: Mill Building

Mill Office and Dry

The mill office and dry facility is comprised of two skid mounted trailer units and one skid mounted wash car with a wooden truss constructed over the top of the 3 units. The two office units are 3.05 x 8.3 meters in dimension and the dry/shower facility is 3.35 x 11.58 meters (Plate 6-8).

Closure measures for the mill office include dismantling the roof truss structure and removing the building from site. Since the office is a portable structure there is no demolition required.



Plate 6-8: Mill Office and Dry

Electrical Substation

An electrical substation is located adjacent to the mill office/dry facility and houses a primary 69 KV – 600 V step down transformer and electrical distribution infrastructure. The substation is enclosed by a 28 m x 15.5 m fence (Plate 6-9).

The step down transformer will be removed and salvaged and the remaining equipment will be removed and either salvaged or buried.



Plate 6-9: Electrical Substation

Mill Process Pond

The mill process pond is located downgradient from the mill building and contains and manages the process water balance required for the milling operation (Plate 6-10). Thickener overflow water from inside the mill building gravity flows via a 6" yellow pipe into the mill process pond. Process makeup water is pumped from the pond to the process water tank for makeup and recycle in the milling process. The mill process pond is 32 x 79 meters in dimension with a total design capacity of 3,500 m³.

Since the mill process pond was not constructed with an engineered fill embankment there is no long term stability concern that needs to be addressed at closure. Closure of the pond consists of removing and burying the HDPE liner, scarification of the side slopes and revegetation. The pond will serve as a sedimentation pond during closure for capture of surface water if necessary until revegetation is stabilized. Although not a component of the closure for the mill area, the pond could also serve as a bioreactor facility if necessary.



Plate 6-10: Mill Process Pond

Crushing Plant

Coarse ore from the Bellekeno underground mine is transported to a crushing plant (Plate 6-11) where the coarse ore is crushed and reduced in size to nominally 3/8". The crushing plant is a portable two-stage closed circuit plant containing a jaw crusher, single deck screen and cone crusher. The crushers, screen deck and conveyors are all portable tire mounted units that can be easily removed from site. Once the material is crushed it is transported to the adjacent fine ore stockpile via a radial stacker conveyor.

Since the crushing plant is a portable unit on wheels, closure consists of transporting the crusher offsite for salvage value. The crusher retaining wall is constructed of 6 stacked sea-containers that likewise can be removed and salvaged.



Plate 6-11: Crushing Plant

Fine Ore Stockpile

Fine ore produced from the crushing plant is stored on a fine ore stockpile covered by a fabric membrane structure to isolate the ore from snow, rain and windy conditions (Plate 6-12). The fabric membrane structure is 11.35 meters tall, 18.3 x 24.5 meters in dimension and is supported by an aluminium support structure sitting on 4 (ea) 40' steel containers that provide containment of the fine ore as well as storage units for the crushing plant and mill spare parts inventory.

Closure of the stockpile includes excavation and milling of any residual fine ore remaining on surface, removal and salvage of the sprung structure and sea-containers. The buried tunnel will be removed and salvaged for steel scrap value.



Plate 6-12: Fine Ore Stockpile

Crusher MCC

A Motor Control Centre (MCC) for the crusher (Plate 6-13) is located adjacent to the crushing plant and provides electrical distribution for the various motors located in the crushing plant. The main electrical substation distributes 600 V electrical power directly to the crusher MCC and then individual motor starters within the MCC distribute power to the motors. The crusher MCC is a portable skid mounted steel insulated building with dimensions of 2.4 x 6.1 meters.

Closure measures for the crusher MCC consist of transporting the unit offsite for salvage value.



Plate 6-13: Crusher MCC

Assay Lab

The assay lab is located immediately adjacent to the mill building and consists of 3 skid mounted trailer units separated by a wooden deck and winter roof truss (Plate 6-14). The sample prep trailer is a skid mounted trailer used for preparation of mill and underground samples. The trailer is 13.47 x 3.05 meters in dimension.

The assay lab trailers consist of 2 separate skid mounted units that are joined together with assay capability for AA digestion and fire assay. The two assay trailers are 2.4 x 6.1 meters in dimension.

Closure measures for the assay lab consist of transporting the units offsite for salvage.



Plate 6-14: Assay Lab

Mill MCC

A Motor Control Centre (MCC) for the mill building (Plate 6-15) is located immediately adjacent to the mill and contains the motor control starters and distribution for the mill equipment. The main electrical substation distributes 600 V electrical power to the mill MCC. The mill MCC is a skid mounted unit mounted on a steel support structure and has a dimension of 15.24 x 3.04 meters.

Closure measures for the mill MCC consist of transporting the unit offsite for salvage.



Plate 6-15: Mill MCC

Fresh Water Tank

A steel fresh water tank (Plate 6-16) is located next to the mill building and sits on a compacted gravel pad. Fresh water is delivered to the fresh water tank via a water truck and the fresh water is used in eye wash stations located throughout the mill building, for reagent mixing and for pump gland water. The fresh water tank has a capacity of 50.26 m³ and is 4 meters tall and 4 meters in diameter.

Closure of the fresh water tank consists of dismantling and cutting up for salvage value.



Plate 6-16: Fresh Water Tank

Diesel Storage Tanks

Two skid mounted double walled diesel storage tanks (Plate 6-17) are located adjacent to the concentrate loadout area and are used for general fuelling of mobile equipment and vehicles. The tanks each have a storage capacity of 3.78 m³.

The diesel storage tanks are supplied by the diesel supply vendor and closure consists of returning the tanks to the supplier.



Plate 6-17: Diesel Storage Tanks

Propane Tank

A tire mounted portable propane (Plate 6-18) storage tank sits near the mill building with a capacity of 45,425 litres of propane. Propane is used at the mill for heating the mill building during winter conditions.

The propane tank is supplied by the vendor and closure consists of returning the tanks to the supplier.



Plate 6-18: Propane Storage Tank

Mill Wastes

Extra reagents or chemicals will be loaded up and returned to the supplier where possible. Concrete footings will be demolished and buried in situ. Any additional debris will also be removed for reuse or proper disposal. All solid waste will be disposed of in accordance with the *Solid Waste Regulations*. All waste petroleum products and any other special waste, as defined in the *Special Waste Regulations* will be disposed of in accordance with the Regulations. Any soils contamination will be documented through a final site contamination assessment. Contaminated soil would be removed and/or remediated in an approved manner (i.e. land treatment facility in Mayo or Elsa if one is developed there). The pad area will have its embankment shoulders re-graded to prevent water ponding, and the surface will be scarified and reseeded to promote vegetative cover.

It is expected that at closure the material beneath the ore stockpiles will be processed through the mill to remove any remaining economic values as well as eliminating any potential contaminant of concern from the material. The impermeable rehandling pads will be demolished and buried once cleaned of all metal contaminants.

Buried Infrastructure

All buried piping and electrical cabling will be de-energized, drained and truncated where they break surface with the buried portions left remaining in the ground. The ends of all buried piping and cable runs will be cut off at 1 m below grade with the resulting excavations backfilled. Prior to abandonment all possible piping will be drained and washed to remove its contents.

The location of all known buried piping and cabling to be left in the ground will be marked on a site plan to be submitted to regulatory authorities for future reference.

Where appropriate, surface piping will be decontaminated by flushing the respective section of pipe with water and then removing the pipe for disposal. Large diameter piping will be sold for salvage where feasible. Piping with no salvage value will be disposed of in the site landfill area.

All above ground electrical cabling will be de-energized and removed. In most cases the cable will be recovered for its salvage value. Cable with no salvage value will be disposed of in the site landfill area.

6.6 DRY STACK TAILINGS FACILITY

The dry stack tailings facility (DSTF) is located adjacent to the mill site (Figure 6-10). The DSTF will be progressively constructed and reclaimed over five years as tailings are generated by the mill. A portion of the DSTF will be built on an on-going basis each year. In the summer of each year or as the progression of the facility allows, progressive reclamation will occur through recontouring the side slopes to a 3:1 slope and placing granular/organic material as a cover.

Geochemical characterization of the tailings is being conducted as part of the Bellekeno Mine Tailings Characterization Plan which was submitted in December 2010 as a requirement under Water Licence QZ09-092. These results of this program are included in the Annual Reporting submitted for that Licence. Future revisions of the Bellekeno RCP will include summaries of these results in order to support closure measures for this facility.

6.6.1 Closure Objectives

In the closure of a DSTF, objectives to be met include:

- physical stability (erosion and dust control);
- geochemical stability;
- water management;
- reducing water infiltration with an evapotranspiration cover and revegetation; and
- decommissioning of the sediment ponds.

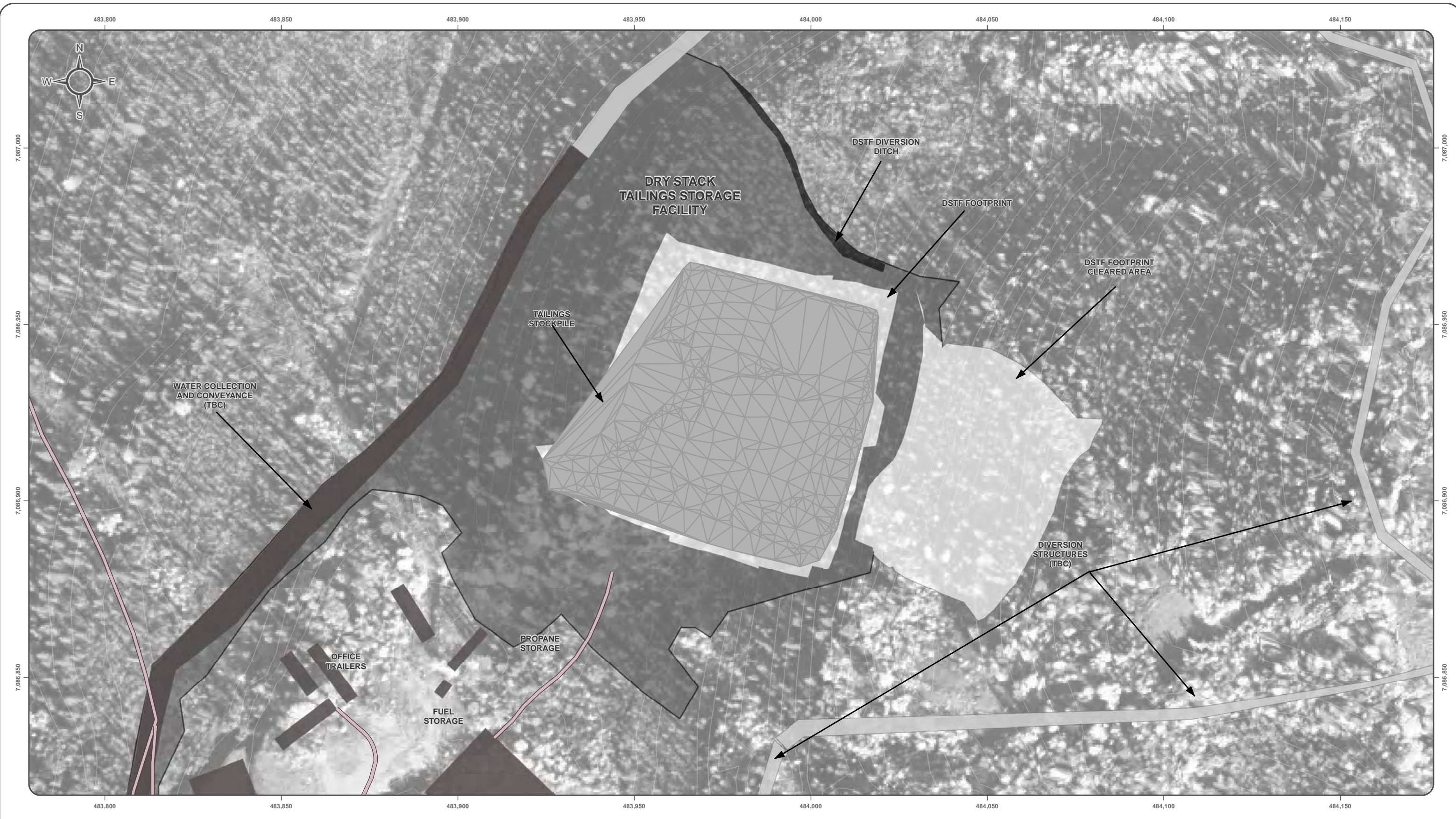
6.6.2 Closure Measures

Closure measures for the DSTF are included in the final design report for the facility. Although the DSTF will be built in compacted 1 to 2 foot lifts to limit water penetration, closure measures will include covering the stack with an approximately 0.5 meter thick evapotranspiration cover consisting of growth media and granular material that is locally stored in stockpiles. This cover will be fertilized and seeded to encourage revegetation. This cover will limit water migration through the stack. A similar evapotranspiration cover has been constructed at Alexco's Brewery Creek mine both on the heap leach pad (0.25 m cover) and a waste rock storage dump (0.5 m cover). The performance results of those covers indicate precipitation infiltration rates between 7% – 22% with the variation related to differences in cover thickness and topography.

As of November 2011 approximately 50,000 tonnes of tailings has been placed in the DSTF. Placement of tailings into the DSTF began during the first week of January. Tailings placement covers an area of approximately 0.25 ha which would correspond to a cover

volume of 1,250 m³. There is currently sufficient fine grained granular material in the area of the DSTF to allow for construction of the proposed evapotranspiration cover.

A conceptual evapotranspiration cover design is shown in Figure 6-11 and is based on the cover design constructed at Brewery Creek and operating successfully.



Aerial photography flight date: July 13th 2006. Ortho-rectification produced by Challenger Geomatics Ltd. Data obtained from EBA: "As built" spatial data: Mill pond (Y.E.S.), Mill structure, and current DSTF footprints, Roads (In House survey December 11th 2011). Design spatial data: Conveyance and water collection, diversion ditches and berm.

Datum: NAD 83; Projection: UTM Zone 8N

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Main Map: 1:1,000 Inset Map: 1:50,000
(when printed on 11 x17 inch paper)

- As Built, Dry Stack Tailings Facility Footprint (phase 1)
- As Built, Dry Stack Tailings Facility Footprint Cleared area (phase 3)
- As Built, DSTF
- As Built, DSTF Diversion Ditch
- Design, DSTF Diversion Berm
- Tailings Stockpile Oct2011



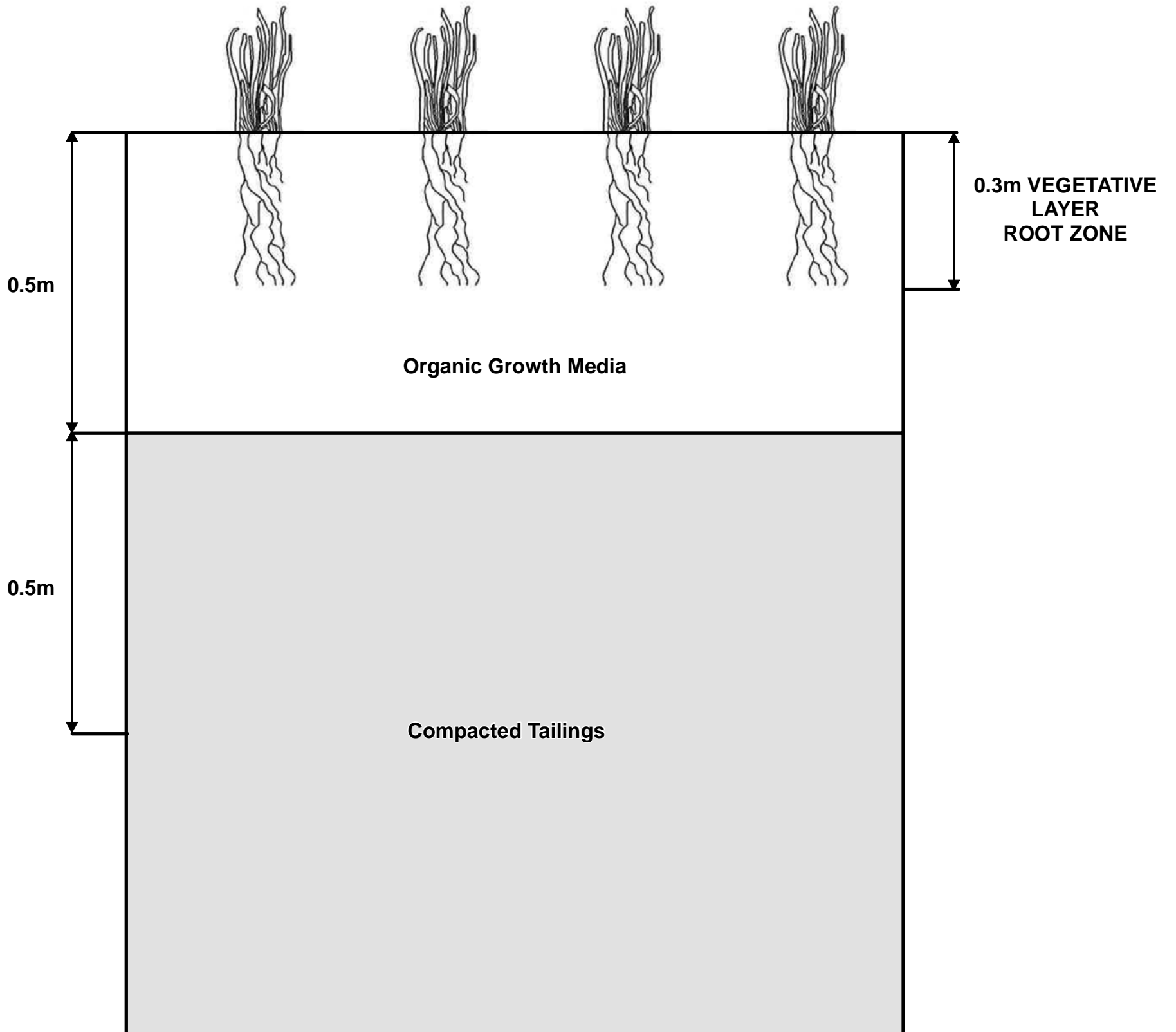
ALEXCO KENO HILL MINING CORP.
BELLEKENO MINE - RECLAMATION AND CLOSURE PLAN

FIGURE 6-10
DRY STACK TAILINGS FACILITY LAYOUT

Drawn By JP	NOVEMBER 2011	Verified by BT
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CONCEPTUAL SOIL COVER DESIGN



Conceptual drawing only. Drawing is not to scale.



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**FIGURE 6-11
CONCEPTUAL SOIL COVER DESIGN**

DRAWN BY JP

NOVEMBER 2011

VERIFIED BY BT

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If monitoring during operations indicates that treatment will be required for meteoric water after final closure, a passive bioreactor treatment system will be constructed at the site immediately down slope from the DSTF. The area at the toe of the DSTF occupied by the runoff collection pond and polishing pond during operations can be reconstructed and used for the development of a gravel infiltration gallery, ethanol-based bioreactor cell (similar to the one currently in use at Galkeno 900 adit across Christal Lake and proposed for the Bellekeno mine).

6.7 RECLAMATION AND REVEGETATION

Alexco has proposed a reclamation and revegetation program that meets the EMR technical guidelines for erosion control and revegetation. The Yukon Mine Site and Reclamation Closure Policy includes establishment of stable slopes that prevent surface erosion and are conducive to successful re-vegetation by native plant species or other species adaptable to that environment (EMR, 2008).

To maximize the efficacy of the cover, an engineering evaluation of the proposed 0.5m cover will be carried out using information collected at the site as a part of the environmental monitoring programs. This includes hydrologic information available for the site, as well as precipitation and snowpack data, together with laboratory soil properties and in-situ measurements of the hydraulic conductivity for waste rock, the DSTF and identified cover material. Together, this information would determine the soil characteristics necessary to complete a final design and infiltration model appropriate for both waste rock and the DSTF. This work will be carried out over the life of the project and as the facilities near completion and data are available for analysis. The evaluation will follow a similar methodology to work done at the Brewery Creek mine for the Blue WRSA and heap leach facilities by BGC Engineering (BGC, 2002a, 2002b).

The use of growth media for revegetation will be prioritized in the following order:

1. Sufficient growth media will be identified from existing borrow stockpiles in the DSTF and Mill areas and left in place to construct a 0.5 meter storage and release cover over the DSTF.
2. Sufficient growth media will be identified and used to construct the soil/vegetative cover over the waste rock disposal areas containing non-AML material. The volume of material that will be required is yet to be determined as this material will be used for road and other construction purposes insofar as possible over the life of the mine.
3. Sufficient growth media will be identified and used to construct the soil/vegetative cover over the waste rock storage facilities, in the case that additional facilities are required after the rehandling of P-AML to the underground. All P-AML lined facilities will be covered with growth media, the volume of which will be determined upon design and construction of the facilities.

4. Growth media will be spread in those recontoured slopes that do not contain the necessary fines content to promote successful revegetation.
5. The growth media if any that remains in stockpiles will be recontoured and revegetated.

It is important to note that not all of the growth media placement requires a loader and truck mode of operation. Some of the growth media placement can be completed by dozer push alone.

A revegetation research program will be carried out over the life of the mine to determine the seed mix characteristics to be used in seeding and revegetating the covered waste rock dumps and DSTF. This program will be commensurate with research investigations carried out for waste rock dumps under District closure, and will also be sensitive to the desired level of infiltration into mine facilities. As a starting point, Alexco will use the seed mixture after the success demonstrated at the Brewery Creek Mine. The seed mixture recommended for the leach pad at Brewery Creek was tailored around the objective of limiting infiltration by using plant species that maximize water uptake through evapotranspiration and consisted of the following:

- 50% Violet Wheatgrass
- 20% Kentucky Bluegrass
- 20% Red Fescue
- 10% Alfalfa

This seed mix provides a denser growth and therefore results in a higher water uptake. It is likely that the DSTF and P-AML WRSFs will follow a similar design. However, this will be confirmed through additional site-specific studies. The final seed mix will be tailored specifically to the goals and objectives of the particular site, whether it is the DSTF, mine-area recontoured slopes, or waste rock disposal areas. The seed mix will be consistent with the objective of slope stabilization and prevention of soil erosion in the short-term, and returning the site in the longer-term to an environment that closely resembles pre-mining conditions.

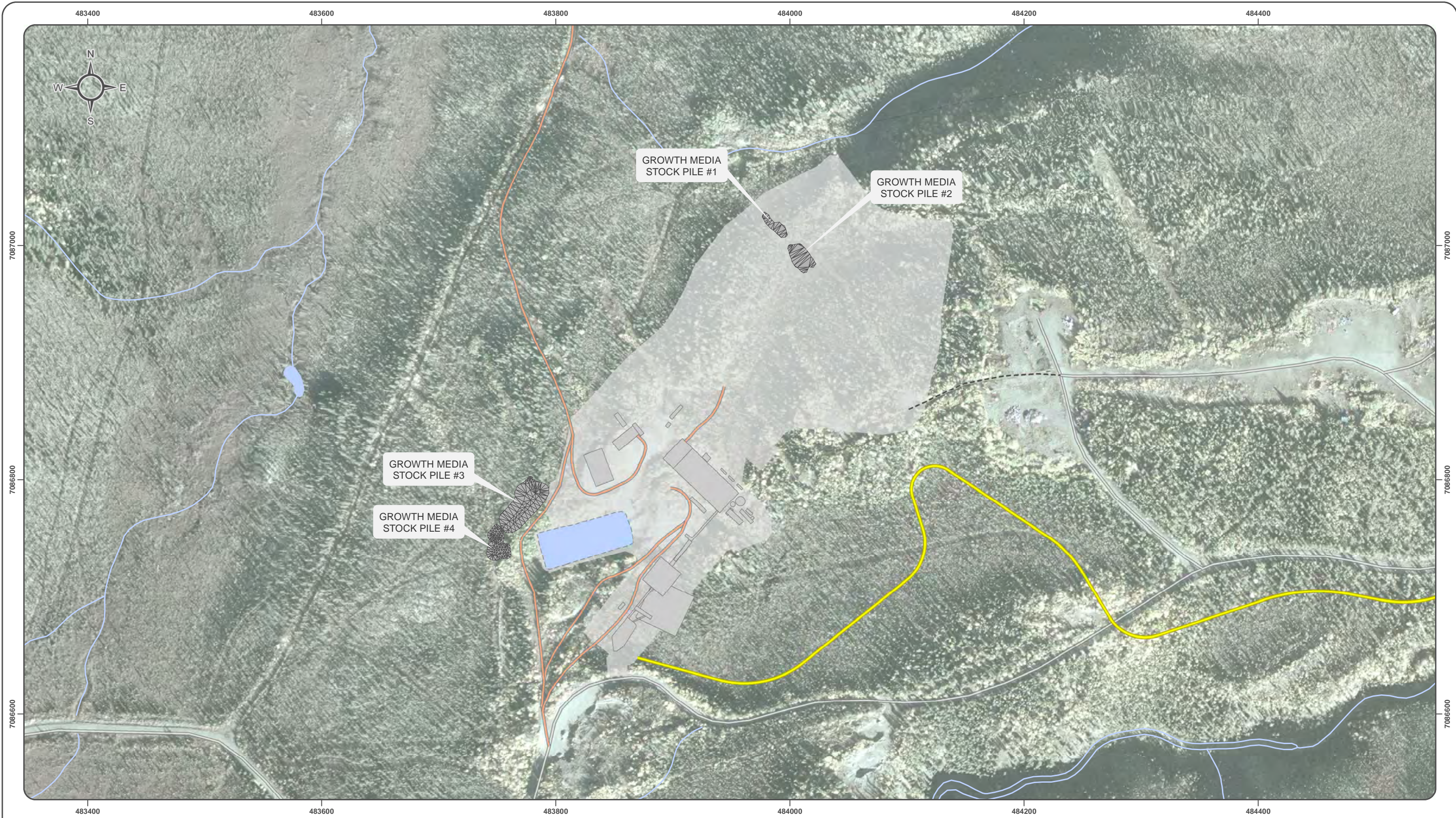
Appropriate diversions will be in place to meet erosion prevention objectives. Alexco's revegetation program includes resloping to 3H:1V, providing growth media material where it is necessary and active fertilization and seeding.

Assessment of revegetation programs carried out as a part of the Keno Hill District closure will be carried out to ensure that Bellekeno closure is commensurate with the overall plan for the district.

6.7.1 Borrow and Cover Sources

Borrow material will be required for cover systems (WRSF, WRDA and DSTF). Any borrow areas used will be reclaimed through slope stabilization and revegetation.

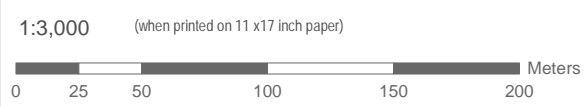
There are four existing borrow storage sites located at the mill area (Figure 6-12) that are suitable for cover construction and reclamation purposes. There are also a number of known granular deposits on the hill slope above the mine access road which have old access trails which could be sourced for the required borrow materials. The total volume of growth media stored in the piles shown in Figure 6-12 is approximately 4224.7m³.



Aerial photograph obtained from Geodesy Remote Sensing Inc., Calgary Alberta. Imagery acquired September 13 and 14 2006. Site hydrography and contours provided by Aero Geometrics LTD, derived from aerial photograph.

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

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- Growth Media Stockpiles
- Building (As Built)
- Pond (As Built)
- Site Footprint
- Haul Road
- Mill Access
- Local
- Track



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FIGURE 6-12
MILL SITE
GROWTH MEDIA STOCKPILES

DRAWN BY JP NOVEMBER 2011 VERIFIED BY BT

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7. CLOSURE MANAGEMENT AND MONITORING

The closure phase of the Bellekeno mine will commence with the cessation of economic mining. Closure management and monitoring of the site will be guided by licence requirements, the performance of physical structures remaining on site and the ability to achieve and demonstrate long-term compliance with effluent discharge standards. Once overall closure performance has been demonstrated for all aspects of decommissioning, the necessity of maintaining licences or permits would be examined. At this point, a Certificate of Closure, under the Quartz Mining Act would be requested. The following sections provide a general outline of the site management approach that will be taken at the Bellekeno mine during the closure phase.

Care & maintenance personnel will be on-site to implement decommissioning and reclamation tasks. Generally these tasks entail closure of mine components, salvage and removal of infrastructure, equipment and reagents, maintaining contingency water treatment facilities, decommissioning of roads and reclamation and revegetation of disturbed lands. A site contamination assessment plan will be prepared leading up to closure which:

- Locates through a site investigation program all contaminated material, if any, on the mine site arising from any operation, transportation, storage, handling or processing;
- Characterizes the type, concentration, and horizontal and vertical extent of the contamination; and
- Proposes methods for dealing with the contamination.

These activities would be undertaken on a seasonal basis and directed by an on-site manager responsible for decommissioning and reclamation of the Bellekeno mine.

During site decommissioning, camp accommodations would be available to support site personnel. As other activities are currently scheduled to continue to be undertaken in the District a site caretaker or security personnel will not be required.

7.1 IMPLEMENTATION SCHEDULE

Progressive reclamation will begin during operations to promote slope stabilization and reduce erosion during the life of the mine. Disturbed slopes will be stabilized and revegetated as required. Construction areas not able to be progressively reclaimed due to the onset of winter will be targeted for the following snow-free period. Progressive reclamation of the DSTF cover will occur for the most part during operations; however the installation of the final closure cover system will be conducted in the next snow-free period following the end of commercial milling unless there is additional milling of ore from other Production Units which may be permitted during the life of the Bellekeno Mine.



Mine decommissioning and reclamation including removal of equipment and infrastructure will mainly take place during the first year of mine closure. The Bellekeno 625 and mill water treatment facilities will be transitioned from active to passive treatment. The schedule for implementation of water management and treatment at Bellekeno is shown in Table 6-1: Bellekeno Mine Water Management Schedule. Please see Table 7-1, which shows the project decommissioning and reclamation schedule.

Table 7-1 Bellekeno Decommissioning and Reclamation Plan Closure Schedule

Phase / Activity	Years															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
	Construction		Operations				Closure									
Progressive Reclamation																
Closure and Reclamation Optimization/Research																
Bellekeno Mine																
- Bellekeno East Underground																
- Reclaim Bellekeno East Portal Site																
- Reclaim Bellekeno 625 Adit Site																
- Bulkhead 625 Installation																
- Bellekeno Mine Flooding and Insitu Pool Treatment																
- Bellekeno 625 Bioreactor and Commissioning																
- 200 Level Vent Raise																
Waste Rock Storage																
- Temporary Potential AML WRSF - Bellekeno East																
- Permanent Potential AML WRSF																
- Non-AML WRDA - Bellekeno 625																
- Reclaim Borrow Area																
Roads																
- Access Road Extension Bellekeno East to Bellekeno 625																
- Powerline Haul Road																
- Keno City Bypass																
- Mill Site Access Including Christal Lake Road																
- Other Roads and Trails																
Camp Downsize																
Mill																
- Mill and Ancillary Facilities																
- Mill Pad																
- Ore/Tailings Stockpile Pads																
- Runoff Collection Pond(s)																
- Diversion Ditches to Collection Pond																
Dry Stack Tailings Facility Cover																
Closure Site Management (monitoring & maintenance)																

7.2 CLOSURE MONITORING AND MAINTENANCE

Prior to Bellekeno mine development, a number of monitoring programs and a surveillance network were already in place for care and maintenance activities and for advanced exploration and preliminary development activities at the Keno Hill Property. These programs include physical inspections, effluent treatment systems and flow monitoring, a water quality surveillance network, old mine workings monitoring, aquatic effects monitoring for benthic invertebrate populations, sediment monitoring, waste rock and mine wall sampling and the adaptive management plan.

When mining commenced at Bellekeno, several more monitoring programs came on line to assess the efficacy of the environmental measures implemented for mining and to determine environmental impacts of mining, if any. These programs will be tailored to assess closure measures and continue as necessary with cessation of mining. At closure, the Type A water licence will undergo amendments to regulate activities around reclamation and reclamation monitoring. The details of the programs will be worked out at that time. The programs will reflect the future scenario. The following existing programs will continue in modified form after closure:

- (a) Surface water quality monitoring (as per Table 7-2)
- (b) Hydrological monitoring
- (c) Groundwater monitoring
- (d) Physical and engineered structures monitoring (geotechnical assessment)
- (e) Sediment, benthic and aquatic resources monitoring
- (f) Climate monitoring (as required for assessment of other resources)

It is assumed that monitoring activity will be required to determine the on-going and continued success of closure measures in meeting the closure objectives for a period of 10 years. The adaptive management approach (Section 7-3, below) will be used to determine if criteria triggers for remedial action have been triggered, and then the success of the remedial measures will need to be incorporated into the monitoring and surveillance regime.

At the time of closure, monitoring would continue to be undertaken by an Environmental Monitor:

Continued water quality sampling at monitoring stations identified in the Type A Water Licence.

- Table 7-2 shows the proposed closure monitoring schedule used as the basis for cost estimating. The schedule includes those sites that are relevant to post closure monitoring and not duplicated and monitored under other licences such as QZ06-074 ;
- Monitoring of road bank and drainage along access road;
- Physical inspection of tailings area;
- Physical inspection of the passive water treatment;
- Physical stability of all waste rock storage areas;
- Success of revegetation measures where employed (principally portal area and mill pad area);
- Monitoring of cover system integrity (potentially-AML WRSF and DSTF); and
- Physical inspection of impacted earthen surfaces for evidence of erosion, gulying, or sediment transport to watercourses.

The condition of permafrost beneath the WRDA will be monitored throughout operation and at least 10 years past closure. The requirement for ground temperature monitoring will be reviewed 10 years after closure, depending on the status of the construction of the Bellekeno WRDA. An annual geotechnical inspection should be conducted on the WRDA for at least 5 years after closure. The requirement for an annual geotechnical inspection will be reviewed 5 years after closure.

7.2.1 Site Presence and District-Wide Closure

Currently, the Keno Hill Silver District is undergoing planning for full-scale district-wide closure. Elsa Reclamation and Development Company (ERDC) and Aboriginal Affairs and Northern Development Canada (AANDC) are in partnership to reclaim the abandoned former United Keno Hill Mine (UKHM) mines. The tenure of this project is on the order of decades, and as such there will be a site presence for many years to come. Decommissioning and reclamation of the Bellekeno mine will occur in tandem with closure of the UKHM sites and therefore can be orchestrated together with district monitoring programs over the long term.

7.3 ADAPTIVE MANAGEMENT STRATEGY

To address risks or hazards over the short term, an adaptive management strategy is required in the event conditions reach a point where management actions are required. Adaptive management planning (AMP) is a recognized and effective tool to ensure that changing site conditions are not subject to static reclamation initiatives, and that closure measures can be adapted to these conditions to achieve desired performance. The adaptive management approach will be used to determine if indicators for remedial action have been

triggered. The success of remedial actions would then be incorporated into the monitoring and surveillance regimen.

An Adaptive Management Plan has been developed for the entire Keno Hill Silver District which provides adaptive management implementation protocol for the Company and includes provisions for monitoring at Bellekeno. During the decommissioning phase, environmental and physical compliance monitoring and inspections will continue according to the site-wide Environmental Monitoring Program and Adaptive Management Plan. This plan is summarized in Section 12.0 of the existing QML Monitoring and Surveillance Plan, which is attached as Appendix B.

Table 7-2: Bellekeno Mine Surveillance Network Monitoring Schedule

Monitoring Stations QZ09-092	Stations duplicated in QZ06-074	Proposed closure monitoring schedule	Easting	Northing	Description	Total Metals	Dissolved Metals	Ammonia	Nitrite	Nitrate	Phosphorous	Sulphate	DOC	Hardness	Alkalinity	pH	Conductivity	TSS	Radium	LC50	
KV-1	✓		4742790	7092790	South McQuesten River u/s Christal Creek	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
KV-2	✓		472076	7090036	South McQuesten River @ Pumhouse	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
KV-6	✓		483909	7088242	Christal Creek at Keno Highway	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
KV-7	✓		478657	7092413	Christal Creek at Hanson Road	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
KV-8	✓		465836	7088410	Christal Creek @ Mouth	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
KV-37	✓		490315	7087776	Lightning Creek u/s Hope Gulch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
KV-38*	✓		488193	7087341	Lightning Creek u/s Thunder Gulch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
KV-39	✓		490252	7087783	Hope Gulch u/s Lightning Creek	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
KV-40	✓		488982	7087503	Charity Gulch u/s Lightning Creek	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
KV-41	✓		485429	7086764	Lightning Creek u/s bridge at Keno City	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
KV-42	✓	✓	487363	7087062	Bellekeno 625 Adit	W	W	W	W	W	W	W	W	W	W	W	W	W			
KV-43	✓	✓	487318	7087147	Bellekeno 625 Treatment Pond Decant	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	
KV-44	✓	✓	487361	7087195	Bellekeno 625 Seep	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
KV-45	✓	✓	485101	7087288	Onek Adit	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
KV-49	✓		483582	7087009	Hinton Creek u/s Christal Creek	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
KV-50	✓		483575	7086897	Christal Creek u/s Hinton Creek	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
KV-51*	✓		483600	7087010	Christal Creek d/s Hinton Creek	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
KV-52	✓	✓	483756	7087869	Mackeno Creek	M	M	M	M	M	M	M	M	M	M	M	M	M	M	-	-
KV-65	✓	✓	487464	7086873	Thunder Gulch Upstream of Bellekeno	M	M	M	M	M	M	M	M	M	M	M	M	M	M	-	-
KV-72		✓	482492	7104476	South McQuesten River at McQuesten Lake	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
KV-76		✓	487414	7087118	Thunder Gulch d/s of Bellekeno 625 adit	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
KV-77		✓	487742	7086013	Thunder Gulch upstream of Bellekeno East	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
KV-78		✓	487126	7087052	Bellekeno Waste Rock Storage Facility	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
KV-79		✓	483796	7087919	Christal Creek d/s MacKeno Tailings	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
KV-80		✓	483790	7087869	Christal Lake u/s Mackeno Tailings	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
KV-81		✓	483548	7086423	Lightning Creek, South of Mill Site	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
KV-83		✓	483787	7086750	Bellekeno Mill Pond Discharge	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD
KV-84		✓			Keno City Well	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
KV-85		✓	7086952	483864	Flame and Moth Site Groundwater Well #1 PH2	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
KV-86		✓	7086707	483836	Flame and Moth Site Groundwater Well #2 PH5	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
KV-87		✓	7086854	484104	Flame and Moth Site Groundwater Well #3 PH6	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
KV-88		✓			Flame and Moth Site Groundwater Well #4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KV-89		✓			Flame and Moth Site Groundwater Well #5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KV-90		✓			Flame and Moth Site Groundwater Well #6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KV-91					Bellekeno Waste Rock Disposal Area Well #1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KV-92					Bellekeno Waste Rock Disposal Area Well #2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KV-93					Bellekeno Waste Rock Disposal Area Well #3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KV-94					Bellekeno Waste Rock Disposal Area Well #4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

7.4 TEMPORARY CLOSURE

In the event of a premature closure, the following monitoring and “care and maintenance” activities (focused on a temporary closure scenario occurring after mine start-up) will be instigated. Alexco’s priority during any temporary closure scenario will be to ensure that the site remains geochemically and physically stable, secure and safe, monitored and in compliance with applicable licences and legislation. This will include initial stabilization and on-going routine monitoring and maintenance of the site infrastructure and facilities until mining recommences or full closure is initiated.

Table 7-3 provides a summary of the various project components and associated inspection and maintenance activities during any temporary cessation of mining activities. Alexco’s on-going Care and Maintenance activities in the District are currently scheduled to continue beyond the next 5 years which means that there would be minimal additional costs related to a temporary closure at the Bellekeno Mine. These costs are already identified in the current closure plan costs.

Table 7-3: Summary of Care and Maintenance Activities and Surveillance during Temporary Cessation of Mining Activities

Project Component	Objectives	Care & Maintenance Activities	Monitoring	Monitoring Responsibility	Monitoring Timing/Frequency
Bellekeno Mine	Water Management	Maintain Bellekeno 625 water treatment facility and related water management infrastructure.	WUL Water Quality Surveillance Program	Care & Maintenance Crew	As per WUL
	Physical Stability	Restrict access to hazardous areas with physical barriers.	QML Physical Monitoring Program	Care & Maintenance Crew	As per QML
Waste Rock Storage	Physical stability	Runoff/Erosion/Sediment control. Progressive reclamation will occur during operations.	QML Physical Monitoring Program	Care & Maintenance Crew	As per QML
	Geochemical Stability	Cover AML WRSF with HDPE Monitor WRSF & WRDA for seepage.	WUL Water Quality Surveillance Program	Care & Maintenance Crew	As per WUL
Roads	Physical Stability	Surface grading and granular amendments, ditch and culvert maintenance.	Visual inspection periodically for signs of instability/erosion	Care & Maintenance Crew	Weekly and after heavy precipitation events
Mill	Buildings, Equipment and Infrastructure	Secure buildings and retain necessary equipment for site maintenance. Concentrate removed from site.	Visual inspection for signs of instability.	Care & Maintenance Crew	Monthly
	Physical Stability	Inspect for site stability. Reduce ore stockpile inventory.	Structural Inspection	Engineer	Twice Annually
	Water Management	Maintain water treatment system and related water management infrastructure.	WUL Water Quality Surveillance Program	Care & Maintenance Crew	As per WUL
Dry Stack Tailings Facility	Physical stability	Surface water diversion structure repair/ maintenance.	Monitoring Program from DSTF Operating Plan; &	Care & Maintenance Crew	As per Monitoring Programs & QML
		Runoff/Erosion/Sediment control. Dust Control. Progressive reclamation will occur during operations.	QML Physical Monitoring Program		
	Geochemical Stability	Monitor for seepage and water quality.	WUL Water Quality Surveillance Program; & Monitoring Program from DSTF Operating Plan	Care & Maintenance Crew	As per WUL
Entire Site	Physical stability	Runoff/Erosion/Sediment control. Road/culvert maintenance.	QML Physical Monitoring Program	Care & Maintenance Crew	As per QML
		Progressive reclamation will occur during operations.			
	Security	Full time site care & maintenace crew will check, repair and replace as required: · precautionary signage · security gates – installed to restrict access to the mill	Care & Maintenance Monitoring of all infrastructure and site elements	Care & Maintenance Crew	Daily: Inspection Sheets included in Annual Reporting
	Miscellaneous Infrastructure	Minimize camp size. Inspect power line	Care & Maintenance monitoring of all infrastructure and site elements	Care & Maintenance Crew	Daily: Inspection Sheets included in Annual Reporting
Reporting		Prepare and submit annual report to Yukon Water Board pursuant to		Alexco	Annually
		Prepare and submit annual report to YG Mineral Resources Branch			Quarterly, Online RISS Registry
		Prepare and submit quarterly monitoring reports to Environment Canada under MMER.			

7.4.1 Physical Stability and Geochemical Stability

Stabilization of site works during any temporary closure will be addressed initially well in advance of any closure scenario through the Company's commitment to progressive reclamation and stabilization measures. Progressive reclamation will be implemented on an ongoing basis (Section 4) to fulfil the Company's commitment to maintaining site stability and reclaiming areas as soon as operationally possible, therefore reducing both financial and operational liability.

Site infrastructure, including primarily buildings, equipment and machinery, will be emptied/drained of hazardous reagents and process fluids where appropriate and stabilized for temporary closure based on recommendations from mechanical and chemical suppliers, contractors and engineers. This includes the removal of all hazardous wastes, including waste hydrocarbons, coolants, lubricants, mill reagents and process chemicals. Depending on the anticipated length of a temporary closure, mill reagents and chemicals may remain on site in a secure condition for reuse once active operations recommence. The bulk explosives inventory will be removed from site and explosives storage containers and facilities will be inspected regularly. In the event of suspended operations, the Bellekeno 625 water treatment facilities will be maintained by the existing care and maintenance crew.

This temporary closure will be conducted to a level whereby the infrastructure and mine components are ensured to be stable in the short term (5 years) and whereby mining and milling operations can be resumed in a timely manner should the decision be made to transition back into operations. This will include:

- the retention of essential equipment/assets onsite to maintain infrastructure; and
- the storage of hazardous materials (not waste) in competent primary and secondary containment ensuring compliance with applicable legislation.

7.4.2 Security and Monitoring

Uncontrolled access to the mine components and facilities could pose a risk to the public and to the site assets. As such, the full-time care and maintenance crew will conduct daily monitoring of all infrastructure and site elements. Equipment and vehicles will be available onsite for the staff should more intensive earthworks be required during the temporary closure period.

During temporary closure gates may be required and locked with warning signs erected at the gates and key locations around the site indicating the risks of entry. Site buildings will be locked and secured. Roads will be maintained as required.

The care and maintenance crew will be responsible for:

- Regular inspections of the site to observe and document the condition of, and any changes to: site security and public safety measures, infrastructure, mine components, etc., as well as to document potential emerging environmental or public health and safety objectives;
- Conducting routine physical monitoring activities;
- Regular water quality and flow monitoring;
- Submitting inspection and monitoring reports to managers on a regular basis;
- Responding to any security/safety objectives as required; and
- Conducting routine site maintenance and basic repairs to infrastructure and works as required (snow removal, culvert and road maintenance, building maintenance).

Site inspections and monitoring will be conducted by vehicle when seasonally possible. Some sites may be difficult to access in winter as snow removal would not be reasonable at all locations. Inspection results will be documented on a form and submitted to management on a regular basis. Reports of changes to physical status of any part of the site may warrant a follow-up investigation by managers and/or professional personnel.

The Company's Environmental Monitoring Program and detailed design reports further commit to structural monitoring, which will continue in the event of temporary closure.

Some elements of the monitoring program (geotechnical and structural inspections and non-routine water quality and biological monitoring) will be conducted by appropriate professional personnel, and results of these inspections will be included in annual reports and other required submissions.

7.4.3 Reporting

Monitoring and inspection data collected will be compiled and submitted according to the required annual reporting timeframes for both the Quartz Mining and Water Licences.

7.5 SUPERVISION AND DOCUMENTATION OF WORK

All decommissioning and reclamation works will be supervised to ensure that works are constructed according to their design and that this work is properly carried out and documented. The project manager or construction supervisor would supervise all closure works. Regular inspection procedures would be completed to document work progress, deficiencies and completion.



Upon completion of the decommissioning and reclamation works, a final site plan report (summary text and drawings) will be prepared that will outline the facilities or works remaining on the site following closure including the locations of subsurface features. It is expected that this plan would be used to support an Application for a Certificate of Closure under the Quartz Mining Act.

8. RECLAMATION SECURITY AND COSTING

Costing of the proposed decommissioning and reclamation measures is the basis for the provision of security held by Yukon Government (YG). YG currently holds a security bond (100% cash Letter of Credit) to cover the potential liabilities arising from the operation of the Bellekeno mine project. Alexco has completed a cost estimate to implement this RCP and the estimated cost to implement the reclamation and closure plan is **\$3,083,000**. The amount of security currently held by YG for reclamation and closure of the Bellekeno mine project is **\$3,678,100**. In addition to the excess security held in comparison to Alexco's cost estimate it is important to note that not all of the liabilities including in the cost estimate have yet been realized or created.

Closure liability cost estimate summary tables are provided below. Where possible, cost estimates were made using unit cost per volume. Where the use of unit costs proved difficult, then an estimation of equipment and labour hours were used. The unit costs and job hours were derived from Access Consulting Group's professional experience with other closure program costing estimates prepared for Yukon Government as well as Alexco's operational experiences. Unit costs are presented in Table 8-1.

As the mine continues to operate this Reclamation and Closure Plan will be reviewed every two years and closure costs updated based on more detailed engineering plans. Assumptions for the current closure liability cost estimates are based on current site conditions, as well as Alexco retaining the contract to perform site care and maintenance. Alexco maintains a constant presence on site fulfilling the care and maintenance contract and obligations, and this is reflected in closure costs for site management, the incremental costs of water treatment, as well as camp costs.

Certain pre-existing terrestrial liabilities are the responsibility of the Federal Government and have not been included. The need to reclaim these areas is still noted in the tables below as well as where further discussion is needed.

Table 8-2 summarizes closure liability cost estimates for the end of mine life. Cost estimates for the separate reclamation components including site management are provided in the remaining tables.

Table 8-1 Belekeno Mine Unit Rate Cost Table

EQUIPMENT RATES		
Bulldozer-small (Cat D6)	\$130	per hr
D8K Dozer	\$190	per hr
D9H Dozer	\$260	per hr
D250E Haul Truck	\$220	per hr
Tandem Haul Truck	\$110	per hr
A35 Haul Truck	\$190	per hr
Cat 325 Hoe	\$190	per hr
Cat 235 Excavator	\$240	per hr
235 Excavator w Hammer	\$275	per hr
Cat 16H grader	\$220	per hr
988B Loader	\$250	per hr
Tractor Trailer (lowbed)	\$130	per hr
30 ton Crane	\$160	per hr
Hiab Flatdeck truck	\$125	per hr
Cat 950 Loader	\$125	per hr
Underground LHD 4-6yd Placement	\$219	per hr
Underground Truck 20t	\$113	per hr
Misc Mine Infrastructure	\$100	per hr
Vacuum Truck	\$100	per hr
Gas Powered Pump	\$100	per day
Pickup Truck	\$2,500	per month
Support Equipment		lump sum

PERSONNEL RATES		
Blaster	\$60	per hr
General Labourer	\$45	per hr
Underground Labourer	\$65	per hr
Trades Labourer	\$80	per hr
Underground / Site Supervisor	\$95	per hr
Medical Safety	\$50	per hr
Technician	\$75	per hr
Design Engineer	\$130	per hr
Environmental Scientist	\$95	per hr
Project Manager	\$9,700	per month
Camp Labourer	\$4,000	per month
Site Caretaker	\$6,100	per month
Environmental Monitor	\$90	per hr
Analytical Costs	\$500	Unit cost
Misc.		lump sum

REVEGETATION RATES		
Revegetation Seed Mix	\$13	per kg
Revegetation Seed Mix - 50kg/ha	\$510	per ha
Fertilizer	\$1	per kg
Fertilizer - 250kg/ha	\$250	per ha
Tree Seedlings	\$1,750	per ha (1,000 seedlings per ha)
Seed/Fertilizer Application	\$1,500	per ha
Revegetation cost per ha. Including application cost	\$2,260.00	per ha

Table 8-1 Bellekeno Mine Unit Rate Cost Table

CONTRACTOR UNIT RATES & CAMP COST		
Custom Rate A (Load, haul and place overburden cover on AML Waste Rock)	\$4.50	cu.m
Custom Rate B (Load, haul and dump mineralized rock stockpile in BK East Decline)	\$4.50	cu.m
Compact and Contour Cover	\$2	cu.m
Excavation of Soil	\$5	cu.m
Supply and place Geotextile	\$7	sq m
Load, haul and place soil cover	\$8	cu.m
Haul & Place rock cover	\$8	cu.m
Drill, Blast and Screen Rip Rap	\$22	cu.m
Load and Haul and Place Rip Rap	\$13	cu.m
HDPE Liner Install	\$10	sq m
Erosion barriers	\$3	sq m
Freight run to Whitehorse	\$1,000	per load
Camp Cost	\$55	per day per person
Power and Heat	\$5,500	per month
Sundry equipment maintenance	\$5,000	yearly
General Administrative expenses	\$2,000	per month
Employee Transport Costs	\$3,000	per month

Note: Custom Unit Rates have been developed specifically for Bellekeno Mine, taking into account such factors as haul distance, grade, machinery required, time required, etc.

Table 8-2 Bellekeno Mine Cost Estimate - End of Mine Life		
Item No.	Mine Component	Cost
1	BELLEKENO MINE	\$658,000
1.1	Bellekeno East Underground	\$32,000
1.2	&[Picture]	\$89,000
1.3	Reclaim Bellekeno 625 Adit Site	\$34,000
1.4	<i>Bulkhead Installation*</i>	<i>\$237,000</i>
1.5	Bellekeno 625 Water Treatment Facility Transition	\$235,000
1.6	200 Level Vent Raise	\$31,000
2	&[Picture]	\$200,000
2.1	Temporary P-AML WRSF - Bellekeno East	\$38,000
2.2	Permanent P-AML WRSF	\$60,000
2.3	Non-AML WRDA - Bellekeno 625	\$94,000
2.4	Reclaim Borrow Area	\$8,000
3	ROADS	\$86,000
3.1	Access Road Extension Bellekeno East to Bellekeno 625 (~600 m)	\$15,000
3.2	<i>Powerline Haul Road (~2.3 km)*</i>	<i>\$27,000</i>
3.3	Keno City Bypass (~650 m)	\$14,000
3.4	<i>Mill Site Access Including Christal Lake Road (1.9 km)*</i>	<i>\$25,000</i>
3.5	Other Roads and Trails (~5 km)	\$5,000
4	CAMP DOWNSIZE	\$27,000
5	MILL	\$484,000
5.1	Mill and Ancillary Facilities	\$308,000
5.2	Mill Pad (~3 ha)	\$30,000
5.3	Ore/Tailings Stockpile Pads	\$12,000
5.4	Water Treatment Plant Operation (~2 yrs)	\$87,000
5.5	Runoff Collection Pond (4,700 m3)	\$38,000
5.6	Diversion Ditches to Collection Pond	\$9,000
6	DRY STACK TAILINGS FACILITY	\$271,000
6.2	Mine Year 2 DSTF Cover	\$32,000
6.3	Mine Year 3 DSTF Cover	\$36,000
6.4	Mine Year 4 DSTF Cover	\$63,000
6.5	Mine Year 5 DSTF Cover	\$65,000
6.6	Mine Year 6 DSTF Cover	\$75,000
7	SITE MANAGEMENT	\$955,000
7.1	Onsite Management	\$213,000
7.2	Compliance Monitoring and Reporting	\$690,000
7.3	Contaminated Site Assessment Plan	\$12,000
7.4	Closure Maintenance	\$40,000
	TOTAL CLOSURE COSTS	\$2,681,000
	Contingency Costs (15%)	\$402,000
	GRAND TOTAL CLOSURE COSTS - END OF MINE LIFE	\$3,083,000

Table 8-3 Bellekeno Mine Estimated Closure Costs

Item No.	Reclamation Component	Equipment / Labour	Units	Quantity	Unit Cost	Cost	Total Cost
1.1	Bellekeno East Underground						
	Removal of underground equipment (e.g. paste plant; switch gear; electrical; hydraulic control structures)	Underground LHD 4-6yd Placement	per hr	60	\$219	\$13,140	
		A35 Haul Truck	per hr	60	\$190	\$11,400	
		General Labourer	per hr	120	\$45	\$5,400	\$29,940
	Project Management	7% of Total Cost	%		7.00%	\$2,096	\$2,096
	Sub-Total						\$32,000
1.2	&[Picture]						
	Remove shop and other buildings (explosives and cap magazine)	Misc.	lump sum	1	\$25,000	\$25,000	
	Supply rockfill for portal barrier	Load and Haul and Place Rip Rap	cu.m	700	\$13	\$9,100	
	Labour for portal barrier	General Labourer	per hr	40	\$45	\$1,800	
	Characterize settling ponds sediments	Analytical Costs	Unit cost	1	\$500	\$500	
	Remove settling ponds liners to landfill	A35 Haul Truck	per hr	2	\$190	\$380	
		General Labourer	per hr	8	\$45	\$360	
	Clean out fuel tank residue	Misc.	lump sum	1	\$1,000	\$1,000	
	Haul fuel tank and liner for reuse or landfill	Cat 325 Hoe	per hr	6	\$190	\$1,140	
		A35 Haul Truck	per hr	6	\$190	\$1,140	
		General Labourer	per hr	16	\$45	\$720	
	Area cleanup and haul debris to landfill	Cat 325 Hoe	per hr	20	\$190	\$3,800	
		A35 Haul Truck	per hr	20	\$190	\$3,800	
		General Labourer	per hr	40	\$45	\$1,800	
	Test area soils for contamination	Environmental Monitor	per hr	8	\$90	\$720	
	Laboratory Analysis for soils testing	Analytical Costs	Unit cost	2	\$500	\$1,000	
	Haul any contaminated soils to nearest Land Treatment Facility	Cat 325 Hoe	per hr	16	\$190	\$3,040	
		A35 Haul Truck	per hr	16	\$190	\$3,040	
	Recontour and scarify area and slopes to establish drainage	D8K Dozer	per hr	24	\$190	\$4,560	
		Cat 16H grader	per hr	20	\$220	\$4,400	
	Install Signage	Misc.	lump sum	1	\$1,000	\$1,000	
	Mob/Demob (entire mine)	Misc.	lump sum	1	\$15,000	\$15,000	\$83,300
	Project Management	7% of Total Cost	%		7.00%	\$5,831	\$5,831
	Sub-Total						\$89,000
1.3	Reclaim Bellekeno 625 Adit Site						
	Remove lab	Misc.	lump sum	1	\$5,000	\$5,000	
	Remove electrical substation*	Misc.	lump sum			\$0	
	Remove electrical transmission line (Keno City to BK 625)*	Misc.	lump sum			\$0	
	Remove shop/loadout facility, compressor shack*	Misc.	lump sum			\$0	
	Area cleanup and haul debris to landfill	Cat 325 Hoe	per hr	20	\$190	\$3,800	
		A35 Haul Truck	per hr	20	\$190	\$3,800	
		General Labourer	per hr	40	\$45	\$1,800	
	Test area soils for contamination	Environmental Monitor	per hr	8	\$90	\$720	
	Laboratory Analysis for soils testing	Analytical Costs	Unit cost	2	\$500	\$1,000	
	Haul any contaminated soils to nearest Land Treatment Facility	Cat 325 Hoe	per hr	16	\$190	\$3,040	
		A35 Haul Truck	per hr	16	\$190	\$3,040	
	Recontour and scarify area and slopes to establish drainage	D8K Dozer	per hr	24	\$190	\$4,560	
		Cat 16H grader	per hr	20	\$220	\$4,400	
	Install Signage	Misc.	lump sum	1	\$1,000	\$1,000	\$32,160
	Project Management	7% of Total Cost	%		7.00%	\$2,251	\$2,251
	Sub-Total						\$34,000
1.4	Bulkhead Installation*						
	Hydrogeologic study & engineering for concrete bulkhead	Misc.	lump sum	1	\$45,000	\$45,000	
	Underground Rehab for bulkhead	Misc.	lump sum	1	\$50,000	\$50,000	
	Construct concrete plug	General Labourer	per hr	120	\$45	\$5,400	
		Underground Labourer	per hr	200	\$65	\$13,000	
		Underground Truck 20t	per hr	120	\$113	\$13,560	
	Concrete Batch	Misc.	lump sum	1	\$75,000	\$75,000	
		Cat 950 Loader	per hr	80	\$125	\$10,000	
	Install Instrumentation (e.g. pressure gauge)	Misc.	lump sum	1	\$10,000	\$10,000	\$221,960
	Project Management	7% of Total Cost	%		7.00%	\$15,537	\$15,537
	Sub-Total						\$237,000
1.5	Bellekeno 625 Water Treatment Facility Transition						
	Remove salvageable equipment	General Labourer	per hr	16	\$45	\$720	
		Trades Labourer	per hr	16	\$80	\$1,280	
	Load & return extra reagents/chemicals	General Labourer	per hr	8	\$45	\$360	
		Misc.	lump sum	1	\$2,000	\$2,000	
	Dismantle building	Cat 235 Excavator	per hr	4	\$240	\$960	
		Cat 950 Loader	per hr	10	\$125	\$1,250	
		Tractor Trailer (lowbed)	per hr	30	\$130	\$3,900	
		General Labourer	per hr	40	\$45	\$1,800	
	In mine pool treatment 5 years	Misc.	lump sum	5	\$3,000	\$15,000	
	Characterize settling ponds sediments/sludge	Analytical Costs	Unit cost	1	\$500	\$500	
	Remove sludge from settling ponds	Vacuum Truck	per hr	40	\$100	\$4,000	
		General Labourer	per hr	40	\$45	\$1,800	
	Construct Bellekeno 625 bioreactor	See detail cost design	lump sum	1	\$110,195	\$110,195	
	Operate Bellekeno 625 Bioreactor 5 years	Misc.	lump sum	5	\$10,000	\$50,000	
	Site levelling	D9H Dozer	per hr	20	\$260	\$5,200	
	Scrap hauled to solid waste facility	Cat 235 Excavator	per hr	8	\$240	\$1,920	

Table 8-3 Bellekeno Mine Estimated Closure Costs							
Item No.	Reclamation Component	Equipment / Labour	Units	Quantity	Unit Cost	Cost	Total Cost
		D250E Haul Truck	per hr	12	\$220	\$2,640	
	Misc. Supplies & Tools	Misc.	lump sum	1	\$10,000	\$10,000	
	625 Sludge Rehandle	Misc.	lump sum	1	\$6,000	\$6,000	\$219,525
	Project Management	7% of Total Cost	%		7.00%	\$15,367	\$15,367
		Sub-Total					\$235,000
1.6	200 Level Vent Raise						
	Engineering for concrete cap	Misc.	lump sum	1	\$10,000	\$10,000	
	Concrete Batch	Misc.	lump sum	1	\$10,000	\$10,000	
		Cat 950 Loader	per hr	12	\$125	\$1,500	
		Hiab Flatdeck truck	per hr	48	\$125	\$6,000	
	Labour for cap	General Labourer	per hr	40	\$45	\$1,800	\$29,300
	Project Management	7% of Total Cost	%		7.00%	\$2,051	\$2,051
		Sub-Total					\$31,000

Table 8-4 Waste Rock Storage Estimated Closure Costs - End of Mine Life							
Item No.	Work Item Description	Equipment / Labour	Units	Quantity	Unit Cost	Cost	Total Cost
2.1	Temporary P-AML WRSF - Bellekeno East						
	Rehandle underground	Custom Rate B (Load, haul and dump mineralized rock stockpile in BK East Decline)	cu.m	6000	\$5	\$27,000	
	Remove liner and haul to solid waste facility	D250E Haul Truck	per hr	2	\$220	\$440	
		General Labourer	per hr	8	\$45	\$360	
	Site recontouring	D8K Dozer	per hr	20	\$190	\$3,800	
	Revegetation &[Picture]	Revegetation cost per ha. Including application cost	per ha	1.8	\$2,260	\$4,068	\$35,668
		7% of Total Cost	%		7.00%	\$2,497	\$2,497
	Sub-Total						\$38,000
2.2	Permanent P-AML WRSF						
	Educt impounded water	General Labourer	per hr	8	\$45	\$360	
		Vacuum Truck	per hr	8	\$100	\$800	
	Recontour waste rock	Cat 235 Excavator	per hr	8	\$240	\$1,920	
	Cover (0.5 m cover for 5 WRSF at 50 m x 50 m)	cover	cu.m	6,250	\$8	\$50,000	
	Revegetation	Revegetation cost per ha. Including application cost	per ha	1.25	\$2,260	\$2,825	\$55,905
	Project Management	7% of Total Cost	%		7.00%	\$3,913	\$3,913
	Sub-Total						\$60,000
2.3	Non-AML WRDA - Bellekeno 625						
	Recontour waste rock - pull back crests	Cat 235 Excavator	per hr	60	\$240	\$14,400	
	Scarification	Cat 16H grader	per hr	24	\$220	\$5,280	
	Revegetation	Revegetation cost per ha. Including application cost	per ha	30	\$2,260	\$67,800	
	Project Management	7% of Total Cost	%		7.00%	\$6,124	\$6,124
	Sub-Total						\$94,000
	Reclaim Borrow Area						
	Stabilize slopes	Cat 235 Excavator	per hr	12	\$240	\$2,880	
2.4	Revegetation	Revegetation cost per ha. Including application cost	per ha	2	\$2,260	\$4,520	\$7,400
	Project Management	7% of Total Cost	%		7.00%	\$518	\$518
	Sub-Total						\$8,000
	Total Estimated Cost in Reclaiming Waste Rock Storage Areas						\$200,000

**contingency cost incorporated into summary table

Table 8-5 Waste Rock Storage Estimated Closure Costs - Current							
Item No.	Work Item Description	Equipment / Labour	Units	Quantity	Unit Cost	Cost	Total Cost
2.1	Temporary AML WRSF - Bellekeno East						
	Rehandle existing temporary AML waste rock (from exploration) underground	Custom Rate B (Load, haul and dump mineralized rock stockpile in BK East Decline)	cu.m	850	\$5	\$3,825	
	Remove liner and haul to solid waste facility	D250E Haul Truck	per hr	2	\$220	\$440	
		General Labourer	per hr	8	\$45	\$360	
	Site recontouring	D8K Dozer	per hr	16	\$190	\$3,040	
		Cat 325 Excavator	per hr	4	\$240	\$960	
	&[Picture]	Revegetation cost per ha. Including application cost	per ha	1.8	\$2,260	\$4,068	\$12,693
	Project Management	7% of Total Cost	%		7.00%	\$889	\$889
	Sub-Total						\$14,000
2.4	Reclaim Borrow Area						
	Stabilize slopes	Cat 325 Excavator	per hr	8	\$240	\$1,920	
	Revegetation	Revegetation cost per ha. Including application cost	per ha	2	\$2,260	\$4,520	\$6,440
	Project Management	7% of Total Cost	%		7.00%	\$451	\$451
	Sub-Total						\$7,000
	Total Estimated Cost in Reclaiming Waste Rock Storage Areas						\$21,000

Table 8-6 Access and Haul Road Closure Estimated Costs

Item No.	Work Item Description	Equipment / Labour	Units	Quantity	Unit Cost	Cost	Total Cost
3.1	Access Road Extension Bellekeno East to Bellekeno 625 (~600 m)						
	Culvert excavation (2 culverts)	Cat 235 Excavator	per hr	10	\$240	\$2,400	
	Culvert removal and install swales	General Labourer	per hr	24	\$45	\$1,080	
		D250E Haul Truck	per hr	1	\$190	\$190	
	Reslope banks/remove safety berm	D8K Dozer	per hr	24	\$190	\$4,560	
	Scarify road surface	Cat 16H grader	per hr	16	\$220	\$3,520	
	&[Picture]	Erosion barriers	sq m	750	\$3	\$2,250	\$14,000
	Project Management	7% of Total Cost	%		7.00%	\$980	\$980
	Sub-Total						\$15,000
3.2	Powerline Haul Road (~2.3 km)*						
	Culvert excavation (20 culverts)	Cat 235 Excavator	per hr	40	\$240	\$9,600	
	Culvert removal and install swales	General Labourer	per hr	40	\$45	\$1,800	
		D250E Haul Truck	per hr	3	\$190	\$570	
	Reslope banks/remove safety berm	D8K Dozer	per hr	32	\$190	\$6,080	
	Scarify road surface	Cat 16H grader	per hr	32	\$220	\$7,040	\$25,090
	Project Management	7% of Total Cost	%		7.00%	\$1,756	\$1,756
	Sub-Total						\$27,000
3.3	Keno City Bypass (~650 m)						
	Culvert excavation (4 culverts)	Cat 235 Excavator	per hr	8	\$240	\$1,920	
	Culvert removal and install swales	General Labourer	per hr	8	\$45	\$360	
		D250E Haul Truck	per hr	1	\$190	\$190	
	Reslope banks/remove safety berm	D8K Dozer	per hr	16	\$190	\$3,040	
	Scarify road surface	Cat 16H grader	per hr	8	\$220	\$1,760	
	Lightning Creek bridge removal	Cat 235 Excavator	per hr	16	\$240	\$3,840	
		Tractor Trailer (lowbed)	per hr	8	\$130	\$1,040	\$12,150
		Erosion barriers	sq m	100	\$3	\$300	
		General Labourer	per hr	16	\$45	\$720	
	Project Management	7% of Total Cost	%		7.00%	\$851	\$851
	Sub-Total						\$14,000
3.4	Mill Site Access Including Christal Lake Road (1.9 km)*						
	Culvert excavation (40 culverts)	Cat 235 Excavator	per hr	40	\$240	\$9,600	
	Culvert removal and install swales	General Labourer	per hr	40	\$45	\$1,800	
		D250E Haul Truck	per hr	5	\$190	\$950	
	Reslope banks/remove safety berm	D8K Dozer	per hr	12	\$190	\$2,280	
	Scarify road surface	Cat 16H grader	per hr	40	\$220	\$8,800	\$23,430
	Project Management	7% of Total Cost	%		7.00%	\$1,640	\$1,640
	Sub-Total						\$25,000
3.5	Other Roads and Trails (~5 km)						
	Scarify road surface	Cat 16H grader	per hr	20	\$220	\$4,400	\$4,400
	Project Management	7% of Total Cost	%		7.00%	\$308	\$308
	Sub-Total						\$5,000
	Total Estimated Cost in Reclaiming Roads						\$86,000

Table 8-7 Camp Downsize Estimated Closure Costs							
Item No.	Work Item Description	Equipment / Labour	Units	Quantity	Unit Cost	Cost	Total Cost
4	Camp Downsize						
	Dismantle 5 trailer units and tranport to Lot 960 private	Misc.	lump sum	1	\$25,000	\$25,000	\$25,000
	Project Management	7% of Total Cost	%		7.00%	\$1,750	\$1,750
	Sub-Total						\$27,000
	Total Estimated Camp Downsizing Costs						\$27,000

Table 8-8 Mill Estimated Closure Costs

Item No.	Work Item Description	Equipment / Labour	Units	Quantity	Unit Cost	Cost	Total Cost
5.1	Mill and Ancillary Facilities						
	Remove equipment (crushers, conveyors, mill equipment, trailer units, other ancillary facilities - fine ore bin)	General Labourer	per hr	600	\$45	\$27,000	
		Trades Labourer	per hr	400	\$80	\$32,000	
		Cat 950 Loader	per hr	150	\$125	\$18,750	
		Cat 235 Excavator	per hr	50	\$240	\$12,000	
		Tractor Trailer (lowbed)	per hr	120	\$130	\$15,600	
	&[Picture]	General Labourer	per hr	75	\$45	\$3,375	
		Misc.	lump sum	1	\$2,500	\$2,500	
	Dismantle Mill Building	Cat 950 Loader	per hr	70	\$125	\$8,750	
		Tractor Trailer (lowbed)	per hr	70	\$130	\$9,100	
		Trades Labourer	per hr	300	\$80	\$24,000	
		General Labourer	per hr	1,000	\$45	\$45,000	
	Concrete Demolition	235 Excavator w Hammer	per hr	60	\$275	\$16,500	
		D9H Dozer	per hr	20	\$260	\$5,200	
	Crane Support	30 ton Crane	per hr	200	\$160	\$32,000	
	Haul scrap to solid waste facility	Cat 235 Excavator	per hr	50	\$240	\$12,000	
		D250E Haul Truck	per hr	100	\$220	\$22,000	
	Misc. Supplies & Tools	Misc.	lump sum	1	\$2,000	\$2,000	\$287,775
	Project Management	7% of Total Cost	%		7.00%	\$20,144	\$20,144
	Sub-Total						\$308,000
5.2	Mill Pad (~3 ha)						
	Test area soils for contamination	Environmental Monitor	per hr	16	\$90	\$1,440	
	Laboratory Analysis for soils testing	Analytical Costs	Unit cost	20	\$500	\$10,000	
	Haul any contaminated soils to nearest Land Treatment Facility	Cat 325 Hoe	per hr	16	\$190	\$3,040	
		A35 Haul Truck	per hr	16	\$190	\$3,040	
	Regrade embankment shoulders	D8K Dozer	per hr	8	\$190	\$1,520	
	Scarify pad area	Cat 16H grader	per hr	8	\$220	\$1,760	
	Revegetate	Revegetation cost per ha. Including application cost	per ha	3	\$2,260	\$6,780	\$27,580
	Project Management	7% of Total Cost	%		7.00%	\$1,931	\$1,931
	Sub-Total						\$30,000
5.3	Ore/Tailings Stockpile Pads						
	Concrete Demolition & Burial	Cat 235 Excavator	per hr	20	\$240	\$4,800	
		D9H Dozer	per hr	20	\$260	\$5,200	\$10,000
	Haul any contaminated soils to DSTF or Mine for disposal	Cat 235 Excavator	per hr	4	\$190	\$760	
		A35 Haul Truck	per hr	4	\$190	\$760	
	Project Management	7% of Total Cost	%		7.00%	\$700	\$700
	Sub-Total						\$12,000
5.4	Water Treatment Plant Operation (~2 yrs)						
	Construct infiltration gallery	A35 Haul Truck	per hr	80	\$190	\$15,200	
		Cat 950 Loader	per hr	60	\$125	\$7,500	
		General Labourer	per hr	60	\$45	\$2,700	
	Operate infiltration gallery (5 yrs)	Misc.	lump sum	5	\$10,000	\$50,000	\$75,400
	625 Sludge Rehandle	Misc.	lump sum	1	\$6,000	\$6,000	
	Project Management	7% of Total Cost	%		7.00%	\$5,698	\$5,698
	Sub-Total						\$87,000
5.5	Runoff Collection Pond (4,700 m³)						
	Pump down impounded water	General Labourer	per hr	36	\$45	\$1,620	
		Gas Powered Pump	per day	2	\$100	\$200	
	Misc. Supplies & Tools	Misc.	lump sum	1	\$500	\$500	
	Characterize pond sediments/sludge	Analytical Costs	Unit cost	1	\$500	\$500	
	Remove sediment/sludge from settling pond	Vacuum Truck	per hr	16	\$100	\$1,600	
		General Labourer	per hr	16	\$45	\$720	
	Breach dyke, relocate and contour materials	Excavation of Soil	cu.m	3,000	\$5	\$15,000	
	Stabilize slopes with erosion barriers	Erosion barriers	sq m	3,000	\$3	\$9,000	
	Remove discharge pipeline	Misc.	lump sum	1	\$5,000	\$5,000	
	Revegetate	Revegetation cost per ha. Including application cost	per ha	0.5	\$2,260	\$1,130	\$35,270
	Project Management	7% of Total Cost	%		7.00%	\$2,469	\$2,469
	Sub-Total						\$38,000
5.6	Diversion Ditches to Collection Pond						
	Recontour	D9H Dozer	per hr	24	\$260	\$6,240	
	Revegetate	Revegetation cost per ha. Including application cost	per ha	1	\$2,260	\$2,260	\$8,500
	Project Management	7% of Total Cost	%		7.00%	\$595	\$595
	Sub-Total						\$9,000
	Total Estimated Mill Closure Cost						\$484,000

Table 8-9 Dry Stack Tailings Facility Estimated Closure Cost

Item No.	Work Item Description	Equipment / Labour	Units	Quantity	Unit Cost	Cost	Total Cost
6.1	Mine Nov 2011 Current Conditions						
	Top with overburden and soil (0.5m)	Load, haul and place soil cover	cu.m	5,000	\$8	\$40,000	
	Revegetate	Revegetation cost per ha. Including application cost	per ha	1	\$2,260	\$2,260	\$42,260
	Project Management	7% of Total Cost	%		7.00%	\$2,958	\$2,958
	Sub-Total						\$45,000
6.2	Mine Year 2 DSTF Cover						
	Top with overburden and soil (0.5m)	Load, haul and place soil cover	cu.m	3,500	\$8	\$28,000	
	&[Picture]	Revegetation cost per ha. Including application cost	per ha	0.7	\$2,260	\$1,582	\$29,582
	Project Management	7% of Total Cost	%		7.00%	\$2,071	\$2,071
	Sub-Total						\$32,000
6.3	Mine Year 3 DSTF Cover						
	Top with overburden and soil (0.5m)	Load, haul and place soil cover	cu.m	4,000	\$8	\$32,000	
	Revegetate	Revegetation cost per ha. Including application cost	per ha	0.8	\$2,260	\$1,808	\$33,808
	Project Management	7% of Total Cost	%		7.00%	\$2,367	\$2,367
	Sub-Total						\$36,000
6.4	Mine Year 4 DSTF Cover						
	Top with overburden and soil (0.5m)	Load, haul and place soil cover	cu.m	7,000	\$8	\$56,000	
	Revegetate	Revegetation cost per ha. Including application cost	per ha	1.4	\$2,260	\$3,164	\$59,164
	Project Management	7% of Total Cost	%		7.00%	\$4,141	\$4,141
	Sub-Total						\$63,000
6.5	Mine Year 5 DSTF Cover						
	Top with overburden and soil (0.5m)	Load, haul and place soil cover	cu.m	7,000	\$8	\$56,000	
	Remediate sludge storage area	D8K Dozer	per hr	8	\$190	\$1,520	
	Revegetate	Revegetation cost per ha. Including application cost	per ha	1.4	\$2,260	\$3,164	\$60,684
	Project Management	7% of Total Cost	%		7.00%	\$4,248	\$4,248
	Sub-Total						\$65,000
6.6	Mine Year 6 DSTF Cover						
	Top with overburden and soil (0.5m)	Load, haul and place soil cover	cu.m	8,000	\$8	\$64,000	
	Revegetate	Revegetation cost per ha. Including application cost	per ha	2.5	\$2,260	\$5,650	\$69,650
	Project Management	7% of Total Cost	%		7.00%	\$4,876	\$4,876
	Sub-Total						\$75,000
	Total Estimated DSTF Closure Cost						\$271,000

Table 8-10 Site Management Estimated Closure Costs - End of Mine Life							
Item No.	Work Item Description	Equipment / Labour	Units	Quantity	Unit Cost	Cost	Total Cost
7.1	Onsite Management						
	Project Management and Engineering - Included in costs for each closure component						
	Pickup truck	Pickup Truck	per month	15	\$2,500	\$37,500	
	Sundry equipment maintenance	Sundry equipment maintenance	yearly	3	\$5,000	\$15,000	
	Power and heat (incremental additional costs)	Misc.	lump sum	15	\$1,000	\$15,000	
	General Administrative expenses	General Administrative expenses	per month	15	\$2,000	\$30,000	
	&[Picture]	Camp Cost	per day per person	2100	\$55	\$115,500	
	Sub-Total						\$213,000
7.2	Compliance Monitoring and Reporting						
	Water Quality Monitoring						
	Years 1-5	Incremental Cost*	annual	5	\$58,010	\$290,050	
	Years 6-10	Incremental Cost*	quarterly	5	\$57,504	\$287,520	
	Disbursements (non-labour/non-analytical)	Misc.	lump sum	10	\$1,000	\$10,000	
	Biological Monitoring - Closure implementation						
	Years 1-5 (Every 2 Years)	Incremental Cost*	yearly	2	\$3,000	\$6,000	
	Years 6-10 (Every 2 Years)	Misc.	yearly	2	\$3,000	\$6,000	
	Bellekeno waste rock & DSTF permafrost monitoring (10 yrs)	Misc.	yearly	10	\$4,000	\$40,000	
	WRDA & DSTF Annual Geotechnical Inspection - 5 yrs after closure	Incremental Cost*	yearly	5	\$10,000	\$50,000	
	Sub-Total						\$690,000
7.3	Contaminated Site Assessment Plan						
	Develop Plan	Misc.	lump sum	1	\$6,000	\$6,000	
	Assessment Reporting	Misc.	lump sum	1	\$6,000	\$6,000	
	Sub-Total						\$12,000
7.4	Closure Maintenance						
	Manage Land Treatment Facility and Testing*	Misc.	per year	5	\$5,000	\$25,000	
	Misc. Maintenance work related to the site after closure (roads, covers, revegetation)	Misc.*	per year	5	\$3,000	\$15,000	
	Sub-Total						\$40,000
	Total Estimated Cost for Site Management at Closure						\$955,000

Table 8-11 Site Management Estimated Closure Costs - Current

Item No.	Work Item Description	Equipment / Labour	Units	Quantity	Unit Cost	Cost	Total Cost
7.1	Project G & A						
	Pre-closure planning and organization	Project Manager	per month	2	\$9,700	\$19,400	
	Sub-Total						\$19,000
7.2	Onsite Management						
	Project Management and Engineering - Included in costs for each closure component						
	Site vehicle	Pickup Truck	per month	8	\$2,500	\$20,000	
	&[Picture]	Camp Cost	per day per person	2,100	\$55	\$115,500	
	Sub-Total						\$136,000
7.3	Compliance Monitoring and Reporting						
	Water Quality Monitoring						
	Years 1-5 (monthly)	Incremental Cost*	monthly	60	\$2,000	\$120,000	
	Years 6-10 (quarterly - spring/summer/fall)	Incremental Cost*	quarterly	20	\$2,000	\$40,000	
	Disbursements (non-labour/non-analytical)	Misc.	lump sum	10	\$1,000	\$10,000	
	Biological Monitoring - Closure implementation						
	Years 1-5 (Every 2 Years)	Incremental Cost*	yearly	2	\$3,000	\$6,000	
	Years 6-10 (Every 2 Years)	Misc.	yearly	2	\$3,000	\$6,000	
	Bellekeno waste rock & DSTF permafrost monitoring (5 yrs)	Misc.	yearly	5	\$4,000	\$20,000	
	WRDA & DSTF Annual Geotechnical Inspection - 5 yrs after closure	Incremental Cost*	yearly	5	\$10,000	\$50,000	
	Sub-Total						\$82,000
7.4	Contaminated Site Assessment Plan						
	Develop Plan	Misc.	lump sum	1	\$3,000	\$3,000	
	Assessment Reporting	Misc.	lump sum	1	\$3,000	\$3,000	
	Sub-Total						\$6,000
7.5	Closure Maintenance						
	Misc. site maintenance	Misc.	per year	2	\$3,000	\$6,000	
	Revegetation maintenance (25% of area revegetated)	Revegetation cost per ha. Including application cost	per ha	2	\$2,260	\$4,690	
	Sub-Total						\$11,000
	Total Estimated Cost for Site Management						\$254,000

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BGC Engineering, 2002(a). Heap Leach Facility Soil Cover Design Report. Viceroy Minerals Corporation, Brewery Creek Mine. July 2002

BGC Engineering, 2002(b). Blue Sediment Waste Rock Storage Area Soil Cover Design Report. Viceroy Minerals Corporation, Brewery Creek Mine. November 2002



ALEXCO KENO HILL MINING CORP.

Bellekeno Mine

Decommissioning and Reclamation Plan

November 2011

Appendix A Galkeno 900 Bioreactor Performance Report

DRAFT



**Galkeno 900 Sulphate-Reducing Bioreactor
2008-2011 Operations
Final Report**

Prepared by:

**Alexco Resource US Corp
For ERDC**

May 2011



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LIST OF ABBREVIATIONS

AKHMC.....	Alexco Keno Hill Mining Corporation
AVS.....	Acid Volatile Sulphides
BK.....	Bellekeno
COC	constituent of concern
gal.....	Gallons
KHSD.....	Keno Hill Silver District
kg.....	Kilogram
l	Litres
lb	Pounds
lpm	Litres Per Minute
lps.....	Litres Per Second
SRR.....	Sulphate Reduction Rate

1. EXECUTIVE SUMMARY

Alexco Environmental Group has operated a test bioreactor at the Galkeno 900 mine site since October 2008. Bioreactor technology is considered a closure option for some adit drainage sites in the Keno Hill Silver District (KHSD) and this closure pilot study has been performed to validate the effectiveness of this treatment technology with special consideration of engineering a stable bioreactor for the KHSD climate. In general, once sulphate reduction onset occurred after a commissioning period, effective treatment (significant mass reduction averaging over 90% during operational periods, and achieving discharge criteria at lower flow rates) was accomplished with a test flow rate range of 0.5-1.0 litres per second (lps). The configuration of the bioreactor was suboptimal due to the very limited footprint available near the Galkeno 900 adit, and the regulatory requirement to operate the bioreactor upstream of the lime treatment system. However, the key objectives of the study were accomplished; specifically sulphate reducing rates were determined across year-round operation, and it was demonstrated that the sulphate bioreactor technology could achieve under some operational flow rates discharge water quality standards as set under the existing water licence QZ06-074. The primary failure mode of the bioreactor was failure of the pumping systems due to power outages, which happened several times during the study, which led to freezing of the antisiphon valves and loss of water by siphoning from the bioreactor.

During the operational treatment phase at 0.5 lps, results showed removal of close to 99.8% zinc was achieved (5-6 mg/L reduced to 0.011 mg/L). During the operational treatment phase at 1.0 lps a maximum of 97.8% removal was occasionally achieved. Section 6, Bioreactor Performance, provides additional information concerning other metals that have also been substantially removed in the bioreactor at flow rates between 0.5 lps and 1.0 lps respectively. While zinc is the primary Constituent Of Concern (COC), the reduction of these other constituents will have beneficial effects in the reduction of toxicity where elevated metals have a combined toxicity more than any one metal alone. Iron and manganese, which had good removal during the recirculation phase (99% for both metals) showed a dissolution and production from the bioreactor during the reduction onset and initial through flow phases. Manganese currently passes through the reactor unchanged, while iron is still slowly releasing from the reactor. Conservative elements show less than 10% change during passage through the bioreactor, including calcium, magnesium, silica, sodium and strontium, demonstrating that dilution is not a significant factor causing metal removal in the reactor.

2. BACKGROUND

A bioreactor was constructed and operated in the Keno Hill Silver District (KHSD) at the Galkeno 900 adit beginning in May 2008. The bioreactor is still in operation as of May 2011, but the results of the bioreactor operations discussed in this report only include data through to March 2011. These results demonstrate the viability of sulphate reduction technology for the removal of metals, especially zinc and other metals that react with aqueous sulphide, in the KHSD.

The bioreactor solid phase substrate utilized to construct the bioreactor was coarse rock from a nearby placer mining operation. Solid organic carbon forms were not utilized to allow for the

simplest assessment of metals removal due to sulphate reduction only. The organic substrate supplied to the bioreactor included dissolved organic carbon forms, with sugars, alcohols and complex carbohydrates and proteins from milk used during the growth phase of the bioreactor operation, and sugars and alcohols used during the maintenance phase. The purpose of the organic substrate was initially to support microbial growth until sulphate reduction became the predominant microbial activity in the reactor, and during the treatment phase to support microbial sulphate reduction. Sulphate reduction is a chemical transformation performed by microbes that transfers electrons from organic carbon to sulphate, causing sulphate to be reduced to sulphide. Sulphide then reacts with many dissolved metals, forming very insoluble metal precipitates. The reactor also had the potential for other reactions to occur as a result of alkalinity being generated from the oxidation of organic carbon, and such as carbonate mineral formation within the bioreactor.

The bioreactor demonstration is part of a multipurpose program to assess the potential of adding an organic substrate to mine adit water to support metals removal, whether within a constructed bioreactor, within a mine pool, or in a naturally permeable zone outside a mine such as in a naturally occurring bog or gravel bed. Conceptually, the sulphide- and carbonate-based mineral precipitation that occurs in a bioreactor is similar to what would occur in a mine pool or natural sulphate reduction zone outside of a mine pool. The sulfate reduction rate observed in the bioreactor is similar to what would be achieved in these other settings.

Alexco has extensive experience with these types of in situ sulphate reduction systems, and owns six patents and has additional patents allowed and pending for the in-situ use of organic substrates and nutrients in earthen materials to stabilize metals. Alexco's technologies and patents provide in-situ encapsulation technologies, whereby soluble toxic metals including arsenic, cadmium, nickel, selenium, and zinc are geochemically encapsulated by more benign minerals within the groundwater aquifer or within and downgradient of sources of contamination such as within a pit lake, tailings impoundment, heap leach pad, or waste storage area. One patent that is applicable to this treatment approach is US patent #5,710,361, which describes amendment of metals-containing water with a carbon source to cause precipitation of metals during flow through rock or earthen materials via sulphate reduction.

Several adit discharge locations are being considered in the Closure Option assessment process for treatment in a bioreactor (Alexco Environmental Group, 2011). At this time, Silver King 100, Birmingham 200, Ruby 400, No Cash 500, Galkeno 900, Onek 400, Sadie Ladue 600 and Keno 700 are all considered as possible locations where bioreactor technology could be employed. Galkeno 900 has water chemistry and flow characteristics that are typical of these other adits in the KHSD. This test was of sufficient scale and operated long enough to provide design information that allows for the design of either a large scale bioreactor or an in-situ reduction field at several other adit drainage locations in the KHSD. The test was operated in a lined bioreactor allowing for the performance of the technology to be assessed while still in containment, but the results of the tests (reaction rates and stoichiometry) can be extended in the design of either a lined or an unlined system. The operation of the reactor continued through the winter season to demonstrate durability of metals removal mechanisms. During the course of the bioreactor demonstration, the conventional lime treatment system was maintained to ensure water license discharge compliance criteria were met.

3. GALKENO 900 TREATMENT LAYOUT

Figure 1 shows the piping and instrumentation setup of the bioreactor and treatment facility at Galkeno 900.

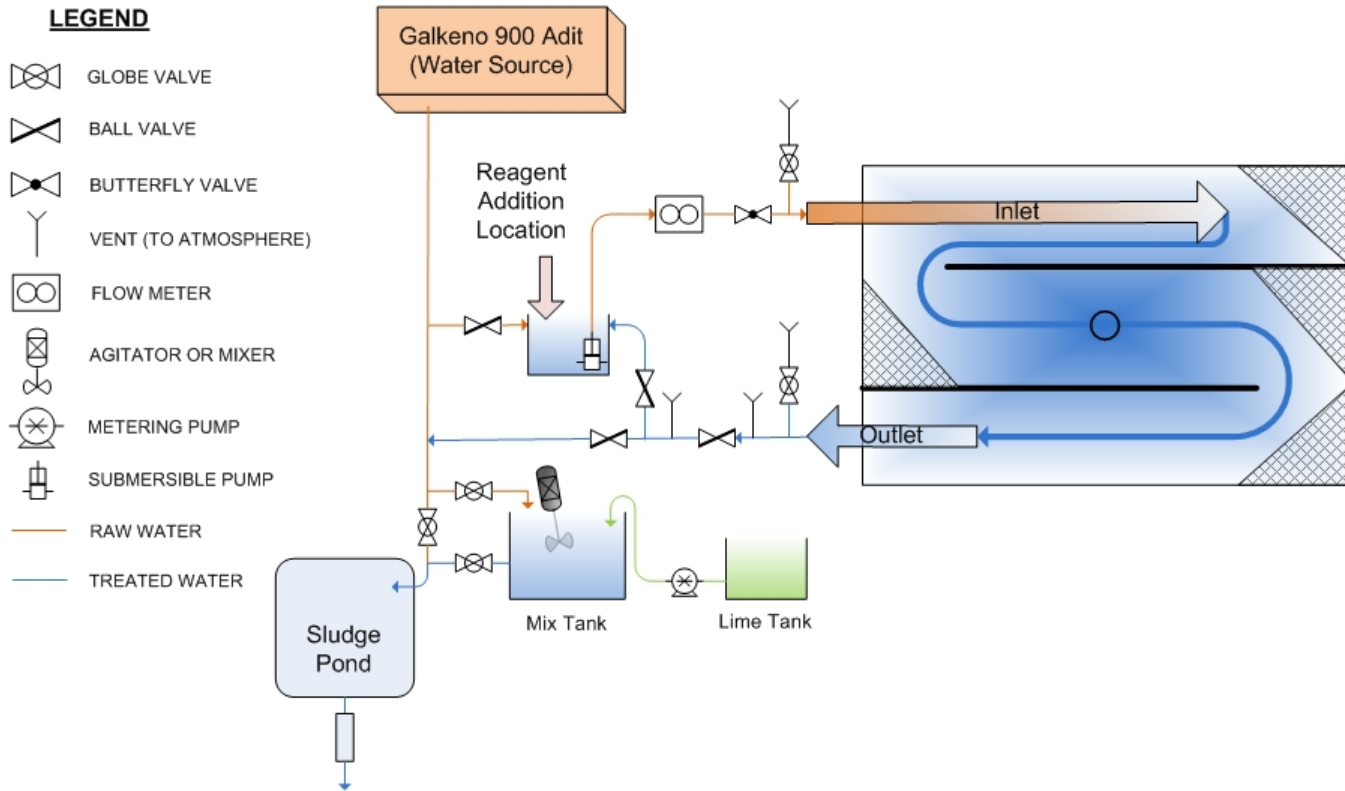


FIGURE 1 - GALKENO 900 LAYOUT

Water drains from the Galkeno 900 adit at an average annual rate of 4 litres per second (lps). This water is collected in a pipe and gravity flows away from the adit. Before the bioreactor system was installed, the water traveled directly to the treatment facility where it was mechanically agitated in a mix tank and dosed with lime slurry through a metering pump. Then the water was discharged to a sludge pond where the heavier particles were allowed to settle at the bottom in the form of sludge, and clean water was decanted and released. When the bioreactor treatment system was installed, additional valves and piping were added upstream of the lime treatment system so that a portion of the untreated adit water could pass through the bioreactor system for the purposes of this study.

Water is supplied to the bioreactor through an initial valve that when opened allows water to travel to the bioreactor's influent sump. Because of the harsh conditions in the Yukon, this valve, and all piping used in this setup was



FIGURE 2 – INLET VALVE

buried over 1 meter below surface, thereby reducing the possibility of freezing. Figure 2 shows the buried vertical pipe that contains this initial valve. In this figure, water travels downward from the adit to the lime treatment area. Opening this valve allows water to flow into the bioreactor's inlet sump.

The bioreactor inlet sump, shown in Figure 3, has a 48 inch diameter and is also located below surface. It is accessed through a cover that allows for reagent addition and water sampling as needed. Normal operation of the bioreactor requires the frequent dosing (constant dosing up to as infrequently as every two weeks, depending on flow rates) of a carbon source such as sugar, ethanol, or methanol. These reagents are slowly added to this sump via a metering pump for the liquids, or as dry powder for the sugar. During initial start-up, and on a few other occasions, an addition of milk sugars/protein as dry milk powder was required to aid the growth of microbes in the bioreactor. These reagents were also added at this location.



FIGURE 3 – BIOREACTOR INFLUENT SUMP

Within in the bioreactor inlet sump is a 1-horsepower submersible pump. The cable seen in Figure 3, stretching from lower left to upper right, attaches to a chain allowing the pump to be removed from the mix tank for servicing and/or replacement. The discharge from this pump is shown in Figure 4.

From the bottom of Figure 4 moving toward the top is a blue datalogger attached to the black Magnetic Flowmeter (Magmeter), a throttling globe valve, and finally a vertical anti-siphon standpipe. The datalogger records and stores the flow rates from the magmeter, allowing the system's operation rate to be tracked and analyzed. The globe valve is used to adjust the flow rate into the bioreactor. The vertical anti-siphon standpipe is exposed to the atmosphere. The system is designed so that in the event of pump failure, air will be pulled into the pipe and breaks the siphon. This series of instruments and valves is also located below grade in an insulated box and can be accessed through



FIGURE 4 – BIOREACTOR INLET

a cover.

The bioreactor is roughly 90 feet by 100 feet and has a liquid-filled portion that is 10 feet deep. It was dug partially into the native ground with an excavator, and the remaining depth was created by forming a berm around the excavated area. The bermed/excavated area was lined with 0.060 inch thick HDPE liner to form a pond, and then filled with waste rock recovered from a local placer mine. Figures 5 and 6 were taken during construction of the bioreactor and Figure 7 shows the overall design.

After the pond was filled with placer oversize rock, a geofabric was laid across the bioreactor, and soil from the excavated area and hillside was used to provide a 4 foot soil cover over the bioreactor. This soil cover layer acted as an insulating layer, minimizing the amount of ice formation in the top layer of the bioreactor. When the bioreactor solids were sampled in March 2011, the ice layer was approximately 18 inches to 2 feet thick.

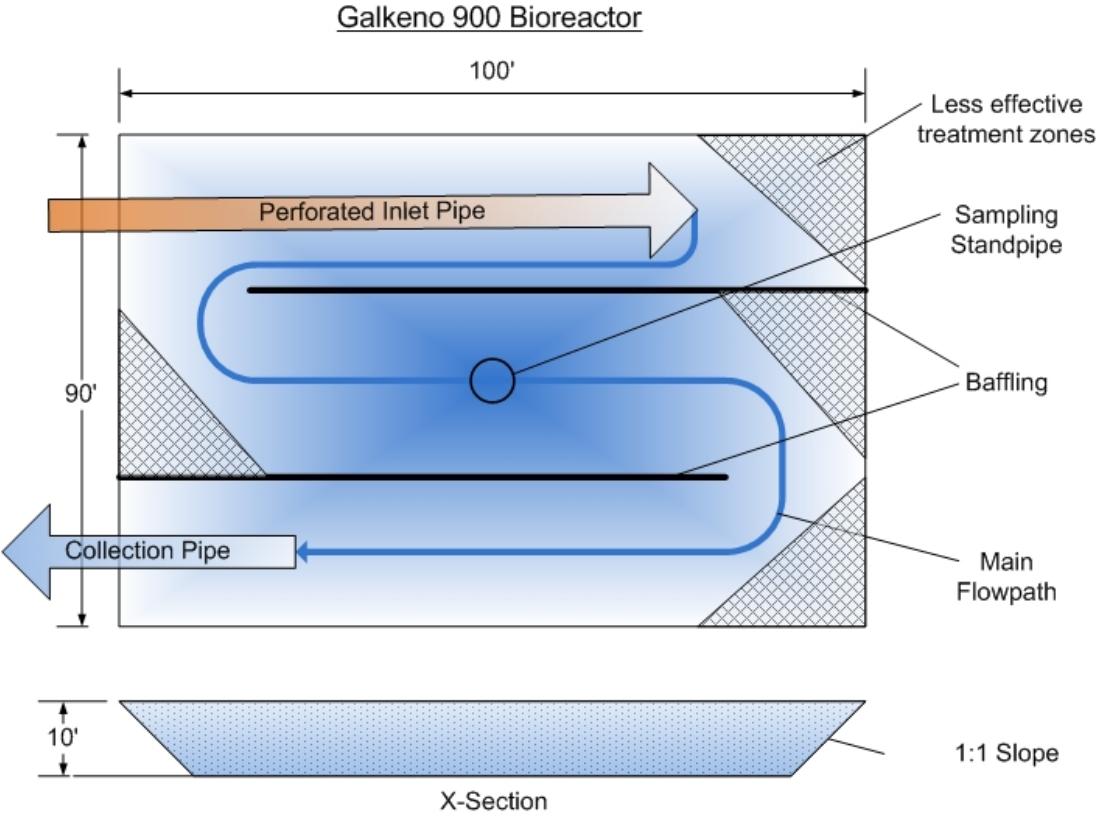
Water enters the bioreactor through an inlet pipe that transports water to the far side of the bioreactor (see Figure 7 for an overall view of the layout). The last half of the pipe is perforated with $\frac{3}{4}$ " holes, allowing water to fill the bioreactor and flow back and forth before final release.



FIGURE 5 - BIOREACTOR CONSTRUCTION



FIGURE 6 – BIOREACTOR STANDPIPE



Baffling was installed in two locations to create a torturous flow path and increase the contact time of the water with the media within the bioreactor,. This forces the water to travel a greater distance within the bioreactor before final release and to contact a greater fraction of the media. Also present at the center of the bioreactor is a sampling standpipe that can be seen in Figure 6. This allows samples to be collected and analyzed once water has passed midway through the bioreactor.

The discharge from the bioreactor is collected in a pipe and can then be either sent back to the bioreactor influent sump for recirculation or mixed with untreated adit water from the Galkeno 900 adit. This co-mingled water then passes through the lime treatment system mentioned earlier and is released into a sludge pond where heavy particulate settles and clean water is decanted and released. Figure 8 is the bioreactor discharge valve set-up. Water travels from the bioreactor on the right (not shown) and can either be sent up (as shown in the photo) to the bioreactor influent sump or to the left (as shown in the photo) to be co-mingled with adit water from the Galkeno adit. This setup is below surface grade and is accessible through a cover.



FIGURE 8 – BIOREACTOR DISCHARGE VALVES

Overall, the system was constructed to provide the operator with the maximum amount of flexibility to study the performance of a bioreactor without introducing the risk of releasing untreated water from the adit. Based on the positions of several valves, the system could be run in one of the following operation modes:

- 1.) Bioreactor influent valve closed – collected adit water bypasses the bioreactor and is treated at the lime treatment facility.
- 2.) Bioreactor influent valve and discharge valve closed – water pumped from the bioreactor influent sump fills the bioreactor and once filled, this mode allowed the water in the bioreactor to be continuously re-circulated. This was important to allow for the initial

growth phase of the bioreactor, allowing the carbon source to be consumed in the bioreactor rather than being released from the discharge.

- 3.) Bioreactor influent valve open and discharge valve open – untreated adit water was pumped into the bioreactor, sampled along several key locations, then discharged from the bioreactor and co-mingled with the untreated adit water where it was transferred to the lime treatment facility.

The water from the adit was a significant heat source for the bioreactor; therefore some amount of influent water from the adit was desired even during the initial growth phase of the bioreactor. In a full scale installation without the requirement of the downstream secondary treatment plant, these valving systems would not be required other than to provide a bypass from the adit if desired, and a temporary recirculation loop to allow discharged water to be sent back to the influent sump.

4. BIOREACTOR OPERATIONAL SUMMARY

Operational notes are included in this report to capture a few of the issues experienced during construction and operation of the bioreactor. The bioreactor construction began in the summer of 2008 with operation starting soon after. The following timeline outlines milestones, as well as issues, that were noted during operation:

- July-August 2008: Pond constructed and lined (see Figures 5 & 6).
- September 2008: Pond filled with oversize rock from a local placer mining operation (some small amounts of fines were present).
- October 4th, 2008: Start filling the bioreactor with untreated adit water.
- October 10th & 11th, 2008: Started recirculation of bioreactor water, added 182 kg sucrose to support microbial sulfate reduction.
- October 16th, 2008: 110 gal methanol and 1.8 kg dried milk solids added.
- October 2008: Bioreactor covered with geofabric and several feet of topsoil.
- October 2008 through May 2009: Occasional “top up” of untreated mine water to maintain full conditions in bioreactor. Make-up water averages ~ 1 m³/day or approximately 1 liter per minute average.
- January 23rd, 2009: 110 gal methanol added.
- January 2009: Determination of slow leakage rate from bioreactor ~ 1.09 m³/day.
- **February 19th, 2009:** Anti-siphon valve on the return recirculation line iced over, draining the bioreactor and flooding covers/box. Estimated ~135 m³ water was lost from the bioreactor through overflow of the tank.
- April 8th, 2009: Bioreactor standpipe blocked with ice – unable to sample.
- May 17th, 2009: Began adding methanol at the bioreactor influent sump at a rate of 1.0 litre per day.
- July 11th & 12th, 2009: Added 10 kg sucrose each day to jumpstart reduction, continued methanol addition at 1.0 litre per day.
- August 25th, 2009: Installed totalizer and flowmeter on the inlet to the bioreactor.

Once methanol was added at a constant rate, the bioreactor began through-flow operation. During that time, the following events occurred:

- October 8th, 2009: Initiated flow-through at a rate of 0.5 litre per second.
- December 18th, 2009: Initiated flow-through at a rate of 1.0 litre per second.

- January 7th-20th, 2010: Valve box flooded and frozen, thawed and repaired on January 20.
- February 15th, 2010: Power loss to submersible and metering pump.
- **February 16th - 18th, 2010**: Power loss while anti-siphon frozen which resulted in the loss of approximately half the bioreactor water volume through the sump; power restoration and line thawed; refilled bioreactor.
- August 6th, 2010: Reduced flow rate to 0.75 l/s to improve treatment.
- March 17th & 18th, 2011: Return line frozen.

A review of the operator's log provides some important details that will guide future design. On February 19th 2009 and February 16th 2010, loss of power and a lack of continued pumping of water, which maintained heat in the bioreactor lines, resulted in ice formation in the anti-siphon valve. With the transfer pump stopped, the bioreactor siphoned water into the sump, which overflowed on the ground around the sump.

5. METALS REMOVAL MECHANISMS IN BIOREACTOR TREATMENT

The removal of metals from mine waters by bioreactors is done around the world, utilizing a variety of approaches. Doshi (2006) summarizes the many different types of bioreactors that are in operation, and discusses the relative advantages and disadvantages of these different bioreactor systems. The bioreactor utilized at Galkeno 900 is one type of reactor, where the only carbon source added to the bioreactor was added in a dissolved form semi-continuously during the operation of the bioreactor. Bioreactors are often constructed utilizing a mixture of substrates which either act as a carbon source for microbial reactions, or these substrates can act as sorptive surface for metals precipitation. However, bioreactors with solid phase carbon sources are often limited in their sulphate reduction rates by the availability of soluble organic carbon (Buccambuso et al, 2007) indicating that the constant supply of a carbon source as was done in Galkeno 900 bioreactor will tend to prevent microbial limitations on treatment.

For context of this discussion, the operation of the Galkeno 900 bioreactor can be divided into three distinct time periods. They are:

- **Recirculation Phase – Operation Mode 2 (October 2009 - July 2009)**: During this period, the bioreactor was placed into service with water from the adit entering at an average rate of one litre per minute (1 lpm), which provided makeup water to replace slow leakage, and also to provide some heat from the adit water during the cold season. An initial carbon source addition consisting of (1.8 kg) milk powder and (182 kg) table sugar (sucrose) and (110 gal) methanol was added to provide an energy and nutrient source for an initial microbial growth phase. No source of microbes other than what was present on the placer rock and what is carried in the mine water was added to the bioreactor. However, researchers studying mine water and sediment at the Penn Mine Church et al (2007) showed that mine water even in an pH 4 mine drainage with high concentrations of heavy metals contained sulphate reducing bacteria and accounted for metals removal processes. The water in the bioreactor was re-circulated at a rate of one to two liters per second to mix and distribute water in the bioreactor. The water was periodically sampled to evaluate microbial growth and activity indirectly by evaluating water quality changes that could be inferred to be caused by microbial action. During this period there was incomplete formation of reducing conditions and the bioreactor likely had both aerobic and anaerobic zones. During the recirculation phase, metal concentrations were decreased over several months (discussed more below) and the

removal mechanisms during this time may have included oxidative mechanisms (iron and manganese oxide formation) with metal co-precipitation on the iron and manganese oxides, carbonate mineral formation, and microbial sulphate reduction and metal sulphide precipitation.

- **Reduction Onset Phase – Operation Mode 2 (July 2009 – September 2009):** During this period, water within the bioreactor continued to be re-circulated while additional carbon sources were added at the bioreactor influent sump. This resulted in elevated carbon concentrations and the onset of more strongly sulphate-reducing conditions. During this time, the development of stronger reducing conditions were observed, characterized by greater sulphate reduction, the dissolution of manganese and iron from the reactor solid phase (likely manganese and iron oxides formed during initial bioreactor operations, as well as structural iron and manganese minerals in the placer rocks), and greater metals removal as sulphides.
- **Operational Treatment Phase – Operation Mode 3 (October 2009 – March 2011):** An initial flow rate of 0.5 litre per second (lps) was established into the reactor, and after stable metal removal conditions were observed this flow rate was maintained for several consecutive bimonthly samples. Soon after, the flow rate was increased to one litre per second (lps) in December 2009. In August 2010, the flow rate of the bioreactor was reduced to 0.75 lps, or approximately 19% of the adit flow. This flow rate was then maintained for the remaining operation of the bioreactor.

The results displayed in this report focus primarily within the operational treatment phase. The other phases, while important, are reflective of treatment performance during the transition of the bioreactor from construction to operation.

5.1. LITERATURE REVIEW AND BACKGROUND DISCUSSION

The formation of metal precipitates in a bioreactor that has carbon sources added to or present in the solid phase of the bioreactor has been extensively studied for 30+ years. There are several different styles of bioreactors, both in terms of carbon sources and flow dynamics. Some very large bioreactors have been created to treat flows as large as 20 lps or greater, and some bioreactors are designed to treat very acidic or concentrated metal-containing mine drainage. Each bioreactor must be designed to reflect the environmental conditions, the water chemistry of the mine water being treated, and other relevant variables as discussed in this report.

To understand the processes that occur in bioreactors many studies have attempted to identify directly by examination of mineral formation or by inference from water chemistry signatures what primary mechanisms are responsible for metals removal. When complex carbon sources are added as a solid phase in the bioreactor construction (i.e., peat, straw, compost, wood chips, etc.), a broad range of mechanisms has been documented (Gusek, 2002; Doshi, 2007; Gusek et al, 2008), that include:

- Sorption of metals on organic matter.
- Precipitation of iron hydrous oxides including ferric and mixed valence minerals, which then provide mineral surfaces for sorptive removal of metals, or metals can also be co-precipitated within the iron mineral matrix.
- Precipitation of manganese oxides including manganese (IV) oxides and mixed valence (III/IV) oxides and manganese carbonates, which then provide mineral surfaces sorptive removal of metals, or metals can also be co-precipitated within the manganese mineral matrix.

- Precipitation of metal sulphides, including primary metal sulphides such as ZnS or CdS, as well as precipitation of iron sulphides such as amorphous FeS and co-precipitation of metals within the FeS matrix. Depending on the pH of the bioreactor and the availability of structural iron, a very large amount of FeS minerals can be formed by aqueous sulphide formed by microbes reductively dissolving iron from the rock matrix, creating a “bank” of amorphous sulphide which has reactivity toward dissolved metals.
- Precipitation of some metals in their reduced forms, for example selenium reduction from a Se(VI or IV) anion to elemental selenium precipitates Se.
- Precipitation of metals as carbonate minerals. Some of the relevant metals have somewhat soluble carbonate minerals (e.g., zinc carbonate minerals including smithsonite, and hydrozincite) which are relatively more soluble than sulphides. When sulphide is not present, these minerals may provide a precipitation-removal mechanism.

Sorption of metals on organic matter is not a relevant metals removal mechanism in the Galkeno 900 bioreactor because only coarse rock was used as a solid substrate. The metal removal mechanisms in this reactor appear to initially relate to removal of iron and manganese during the recirculation phase, and then over time the removal mechanism transitioned to a metal sulphide removal mechanism (inferred because metals removal continued to occur when iron and manganese ceased being removed and actually increased in concentration during flow through the reactor). The precipitation and removal of metals in their reduced forms is not a significant potential mechanism for most of the metals present in Galkeno 900 adit water, with the potential exception of uranium which was only present in very low concentrations in the influent water. Consequently, the formation of sulphide from sulphate, which is a chemical reaction that is catalyzed by microbes and relies on the availability of organic carbon, is the primary performance variable that is relevant in the Galkeno 900 bioreactor performance evaluation. In typical evaluation of bioreactors where sulphate reduction/sulphide precipitation is a dominant mechanism, the Sulphate Reduction Rate (SRR) is determined as a primary design variable.

In a bioreactor with available sulphate and a soluble carbon source added, Dar et al (2007) showed that sulphate reducing bacteria (SRB) are the dominant microbe that accumulates in the bioreactor, and by inference the vast majority of the carbon consumption is performed by SRB. In their study, only a few different strains accounted for the majority of the cells present, indicating that microbes capable of utilizing the carbon source and reduce sulphate will become dominant in the bioreactor.

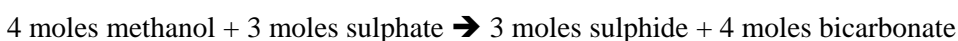
After the bioreactor entered stable operation, metals removal mechanisms appear to have shifted from the mixed reaction that were discussed in the prior report (Alexco Resource US Corp, 2009) to primarily a sulphide-based precipitation process. The stability of metals removed as sulphides are consequently an important consideration for the performance of the bioreactor. Jong and Perry (2004) studied the form of metals that were precipitated from solution as a result of the sulphate reduction process, and determined that arsenic, copper, iron, nickel, and zinc were primarily bound up in a sulphide phase that was also associated with residual organics, and that carbonate or hydroxide phases were relatively minor phases that held the metals removed from solution. The United States Environmental Protection Agency SITE program studied the stability of these sulphate-reducing bioreactor precipitates at the Leviathan Mine, in California. Using a series of different tests, the EPA determined that the metals in the bioreactor precipitates were below regulated total metals thresholds (California standards), the WET extraction test showed that the metals in the bioreactor did not leach above regulated soluble threshold standards, and that as defined by TCLP extraction testing the bioreactor solid materials were not hazardous.

The effectiveness of this sulphate reduction bioreactor process is sensitive to important variables including the hydraulic residence time in the bioreactor, the sulphate reduction rate, and the filtration capacity of the media.

Because the products of the sulphate reduction reaction include both sulphide and bicarbonate alkalinity, it is possible that carbonate precipitation is also an important mode of precipitation for some of the metals removed in the reactor. However, for most of the metals being removed in the bioreactor, including antimony, arsenic, cadmium, cobalt, iron, nickel, and zinc, a sulphide precipitation mechanism appears more likely because sulphide precipitates are less soluble than the carbonate precipitates of these elements. Thus the sulphate reduction reaction is the primary reaction that we will focus on optimizing in the bioreactor operations.

5.2. DETERMINATION OF THE SULPHATE REDUCTION RATE

Microbial production of sulphide from sulphate is dependent on the presence of sufficient numbers of sulphate-reducing bacterial (SRB) cells, and the availability of organic carbon, according to the following reaction:



The rate of the reaction is nearly the same at temperatures in natural environments where the long-term temperature is around freezing (-2°C to 2°C) as it is in natural environments where the long-term temperature is around 20°C when the abundance of SRB is the same (Knoblauch, Jorgensen, and Harder, 1999). This is due to the development of psychrophilic (i.e., ‘cold loving’) SRB. The growth rate of psychrophilic SRB is typically far slower than temperate SRB, which is reflected in the long growth period (October 2008 to August 2009) required for the Galkeno 900 bioreactor to reach maturity so that it could sufficiently treat mine water. However, once the bioreactor was competent to perform sulphate reduction (as evidenced by net sulphide concentrations leaving the reactor in the 1 to 10 μM range, indicating that there is excess aqueous sulphide created above what was required to react with the soluble and solid phase metals) then the bioreactor SRR could be assessed. (Note: it was possible to add more organic carbon to the reactor and support additional sulphate reduction, however it would result in higher dissolved sulphide which would not be required for metals precipitation, and could result in reduction of oxygen in the surface receiving streams. At the amount of sulphide precipitation that was achieved (1 to 10 μM range) dissolved oxygen consumption would be less than 1 mg/L, or less than 10% of what is normally in surface water.)

The SRR is measured in terms of mM sulphate reduced per m^3 of bioreactor substrate per day. The influent sulphate compared to the effluent sulphate is compared to determine the amount of sulphate removal. The average sulphate removal amount during the treatment phase was 128 mg/L, or 1.33 mM. With a known bioreactor volume of approximately $2,550 \text{ m}^3$, and a flow rate of 1 lps, the total sulphate removal per day was 115,200 mM, which yields a SRR of 45 $\text{mM}/\text{m}^3/\text{day}$. For comparison, arctic ocean sediments have SRRs in the range of 5-40 $\text{mM}/\text{m}^3/\text{day}$ (Knoblauch, Jorgensen, and Harder, 1999), showing that the bioreactor has a similar rate as natural systems that have long term adaptation to cold environments.

The SRR calculated for the Galkeno 900 bioreactor is conservatively calculated based on dividing the amount of sulphate reduced by the volume of the entire bioreactor. However, less effective treatment zones or “dead zones” are identified in Figure 7 and were expected based on the sub-optimal configuration that was available at Galkeno 900. These areas can limit the exchange of organic carbon and therefore it is likely that minimization or elimination of these dead zones will improve the performance of the bioreactor.

5.3. RECIRCULATION DYE TEST

The volume of the bioreactor voids needed to be determined independently to assess residence time and other performance characteristics of the bioreactor. The dimensions of the reactor were measured to be approximately 100 feet by 90 feet and 10 feet in depth. Assuming an estimated porosity of 0.35, the volume was calculated to be roughly 890 m³ or approximately 235,000 gallons. Starting on August 25th, 2009, a dye test was completed to independently assess the volume in the reactor.

Roughly eight ounces of rhodamineWT dye was added to the bioreactor on August 25 2009, and water was re-circulated in the bioreactor at a rate of two litres per second. After equilibrium conditions were reached in six days, a final dye concentration of 0.25 ppm dye was measured. The volume of the bioreactor was determined by the following formula:

Volume of reactor = mass of dye added ÷ concentration measured

Using this formula, the volume of the bioreactor was calculated to be approximately 909 m³, or approximately 240,000 gallons, which is consistent with the estimated volume based on the dimensions of the bioreactor and the estimated porosity of the rock.

Understanding the volume of the bioreactor is necessary to understand the potential hydraulic residence time for water passing through the reactor. At 0.5 lps, assuming the total porosity of the bioreactor is utilized, approximately 21 days of residence time is available, and at 1.0 lps, approximately 10.5 days of residence time is available. A 2 lps flow rate should result in a residence time of approximately 5.25 days.

The dye test was run under re-circulating conditions at a relatively fast rate (2 l/s). By definition, when the peak concentration of dye is measured in the effluent, 50% of the dye has passed through the reactor. The time for the peak dye to exit the bioreactor at 2 lps recirculation was determined to be approximately 1.03 days into the bioreactor operation. This much faster flow rate indicates breakthrough of the dye along flow paths that “short circuit” i.e., do not interact with the entire porosity of the bioreactor. Figure 9 shows conceptualization of flow in the bioreactor.

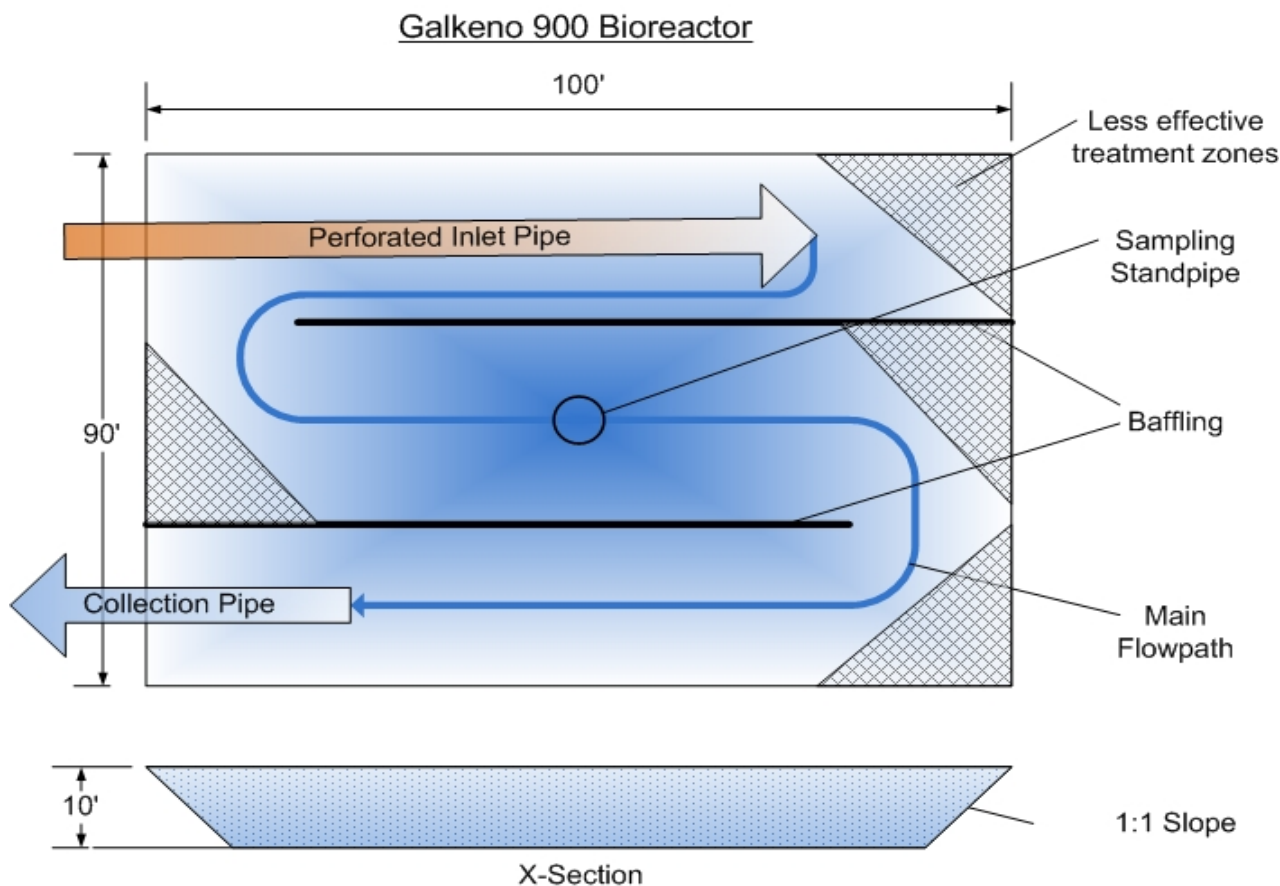


FIGURE 9 - CONCEPTUALIZATION OF FLOW PATHS IN THE BIOREACTOR

The “less effective treatment zones” are where water entering the bioreactor does not interact as much with the media and hence these zones are likely to only minimally contribute to the treatment performance. The activity in these areas is dependent on the availability of carbon sources diffusing from the actively flowing areas to support sulphate reduction. The practical residence time in the bioreactor can be estimated as two times the breakthrough time of the dye peak. This residence time corresponds to the volume of the reactor that participates in rapid exchange of influent water to the bioreactor discharge (this will be termed the “effective residence time”). (Note, in most porous media, there is a tailing phenomenon, where dye concentrations do not behave “normally” in a bell shape curve, but the second half of the curve “tails”, i.e., there is a slow bleed out of dye from slower flowing zones in the reactor which increases the time required for the washout of the dye. For the design of bioreactors these less effective zones cannot be relied upon for treatment and hence the 2X dye peak is used for design purposes.)

Flow rate	Residence time (total porosity)	Residence time (active porosity)
0.5 lps	21.0 days	9.00
1.0 lps	10.5 days	4.50
2.0 lps	5.25 days	2.25

TABLE 1 - RESIDENCE TIME WITHIN THE BIOREACTOR PER FLOW RATE

6. BIOREACTOR PERFORMANCE

The performance of the bioreactor with respect to water chemistry is summarized in the following tables, graphs, and discussion. To better understand the treatment goals, Table 2 provides the Galkeno 900 effluent quality standards per the Conditions of Water Licence QZ06-074. In order to release water from any adit in the KHSD that is currently under the Care and Maintenance of ERDC, the water discharge must meet these standards. It is important to note that some sites such as Keno 700 do not need to meet discharge standards in order to attain aquatic standards in the receiving environment (Lightning Creek). Targeting a mass reduction goal of 90% may be more relevant for some sites of this nature.

Parameter	Maximum Concentration in a Grab Sample Measured in mg/L
pH	6.5 - 9.5 pH units
Suspended Solids	25.0 mg/L
Arsenic (total)	0.50 mg/L
Cadmium (total)	0.05 mg/L
Copper (total)	0.30 mg/L
Lead (total)	0.20 mg/L
Nickel (total)	0.50 mg/L
Silver	0.10 mg/L
Zinc (total)	0.50 mg/L

TABLE 2 – EFFLUENT QUALITY STANDARDS PER WATER LICENCE

6.1. GENERAL PARAMETERS

The pH of the reactor did not substantially change through the operational period, with the inflow and outflow from the reactor in the same range as the pH of the adit drainage. Figure 10 illustrates the pH of the influent and effluent from the reactor.

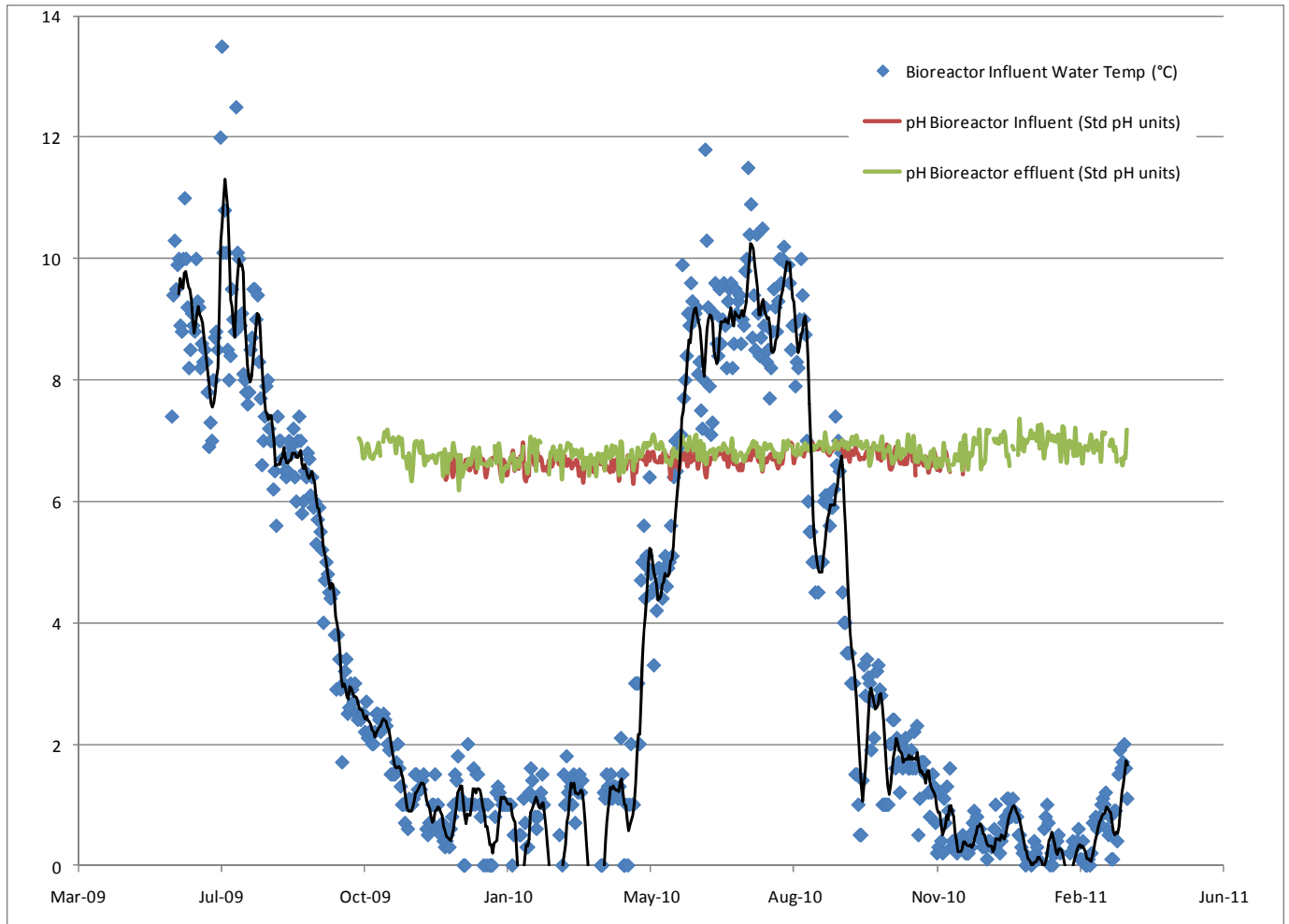


FIGURE 10 - COMPARISON OF GALKENO 900 ADIT PH AND BIOREACTOR PH VS. TEMP

In addition to pH, Figure 10 also displays water temperatures of the bioreactor influent water recorded during operation. Notice how the influent water temperature decreases to less than 2°C from October through April each year. This emphasizes how important it is to keep water moving through both the bioreactor and the piping systems at all times to avoid freezing.

6.2. DISSOLVED METALS

The primary metal that exceeds discharge criteria at the Galkeno 900 adit is zinc, which is true of most of the adit discharge locations in the KHSD. There are other metals that potentially contribute to the toxicity of water and this and other discharge locations, and hence the water chemistry of all dissolved metals present in the Galkeno 900 water has been evaluated.

To better understand the performance of the bioreactor during operation, several graphs have been generated that plot each constituent of concern. These graphs display the results of samples taken at the adit, midway through the bioreactor, and at the discharge from the bioreactor. Within each graph, a blue and green transparent box was added to signify flow rates during operation. Within the blue box, the average flow rate through the bioreactor was 0.5 lps. Within the green box, the flow rate was increased to 1.0 lps or subsequently 0.75 lps.

6.2.1. Zinc

The concentrations of zinc in the bioreactor were approximately 90% reduced during the recirculation phase where only minor additions of water (approximately one litre per minute) was being added to the reactor. During the onset of more strongly reducing conditions in the summer of 2009, dissolved zinc concentrations were decreased to below detection limits (0.01 mg/L). After this removal was confirmed for several consecutive sampling periods, the bioreactor treatment phase was initiated at 0.5 lps in October 2009. Figure 11 illustrates the removal efficiency of the bioreactor during both treatment periods, including the 0.5 lps flow rate (blue rectangle), and the 1.0 lps flow rate (green rectangle). During the 0.5 lps time period approximately three pore volumes were exchanged (calculated on a total porosity basis) and when calculated on a reactive volume estimated by 2X the dye peak, nearly eight pore volumes would have been exchanged during this period. This shows that the treatment cannot be attributed to dilution by previously treated water.

During the 1.0 lps treatment phase, approximately six pore volumes (calculated on a total porosity basis) passed through the bioreactor prior to the loss of power and pump failure that led to the bioreactor being back-siphoned out. The loss of complete treatment that occurred after the refilling of the bioreactor is attributed to the refilling of the bioreactor with approximately half of the volume of the reactor in February 2010. However, even with this refilling, the bioreactor still removed over 95% of the zinc in the sample taken immediately after refilling. (Note: data from the period after refilling the bioreactor indicates that the removal efficiency dropped to closer to 60-80% in the period immediately after the bioreactor siphoned out and was refilled, indicating that the pipe freeze-up and refilling of the reactor has temporary negative effects for a period of a few weeks after an upset.)

The conclusions that can be reached from the bioreactor's operation, before the pump failure, are that dissolved zinc can be effectively removed at 0.5 lps flow rate with an effective residence time of nine days, or a total residence of 21 days, and the first two months of operation at 1.0 lps also effectively removed dissolved zinc. However, there was a difference between dissolved zinc removal and total zinc removal within the bioreactor at the faster flow rate. Table 3 outlines the difference between dissolved and total zinc removal during the different operational phases.

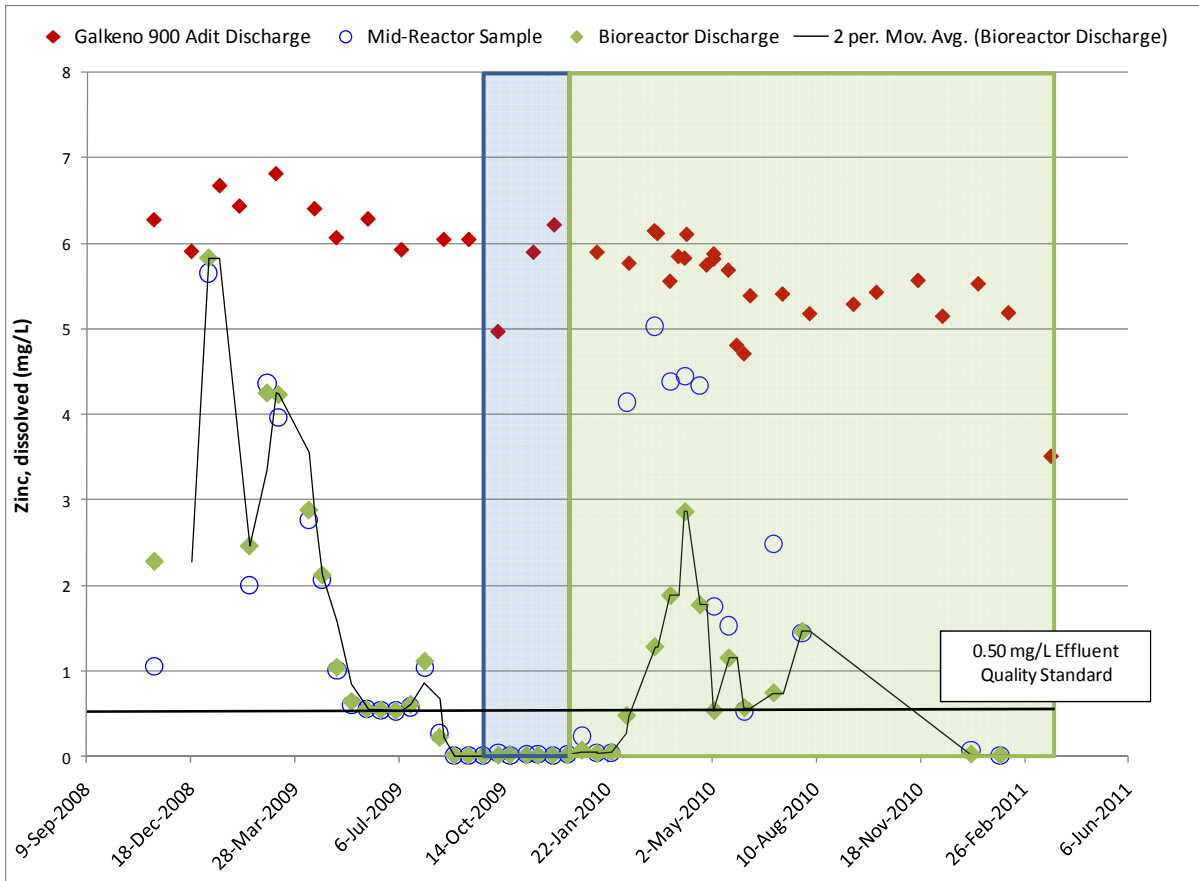


FIGURE 11 – Zinc removal by the Galkeno 900 Bioreactor

	Average total zinc concentration (mg/L)	Average dissolved zinc concentration (mg/L)	% total zinc that is dissolved
Recirculation phase	0.64	0.65	100%
Reduction onset phase	0.32	0.27	86%
0.5 lps treatment phase	0.28	0.012	4%
1.0 lps treatment phase	0.74	0.13	17%
0.75 lps treatment phase	0.29	0.018	6%

TABLE 3 – TOTAL VS. DISSOLVED ZINC PER OPERATION PHASE

The difference between total and dissolved zinc is that total zinc can be filtered out, i.e., it is the particulate zinc in the bioreactor samples that has been reduced from the soluble phase and become a solid zinc phase. Because of the coarseness of the bioreactor rock (see Figure 5) the media does not act as a very good filter. This is consistent with what was observed at a bioreactor in Montana (Gammons and Frandsen, 2001), where fine ZnS particulates passed as colloids through the reactor but could be filtered out with a 0.45 μ m filter. As discussed later, design of

future bioreactors would include finer grained rock than coarse oversize placer rock to encourage some filtration. In addition, freshly formed sulphides are very fine particulates. In rapidly flowing systems, small or colloidal particles can remain suspended and exit the bioreactor without being agglomerated into larger particles that would drop out via gravity or by being caught in bioreactor media pore throats. Dissolved zinc averaged below the discharge treatment objective of 0.5 mg/L during both the 0.5 and 1.0 lps treatment regimes. However, the treatment objective was not achieved for total zinc for the higher flow rate (1.0 lps) regime (0.74 mg/L) except for the final two data points collected in January and February 2011. This indicates that additional residence time may be required in the bioreactor to filter the particulate materials, or a subsequent filtration treatment step could be taken in the discharge if the higher flow rate were to be used. An example of natural filtration is a wetlands or bog system, or infiltration into an underground porous aquifer. Active semi-passive or passive filtration systems such as sand filters, multimedia filters, or sedimentation ponds are other alternatives that could improve filtration.

6.2.2. Antimony

Antimony concentrations declined approximately 80% during the test (0.0025 mg/L reduced to below the detection limit (0.0005 mg/L) for most of the phases of the test (See Figure 12). Antimony removal in an organic carbon-rich reducing system is typically attributed to an antimony sulphide phase, or by sorption to iron or manganese oxides, carbonates, or sulphides that are stable in reducing conditions.

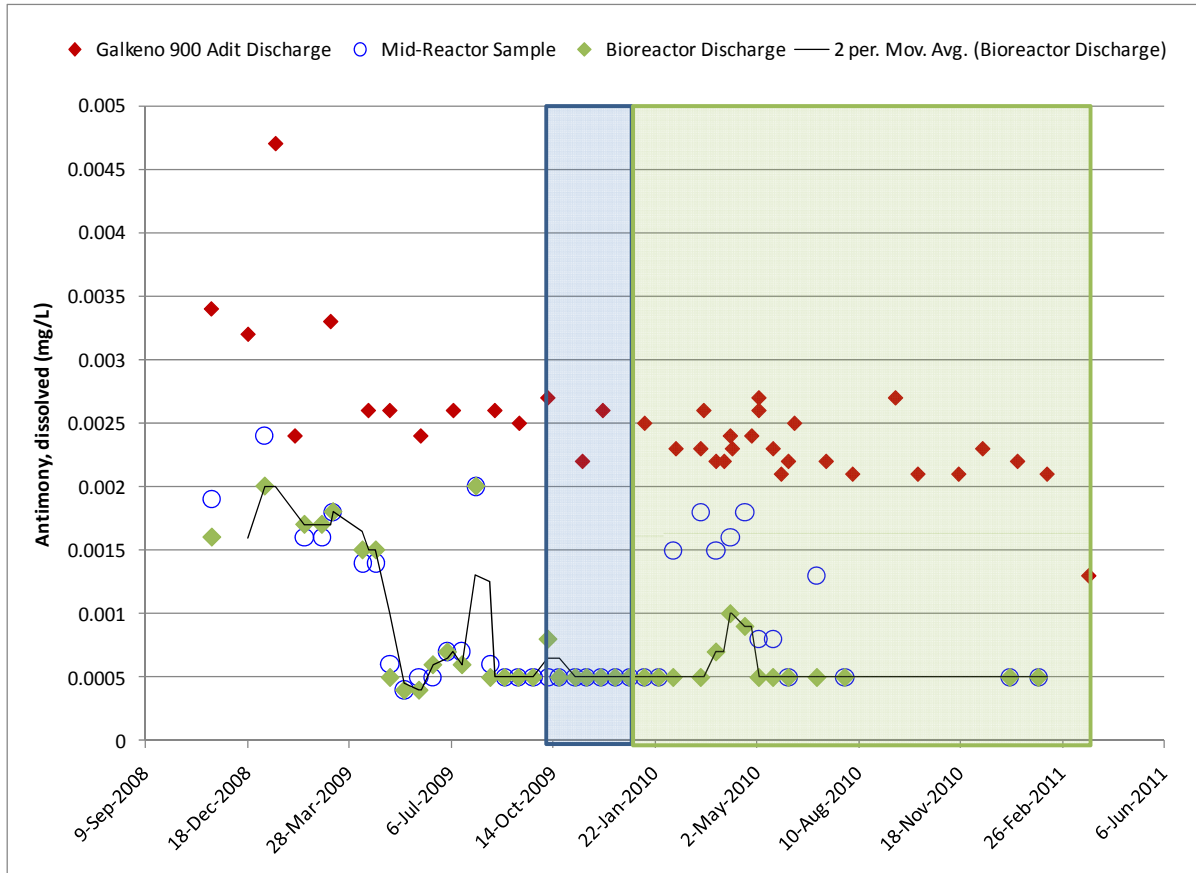


FIGURE 12 – Antimony Removal by the Galkeno 900 Bioreactor

6.2.3. Arsenic

Arsenic concentrations declined approximately 97% (0.068 mg/L reduced to 0.0015 mg/L average of last two months) during the recirculation phase (See Figure 13). Arsenic concentrations increased during the reduction onset phase, indicating a temporary dissolution of arsenic-bearing mineral phases during this transition period. During both treatment phases, arsenic removal increased again as sulphate reducing conditions were established. During the treatment phases, arsenic removal averaged 58% for the 0.5 lps period, and 80% during the 1.0 lps. The performance during the 0.5 lps period was likely affected by the residual washout of dissolved arsenic released during the reduction onset period, so a long term average removal would more likely be similar to the 1.0 lps performance.

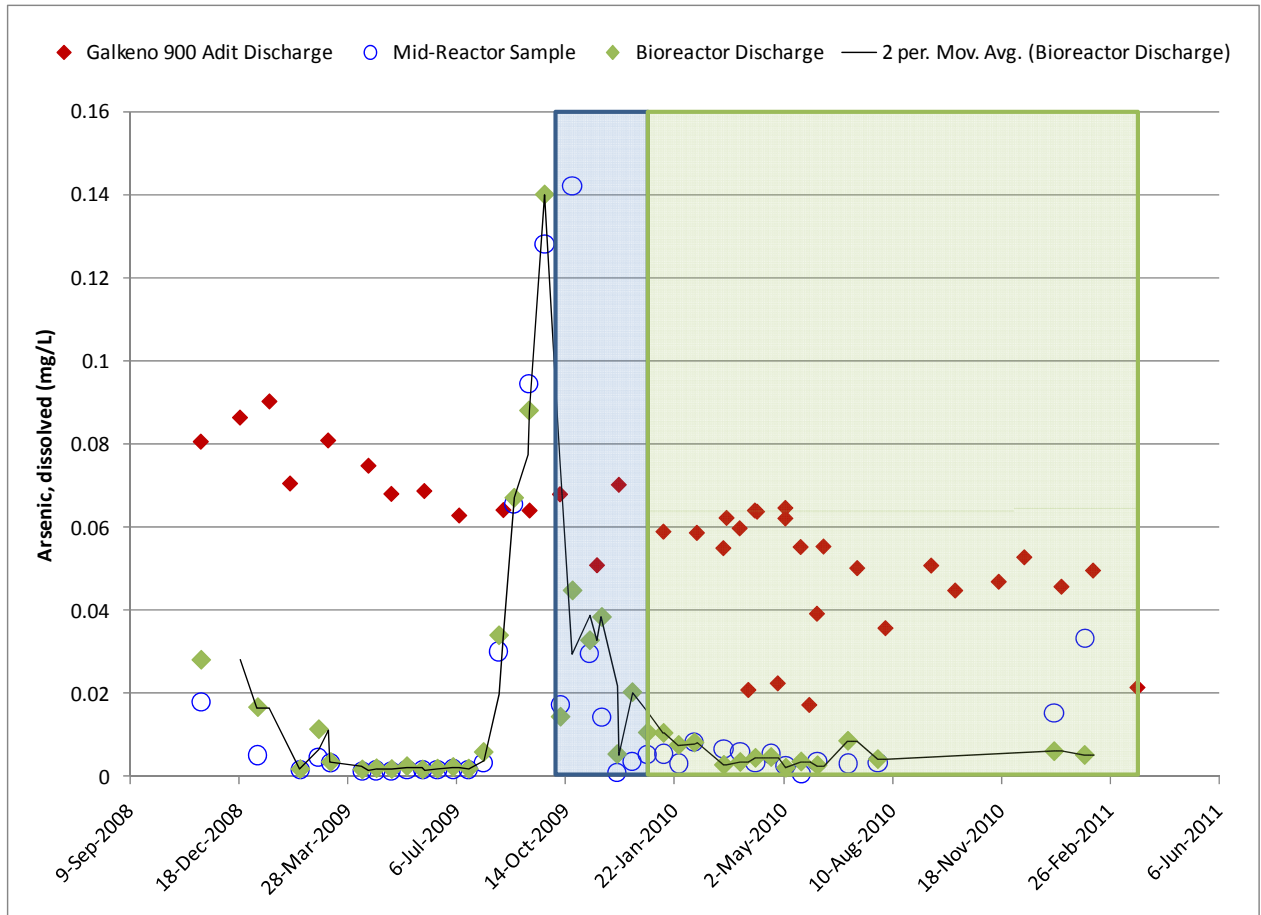


FIGURE 13 – ARSENIC REMOVAL BY THE GALKENO 900 BIOREACTOR

6.2.4. Cadmium

Cadmium concentrations declined approximately 60% (0.0015 mg/L reduced to 0.0005 mg/L average of last two months) during the recirculation phase (See Figure 14). After the beginning of the reduction onset phase, cadmium has been removed to below the detection limit and has remained at those levels during all the recirculation phases.

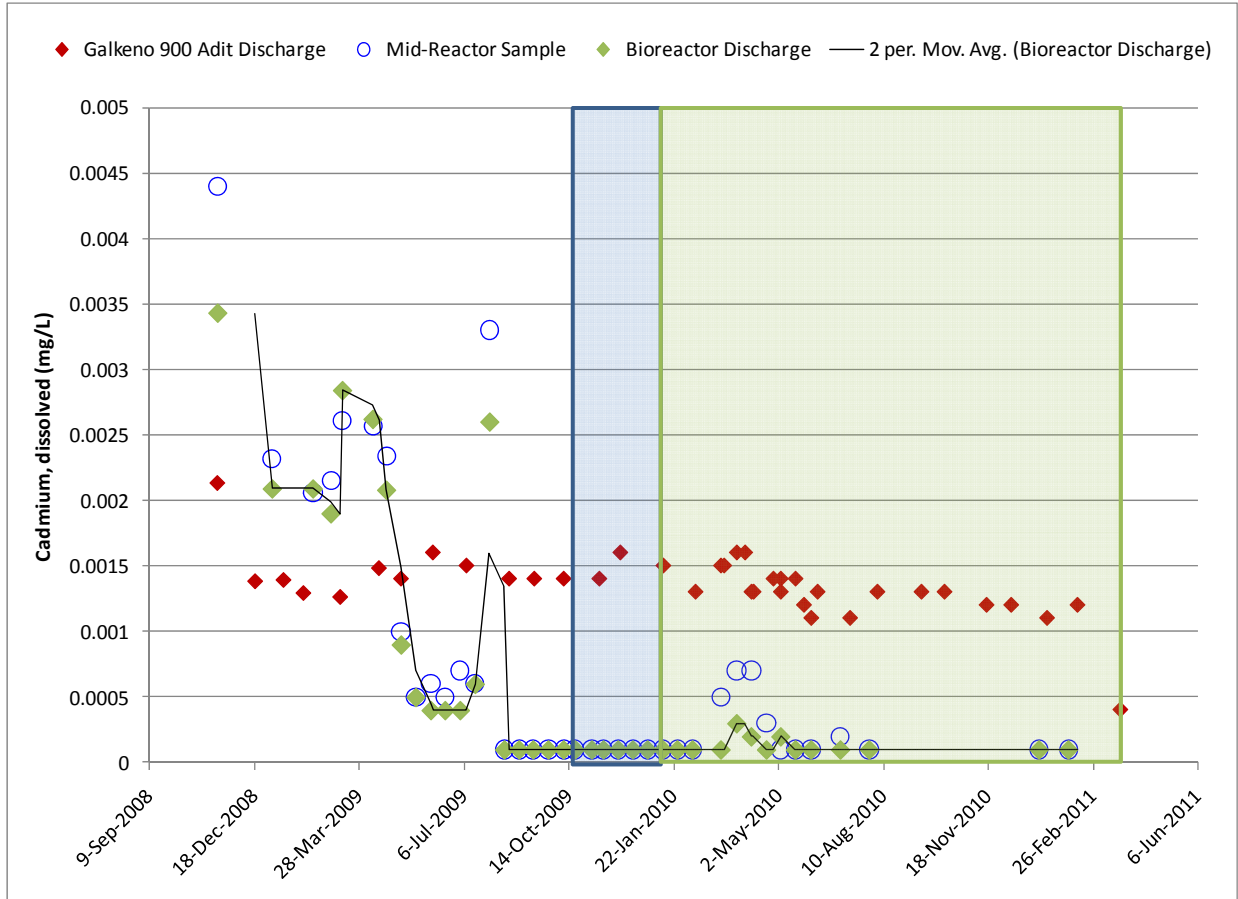


FIGURE 14 – Cadmium removal by the Galkeno 900 Bioreactor

6.2.5. Iron

Iron concentrations declined approximately 97% reduction (1.75 mg/L reduced to 0.032 mg/L average of last two months) during the recirculation phase (See Figure 15). During this phase, iron appears to have been removed primarily by precipitation as an oxide. During the reduction onset phase, iron dissolved from the reactor and has been released at a rate higher than the amount entering the reactor through the recent operations.

Iron removal in the bioreactor provided sorption and co-precipitation phases for other trace metals removal during the recirculation phase. Some of the iron was likely also removed as sulphides in their initial amorphous precipitate form (operationally called Acid Volatile Sulphides or AVS). The rate of formation of this phase may be limited by the residence time provided in the bioreactor. An operational objective could include operating the reactor to create AVS.

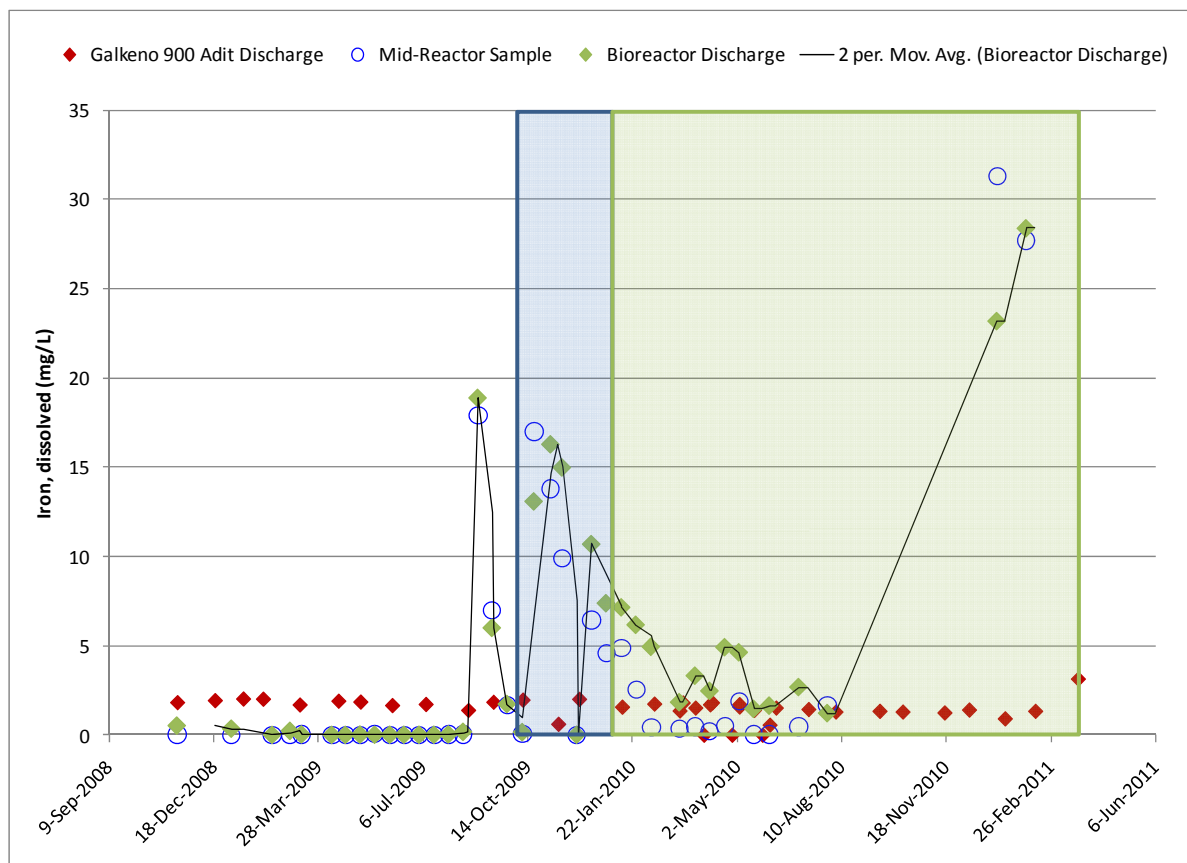


FIGURE 15 – Iron removal by the Galkeno 900 Bioreactor

6.2.6. Manganese

Manganese concentrations declined approximately 98% (18 mg/L reduced to 0.25 mg/L) during the recirculation phase (See Figure 16). During the reduction onset phase, some manganese was released from the bioreactor, indicating that some of the manganese removal in the recirculation phase was as a manganese oxide. In through flow treatment phases the manganese concentrations entering the bioreactor and exiting the bioreactor were nearly the same, indicating manganese is

not being removed from the reaction in the bioreactor under the more strongly reducing conditions and at the hydraulic residence times provided under the current flow regime.

Similar to iron, manganese removal in the bioreactor has important effects for other metals. Manganese carbonates and oxides that may have formed during the initial bioreactor operation phase have good sorption capacity for trace metals. Manganese precipitates may play a significant role in the removal of metals in the bioreactor.

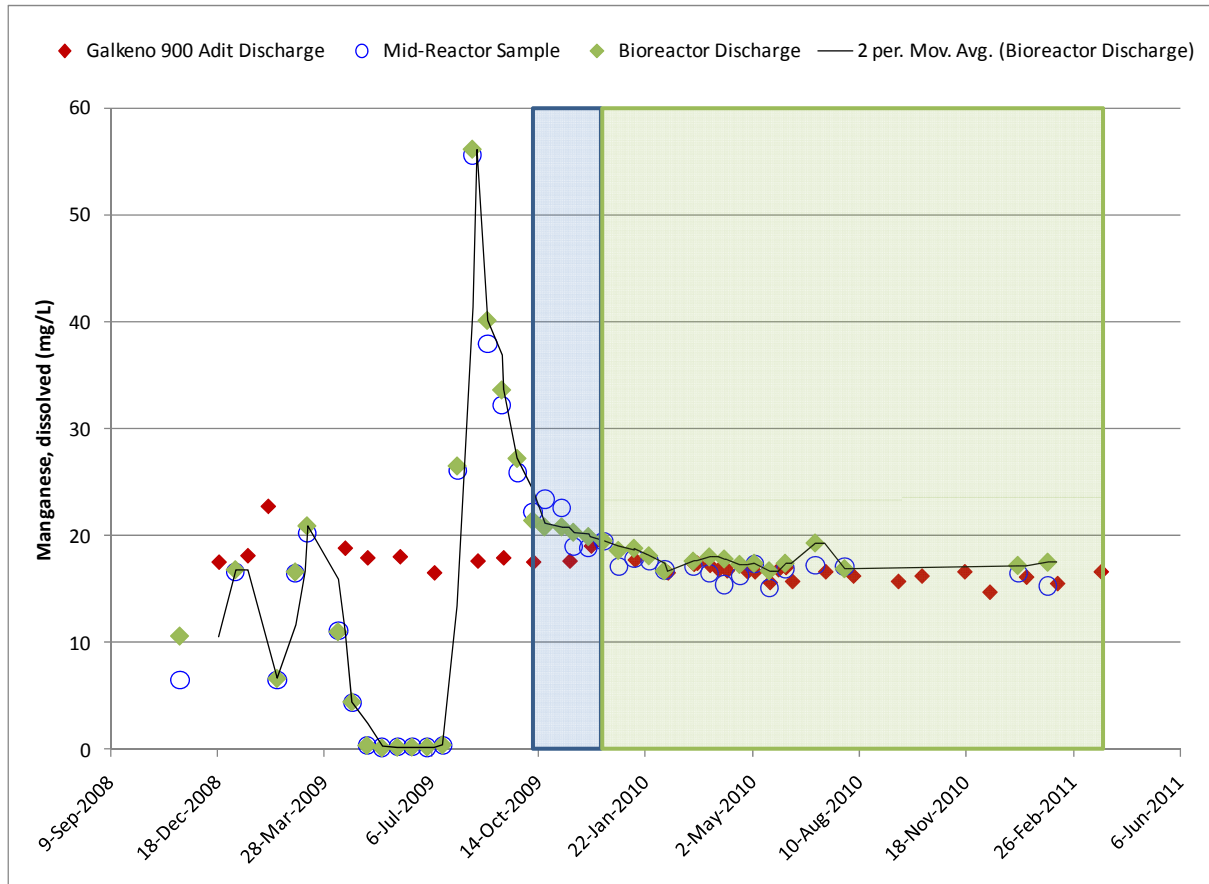


FIGURE 16 – Manganese removal by the Galkeno 900 Bioreactor

6.2.7. Nickel

Nickel concentrations declined approximately 80% (0.2 mg/L reduced to 0.04 mg/L average of last two months) during the recirculation phase (See Figure 17). During the reduction onset, a portion of the nickel was returned to solution, but during the slower flow periods, the nickel concentrations decreased to detection limits. Nickel removal during the 0.5 lps was 97.5%, but declined during the 1.0 lps flow rate. The treatment capacity of the reactor appears to be more sensitive for nickel than some other metals, as the mid-reactor sample increased during the switch to the higher flow rate. If nickel removal were an objective, operation of the bioreactor at a slower flow rate appears to be beneficial. However, the transition back to 0.75 lps improved the nickel removal.

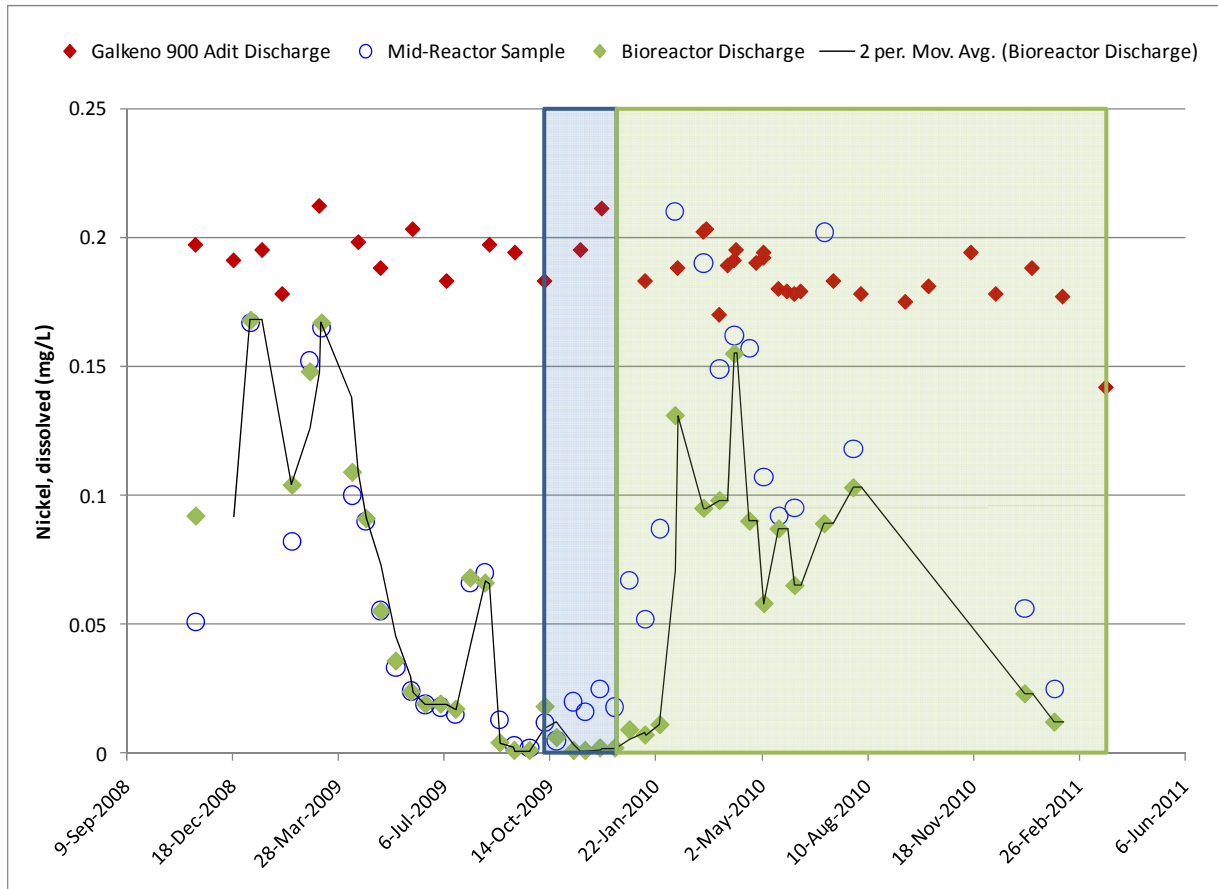


FIGURE 17 – Nickel removal by the Galkeno 900 Bioreactor

7. BIOREACTOR ENGINEERING DISCUSSION

Evaluation of the metals removal obtained in the bioreactor and determination of the SRR that can be achieved in the wintertime at the 0.5 and 1.0 lps flow rates enables an evaluation of the potential scaling factor for the size of the bioreactor that could treat the entire flow from the Galkeno 900 adit. Design improvements would focus on increasing contact with all of the bioreactor, and decreasing ‘dead zones’. Experience at other sites has shown an elongated rather than square bioreactor has better contact parameters and fewer dead zones. In rough parameters, the flow from the Galkeno 900 adit is approximately 4 lps and remains consistent throughout the year and with the improvements and balancing the appropriate conservatism in design an approximate scale factor of four times the volume of bioreactor media would be used to design and cost a bioreactor for a full scale at Galkeno 900.

The minimum goal of 0.5 mg/L zinc was consistently achievable during normal operation of the bioreactor as long as the system remained in operation without interruptions. As shown in the data, a pump failure and/or pipe freezing can have a detrimental effect on the water quality results. This experience has shown the improvements to the design must focus on ensuring flow at all times, not dependent on power availability, and further improvements to insulation could also be achieved.

The removal of other metals was also consistently achieved with the exception of a short period when reduction onset occurred, when some metals were released with the reductive dissolution of iron and manganese.

7.1. GENERAL BIOREACTOR DESIGN IMPROVEMENTS

The following is an assessment of the Galkeno 900 design components that worked well and design components that did not work well. This information will provide the basis of design and inform the construction of future bioreactors within the district.

The following components worked well and should be repeated in future designs:

- 1.) **Torturous Path** - Creating a torturous path within the bioreactor using liner for baffling was needed with the Galkeno 900 design to minimize short-circuiting and increase residence time. However, the use of baffling created zones that did not provide effective treatment and these zones should be minimized or eliminated in future designs if possible. One way to do this is to create a bioreactor that is laid out as a long, gently sloping trench sections. Finding land where trenches could be constructed near adits in the Keno Hill area may be difficult in some areas.
- 2.) **Bioreactor Dead Zones** - As discussed earlier, approximately 60% of the media appears to be actively participating in treating the water as it passes through the bioreactor. The remaining volume is for practical purposes considered as dead zones. These dead zones can be minimized by creating longer and narrower flow paths. This design improvement should be considered for future bioreactors.
- 3.) **Flowing Water** - Water must be kept flowing - This is critical during the winter months in the Keno Hills district. Mine drainage and groundwater is above freezing, and the water temperature must be maintained while passing through the bioreactor. As long as the pump was working and water was continuously flowing through the bioreactor, freezing was avoided. Every freezing failure of the bioreactor was caused by power failures which lead to cessation of pumping and a loss of the heat capacity of the adit influent water. In future bioreactor designs, allowing adit water to flow via gravity through a bioreactor will eliminate the potential for pump failure and maintain flow through the bioreactor. The exact design for each bioreactor will be carefully considered to minimize power usage and prevent the potential for power interruptions to cause treatment failures.
- 4.) **Back-up Treatment System** – During this study, the discharge from the Galkeno 900 bioreactor was co-mingled with the untreated raw water from the adit. This combined water was then treated with a lime slurry and allowed to decant from a settling pond. It is possible to have a mobile system to treat water while the bioreactor until the discharged water meets the applicable standards or performance objectives. Once the bioreactor can demonstrate effective treatment with discharged water meeting standards, the treatment system could be removed or placed on stand-by.

The following components were sources of problems and should be eliminated or redesigned for future bioreactors in the district:

- 1.) **Fill Material** - The fill material used in the Galkeno 900 bioreactor was too coarse. As seen in Figure 5, the material was a mixture of larger, broken rocks mixed with smaller pebbles and sand. By using a consistent fill material that is a smaller, crushed rock

(between 3/8" to 2" diameters) additional surface areas will be available for bio-growth and will help avoid short circuiting.

- 2.) **Metering Pump** - If the metering pump that provided a carbon source to the bioreactor stopped working, there was at best a limited stored carbon source available within the media. For future bioreactor designs, a limited amount of solid phase carbon source such as coarse sawdust or wood chips, and/or peat should be mixed with the media to provide a secondary source of carbon to sustain the bioreactor if the soluble/primary carbon source is interrupted.
- 3.) **Pumps and Heat Trace** - As mentioned earlier, power failures were not planned for in the existing design. Inclusion of heat trace lines and backup power to pumps could have avoided the problems experienced in the Galkeno 900 bioreactor. In most cases, the location of the bioreactors could be placed in a downgradient location where power would only be required for the addition of a soluble carbon source. The carbon source could be designed to not require power by using an educator system where flow from the adit would draw in the carbon substrate by a venturi force. If utilized for backup power, a generator would be a very minimal size. The design would also consider placing the valves and controls inside the adit to minimize freezing.

Neither iron nor manganese were removed by the reactor during through flow operational phase. The natural attenuation studies in the district shows that these are readily removed in a very short distance by turbulent flow creating a natural oxidation system. This could be designed as a cascading discharge or could be performed in a natural setting such as an existing stream.

8. DISCUSSION AND CONCLUSIONS

When continuous flow was maintained to the bioreactor at acceptable flow rates, effective treatment was maintained. At higher flow rates the transformation of metals from their dissolved forms to an insoluble form was accomplished, but the filtration efficiency of the coarse rock in the bioreactor did not filter the insoluble precipitates effectively. Full scale application of the sulphate reduction bioreactor technology appears feasible if slight design modifications are made to ensure gravity flow from the adit, avoidance of siphoning due to freezing, and improved sizing of the bioreactor media.

Evaluation of longer term bioreactor studies have been conducted at the Leviathan mine since 1997 by the US EPA. The US EPA SITE program (2006) ranked the bioreactor technology for metals treatment at the Leviathan mine using the criteria shown below. The Discussion of the Galkeno 900 bioreactor in terms of how it performed is presented relative to the same evaluation criteria.

- *For Overall Protection of Human Health and the Environment*, it was determined that the sulphate reducing bioreactor was effective for reducing metals concentration, and produced non-toxic and stable precipitates. A similar conclusion can be reached for the Galkeno 900 bioreactor; confirmation of stable non-toxic precipitates is underway in additional mineralogical studies, but with lower influent metals concentration in the Galkeno 900 bioreactor it is reasonable to believe similar results will be determined.
- *For Compliance with Applicable or Relevant and Appropriate Requirements (ARAR)*, it was determined that the bioreactor generally produced compliant discharge, and with minor adjustments compliance was improved further. Similar conclusions can be stated

for the Galkeno 900 bioreactor.

- *For Long Term Effectiveness and Performance*, it was determined that the bioreactor consistently met the applicable standards over many years, and suggested that with additional engineering a more passive (wind and/or solar powered) system appeared to be feasible. The strength of this conclusion for Galkeno 900 reactor is weakened primarily due to power and freezing issues, but these issues can be engineered in future applications to be less significant and thereby increase the long term effectiveness and performance.
- *For Reduction in Toxicity, Mobility, or Volume through Treatment*, it was determined that the bioreactor concentrated the metals in a stable form. Similar conclusions can be reached for the Galkeno 900 bioreactor: on average over 90% of the metals were removed from solution and filtered out of the bioreactor during operational times.
- *For Short Term Effectiveness*, it was determined that the bioreactor effluent was protective of human health, and that the chemicals required for bioreactor operation could be handled safely with the appropriate engineering controls. Conclusions for the Galkeno 900 bioreactor are that it had short term effectiveness when operating at lower flow rates, and consequently that by appropriate sizing and cold weather engineering a bioreactor can have high short term effectiveness in the KHSD.
- *For Implementability*, it was determined that the technology is simple, could be operated with limited operator involvement, and that it was stable over a long time. For the Galkeno 900 bioreactor, the technology is very simple and required little operator involvement, and if pumping and siphoning the bioreactor could be avoided through gravity feed, the Galkeno 900 bioreactor process has a high implementability ranking.
- *For Cost*, it was determined that it cost approximately \$15 per 1000 gallons to operate the Leviathan bioreactor. By way of comparison, the Galkeno 900 bioreactor costs are in the range of \$5 per 1000 gallons. The main difference is the lower level of reagent requirements due to lower metals concentration and neutral pH at the Galkeno 900 bioreactor.
- *For Community Acceptance*, it was determined that the operation of the bioreactor presented minimal risk to the community, with diesel generation and transportation of chemicals to the bioreactor being the main risks. With the lower chemical usage required for a bioreactor in the neutral drainages in the KHSD, and the availability of line power the Community Acceptance criteria should be even better in the KHSD.
- *For State Acceptance*, it was noted that California has allowed it to be the only water treatment technology used year-round at the Leviathan Mine site. The Galkeno 900 bioreactor is currently approved for pilot scale trials on the Keno Closure program and was approved as part of the environmental assessment of the Bellekeno Mine.

It is recommended that the Galkeno 900 bioreactor cease operation after the metals stability study is complete, and that a subsequent study utilizing a buried trench design without pumping be considered for a next phase of testing.

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ALEXCO KENO HILL MINING CORP.

Bellekeno Mine

Decommissioning and Reclamation Plan

November 2011

**Appendix B Bellekeno Mine Monitoring and Surveillance
Plan**



ALEXCO

MONITORING AND SURVEILLANCE PLAN REVISION 1

QML-0009

September 2011

BELLEKENO PROJECT



ACCESS
CONSULTING GROUP

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Appendix B: Physical Inspections and Reporting Plan, Water Licence QZ09-092
Appendix C: Environmental Conditions Report, Section 2.1
Appendix D: Memorandum: Keno District Mill Preliminary Dustfall Monitoring Results
Appendix E: VDI 2119 Part 2: Determination of Dust Precipitation with Collecting Pots Made of Glass (Bergerhoff Method) or Plastic
Appendix F: Bellekeno Mine Cycle 1 Environmental Effects Monitoring Study Design
Appendix G: Bellekeno Adaptive Management Plan

1.0 INTRODUCTION

This plan describes the environmental monitoring programs that will be carried out to ensure that the Bellekeno mine/mill development operations are conducted in a manner that provides human and environmental protection. These programs are designed to monitor:

- Potential effects to the receiving environment through scheduled physical and environmental monitoring programs and inspection tours of the project components and receiving environment;
- Effluent discharge points and consequently operational treatment performance;
- Site facilities and incorporated design measures to ensure structural stability and prevent accidents and malfunctions;
- Mitigation success; and
- Adaptive management responses to improve procedure/process.

If monitoring indicates that physical structures, treatment systems or other mitigative measures are not performing, then maintenance measures or contingency plans can be implemented following an adaptive management approach as discussed in Section 12.

Prior to Bellekeno mine development, a number of monitoring programs and a surveillance network were already in place for care and maintenance activities and for advanced exploration and preliminary development activities at the Keno Hill Property. These programs include physical inspections, effluent treatment systems and flow monitoring, a water quality surveillance network, old mine workings monitoring, aquatic effects monitoring for benthic invertebrate populations, sediment monitoring, waste rock and mine wall sampling and/or the adaptive management plan. Monitoring and surveillance networks specific to the Bellekeno Undertaking are presented in this plan. Monitoring stations near the mill and mine areas are discussed within the following sections.

2.0 WATER QUALITY SURVEILLANCE NETWORK

The existing water quality surveillance network for the Bellekeno Project includes surface receiving waters in the Bellekeno and Christal Lake area. Most of the monitoring stations have been sampled extensively in the past. Current water quality monitoring is required in these areas under Water Licence QZ06-074 Water Licence QZ07-078, and Water Licence QZ09-092.

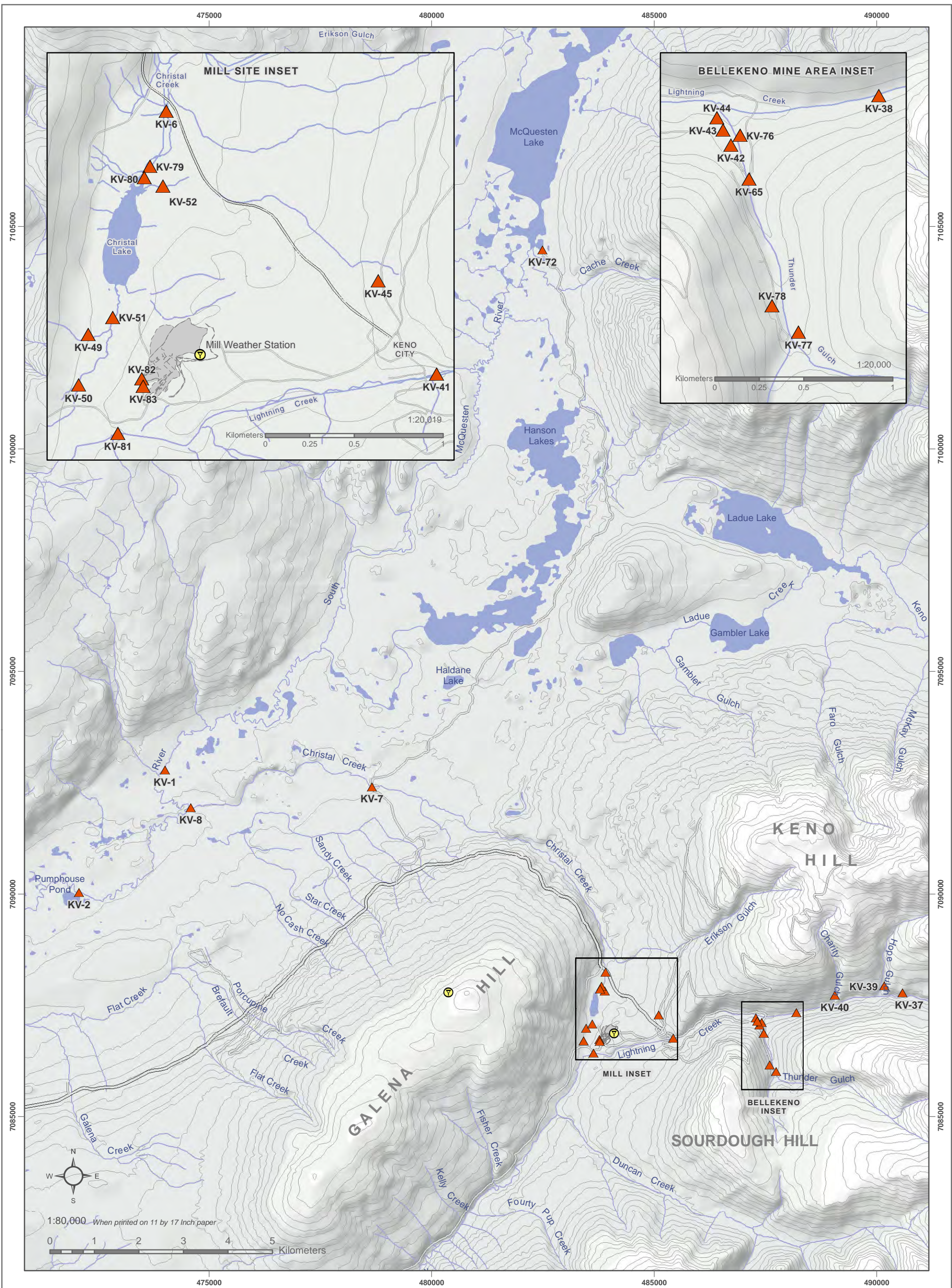
Table 1 outlines existing sampling frequency and schedule for internal and external lab analysis in the area of the Bellekeno Mine and in the vicinity of the Mill Site. Figure 1 shows the existing monitoring station locations. Treatment sites are monitored monthly,

daily, or daily while discharging. Surveillance sites are sampled weekly, monthly, monthly (seasonally) and quarterly as required by QZ09-092. This includes the following sites upstream of Christal Creek and upstream of Lightning Creek:

- KV-6 – Christal Creek at the Keno Highway to monitor downstream of the old Mackeno Mill and tailings location;
- KV-7 – Christal Creek at Hanson Road to monitor effects from the old Mackeno Mill;
- KV-41 - Lightning Creek at Keno City Road Crossing to monitor impacts from adit drainages and waste rock seepage reporting to this creek;
- KV-43 – Bellekeno 625 Treatment pond decant to monitor the impacts from the mine edited to be ongoing weekly sampling;
- KV-78 – Bellekeno Waste Rock Storage Facility;
- KV-52 or KV-80 – Potential mill water sources;
- KV-81 – Mill discharge (final discharge point) to monitor the mill impacts; and
- KV-2, KV-8, KV-38, KV-39 KV-40, KV-42, KV-44, KV-45, KV-49, KV-50, KV-51, KV-65, KV-72, KV-75, KV-76, KV-77 and KV-79 (refer to Table 1 for complete station descriptions) are additional upstream and downstream monitoring locations in Lightning and Christal Creek drainages.

SITE	SITE DESCRIPTION	WATER LICENCE			MMER		PARAMETERS																			EEM PROGRAM ¹											
		Q206-074	Q207-078	Q209-092	Effluent Monitoring Conditions	Effluent Characterization	Inspect	Level	Flow	pH	Temp.	Cond.	Total Zn	Ammonia	Turbidity	Total Metals	Dissolved Metals	Mercury	Ammonia-N	Nitrite	Nitrate	Total Phosphorous (colourimetric)	Sulphate	DOC	Hardness	Alkalinity	pH	Conductivity	TSS	Radium 226	Acute Lethality LC 50	Daphnia Magna	Sediment	Benthic	Sub-Lethal Toxicity		
Bellekeno Treatment Sites																																					
KV-42	Bellekeno 625 Adit	✓	✓	✓	✓	✓	D	-	C	D	D	D	D	D	D	W	W	-	W	W	W	W	W	M	W	W	-	W	W	W	-	-	-	-	-	-	-
KV-43	Bellekeno 625 Settling Pond Decant	✓	✓	✓	✓	✓	D	-	C	D	D	D	D	D	D	W	W	Q	W	W	W	W	W	W	W	W	Q	W	W	W	W/Q	M	M	-	-	-	SA ⁴
KV-74 ²	Bellekeno East Decline		✓				D	-	D	D	D	D	D	D	M	M	-	M	-	-	-	-	-	-	M	-	M	M	M	-	-	-	-	-	-	-	
KV-75 ²	Bellekeno East Settling Pond		✓				D	-	D	D	D	D	D	D	M	M	-	M	-	-	-	-	-	-	M	-	M	M	M	-	-	M	-	-	-	-	
KV-82	Flame and Moth Site Collection and Sediment Pond			✓			D	D	M	M	M	M	M	M	M	M	-	M	M	M	M	M	M	M	M	-	M	M	M	M	M	-	-	-	-	-	
KV-83	Flame and Moth Treatment Plant Discharge			✓	✓	✓	D-WD	-	D-WD	D-WD	D-WD	D-WD	D-WD	D-WD	D-WD	W-WD	W-WD	Q-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	Q-WD	W-WD	W-WD	W-WD	W/Q	M-WD	M-WD	-	-	-	SA ⁴
Bellekeno Mine Development Surveillance Sites																																					
KV-1	South McQuesten River u/s Christal Creek	✓		✓			-	-	Q	Q	Q	Q	-	-	-	Q	Q	-	-	-	-	Q	Q	Q	Q	-	Q	Q	Q	Q	-	-	-	-	-	-	-
KV-2	South McQuesten Rive @ Pumphouse	✓		✓			-	-	Q	Q	Q	Q	-	-	-	Q	Q	-	-	-	-	Q	Q	Q	Q	-	Q	Q	Q	Q	-	-	-	-	-	-	-
KV-6	Christal Creek @ Keno Highway	✓		✓			-	-	C	M	M	M	-	-	-	M	M	-	M	M	M	M	M	M	M	-	M	M	M	M	-	-	BA	BA	-	-	-
KV-7	Christal Creek @ Hanson Road	✓		✓			-	-	M	M	M	M	-	-	-	M	M	-	M	M	M	M	M	M	M	-	M	M	M	M	-	-	-	-	-	-	-
KV-8	Christal Creek @ mouth	✓		✓			-	-	Q	Q	Q	Q	-	-	-	M	M	-	-	-	-	M	M	M	M	-	M	M	M	M	-	-	-	-	-	-	-
KV-37 ³	Lightning Creek u/s Hope Gulch	✓	✓	✓			-	-	Q	Q	Q	Q	-	-	-	Q	Q	-	-	-	-	Q	Q	Q	Q	-	Q	Q	Q	Q	-	-	-	-	-	-	-
KV-38	Lightning Creek u/s Thunder Gulch	✓	✓	✓			-	-	Q	Q	Q	Q	-	-	-	Q	Q	-	-	-	-	Q	Q	Q	Q	-	Q	Q	Q	Q	-	-	-	-	-	-	-
KV-39	Hope Gulch u/s Lightning Creek	✓		✓			-	-	Q	Q	Q	Q	-	-	-	Q	Q	-	-	-	-	Q	Q	Q	Q	-	Q	Q	Q	Q	-	-	-	-	-	-	-
KV-40	Charity Gulch u/s Lightning Creek	✓		✓			-	-	Q	Q	Q	Q	-	-	-	Q	Q	-	-	-	-	Q	Q	Q	Q	-	Q	Q	Q	Q	-	-	-	-	-	-	-
KV-41	Lightning Creek u/s Brige @ Keno City	✓	✓	✓			-	-	C	M	M	M	-	-	-	M	M	-	M	M	M	M	M	M	M	-	M	M	M	M	-	-	A	-	-	-	-
KV-44 ²	Bellekeno 625 Seep		✓	✓			-	-	Ms	Ms	Ms	Ms	Ms	-	-	-	Q	-	Q	Q	Q	Q	Q	Q	Q	-	Q	Q	Q	Q	-	Q	-	-	-	-	-
KV-45	Onek Adit	✓	✓	✓			-	-	Q	Q	Q	Q	-	-	-	Q	Q	-	-	-	-	Q	Q	Q	Q	-	Q	Q	Q	Q	-	-	-	-	-	-	-
KV-49 ³	Hinton Creek u/s Christal Creek	✓		✓			-	-	-	-	-	-	-	-	-	Q	Q	-	-	-	-	Q	Q	Q	Q	-	Q	Q	Q	Q	-	-	-	-	-	-	-
KV-50 ³	Christal Creek u/s Hinton Creek	✓		✓			-	-	Q ⁵	Q ⁵	Q ⁵	Q ⁵	-	-	-	Q ⁵	Q ⁵	-	-	-	-	Q ⁵	Q ⁵	Q ⁵	Q ⁵	-	Q ⁵	Q ⁵	Q ⁵	Q ⁵	-	-	-	-	-	-	-
KV-51 ³	Christal Creek d/s Hinton Creek	✓		✓			-	-	Q	Q	Q	Q	-	-	-	Q	Q	-	Q	Q	Q	Q	Q	Q	Q	-	Q	Q	Q	Q	-	-	-	-	-	-	-
KV-52	Natural spring to Christal Lake @ Old Mackeno Pumphouse	✓		✓			-	-	M	M	M	M	-	-	-	M	M	-	-	-	-	M	M	M	M	-	M	M	M	M	-	-	-	-	-	-	-
KV-65	Thunder Gulch u/s of Bellekeno 625	✓	✓	✓			-	-	Q	Q	Q	Q	-	-	-	M	M	-	-	-	-	M	M	M	M	-	M	M	M	M	-	-	-	-	-	-	-
KV-72	South McQuesten River @ McQuesten Lake			✓			-	-	Q	Q	Q	Q	-	-	-	Q	Q	-	-	-	-	Q	Q	Q	Q	-	Q	Q	Q	Q	-	-	-	-	-	-	-
KV-76	Thunder Gulch d/s Bellekeno 625		✓	✓			-	-	-	Q	Q	Q	Q	-	-	-	Q	Q	-	-	-	Q	Q	Q	Q	-	Q	Q	Q	Q	-	M	-	-	-	-	-
KV-77	Thunder Gulch u/s Bellekeno East		✓	✓			-	-	Q	Q	Q	Q	-	-	-	Q	Q	-	-	-	-	Q	Q	Q	Q	-	Q	Q	Q	Q	-	-	-	-	-	-	-
KV-78	Bellekeno East Temporary Waste Rock Storage Facility			✓			-	Ms	-	Ms	Ms	Ms	-	-	-	Q	Q	-	-	-	-	Q	Q	Q	Q	-	Q	Q	Q	Q	-	-	-	-	-	-	-
KV-79	Christal Creek d/s MacKeno Tailings			✓			-	-	-	Q	Q	Q	-	-	-	Q	Q	-	-	-	-	Q	Q	Q	Q	-	Q	Q	Q	Q	-	-	-	-	-	-	-
KV-80	Christal Creek u/s Mackeno Tailings			✓			-	-	-	Q	Q	Q	-	-	-	Q	Q	-	-	-	-	Q	Q	Q	Q	-	Q	Q	Q	Q	-	-	-	-	-	-	-
KV-81	Lightning Creek Southwest of Mill Site			✓			-	-	Q	Q	Q	Q	-	-	-	Q	Q	-	-	-	-	Q	Q	Q	Q	-	Q	Q	Q	Q	-	-	-	-	-	-	-

- Program design currently underway
 - Station is frequently dry or not expected to produce water
 - Background station
 - Monitoring to occur semi-annually during the first three years of the study program, with the first sample collected 6 months following the start of operations, and once each year after the third year
 - Monitoring to occur monthly for the first year of operations, resuming this schedule after 12 months
- C = Continuous
 D = Daily
 D-WD = Daily While Discharging
 W = Weekly
 W-WD = Weekly While Discharging
 W/Q = Weekly migrating to quarterly to accord with monitoring frequency pursuant to MMR regulations
 M = Monthly
 Ms = Monthly (May - Oct)
 Q = Quarterly
 A = Annually
 SA = Semi Annually (twice per year)
 BA = Bi Annually (every 2 years)



- ▲ Water Quality Stations
- Weather Station
- Highway
- Local Road
- Flame and Moth Mill Site

**BELLEKENO PROJECT
QML-0009
SURFACE WATER QUALITY MONITORING**

**FIGURE 1
MONITORING AND SURVEILLANCE PLAN**

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Datum: NAD 83; Projection: UTM Zone 8N

DRAWN BY: JL JULY 2011 VERIFIED BY: EA

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Currently at Bellekeno 625, treated water (KV-43) is monitored daily through internal analysis for pH, flow, total zinc, ammonia and turbidity with monthly samples sent to an external lab. Similar monitoring is conducted for the Bellekeno East portal, with treated water (KV-75) sampled and analyzed at the same frequencies if it is discharged. The mine and mill discharge will be monitored through stations KV-43 and KV-81, respectively.

3.0 GROUNDWATER SURVEILLANCE NETWORK

A groundwater monitoring plan for the Bellekeno mine has been developed under Water Licence QZ09-092. This program outlines monitoring locations and frequency for the Keno District mill and dry stack tailings facility, the non-AML waste rock disposal area, and Keno City. The groundwater monitoring plan includes sites stipulated in Schedule B to QZ09-092, and is attached as Appendix A.

Groundwater wells are scheduled for monthly monitoring for both water level and quality for the first year after QZ09-092 came into effect to establish well conditions, followed by quarterly sampling thereafter, for the duration of the project.

4.0 PERMAFROST MONITORING

Geotechnical programs have identified areas of permafrost within operational areas of the project. Specifically, some permafrost was encountered beneath the proposed non-AML Waste Rock Storage Area (WRSA) and in the vicinity of the proposed Dry Stack Tailings Facility (DSTF). Ground temperature and permafrost monitoring is currently in place at these locations. Details on monitoring for the DSTF will be included in the DSTF OMS manual, which forms a part of the DSTF Development and Operations Plan. Details on permafrost monitoring for the WRSA are included in the Mine Development and operations Plan.

5.0 PHYSICAL INSPECTION PLAN

The purpose of the physical inspection is to observe and record sufficient information related to physical and water retaining structures to permit development of a course of action, repair or rehabilitation if it is required. Physical inspections are currently inspected under the Physical Inspections and Reporting Plan prepared for Water Licence QZ09-092. The Physical Inspections and Reporting Plan is attached as Appendix B. The Physical Inspections and Reporting Plan describes weekly and monthly physical inspections of infrastructure associated with the Bellekeno mine/mill development and operation. Information is collected through use of weekly and monthly checklists and reporting forms. Photo documentation at photo hubs is undertaken on a monthly basis in order to aid in identifying temporal changes and as a record keeping tool.

In the vicinity of the Bellekeno mine, physical inspections include the Bellekeno 625 settling ponds, the Bellekeno East temporary Waste Rock Storage Facility, the non-AML Waste Rock Disposal Area, and the haul road and Lightning Creek Bridge along the Keno City Bypass road.

In the vicinity of the mill, physical inspections include the water supply and discharge pipelines and infrastructure, the mill site water collection and diversion structures, the mill site collection and sedimentation pond, and the dry stack tailings facility.

6.0 WEATHER MONITORING

6.1 Climate Overview

This section presents an overview of basic variables which affect the water balance at each of the three points of water use and discharge in this project. Data from two historical Environment Canada Atmospheric Environment Service weather stations in the Keno Hill area (Elsa townsite from 1948-1965, and 1974-1989; and Keno Hill from 1974-1982) were used to predict climatic parameters for the three site locations within the Bellekeno Mine and Mill development project.

The most important variables are average precipitation and average evaporation. These two parameters were considered the key parameters in developing the water balance for the Keno Hill area as a whole, see Section 2.1 of the Environmental Conditions Report (attached as Appendix C).

6.1.1 Precipitation and Evaporation

Two climatic variables were assessed to develop an overall water balance for the Keno Hill Silver District. The two variables are average precipitation and average evaporation. These two variables were considered the key parameters in developing the water balance for the site.

Data from various climate stations were used to characterize the climate of the Keno Hill Property. A discussion of this data including mean annual precipitation and rates of evaporation is provided in Section 2.1 of the Environmental Conditions Report (see Appendix C). This data was used to derive site hydrological conditions at the time; however based on comparisons with the latest site data, the original techniques and hydrological inputs were deemed appropriate in deriving site hydrological conditions (Clearwater Consultants Ltd, 2008; see Environmental Conditions Report). This climate data is therefore still considered valid and accurate.

Mean annual precipitation (MAP) has been shown within the Keno Hill Silver District to increase with increasing elevation. The significant relief over which the Keno Hill area spans is well represented by the two historical weather stations with Elsa at 814 m and the Keno Hill weather station at 1472 m. This spread facilitated derivation of the relationship between elevation and precipitation for the site. In combination with site evapotranspiration, calculations have been used to predict annual precipitation, evapotranspiration, and net precipitation for the Bellekeno Mine and Keno District Mill (see Table 2 below). The close proximity and similar elevation allow Elsa to be a proxy for the Flat Creek Camp.

Table 2 Precipitation and Evapotranspiration at Select Keno Hill District Locations

Site	Mean Annual Precipitation (mm)	Mean Annual Evapotranspiration (mm)	Annual Net Precipitation (mm)	Data Source
Keno Hill (1472 m Elevation)	585	205	380	AES Climate Station, UKHM Site Characterization Report, 1996
Elsa Townsite (814 m Elevation)	420	230	190	AES Climate Station, UKHM Site Characterization Report, 1996
Bellekeno Mine (1050 m Elevation)	479	221	258	Calculated based on site elevation-precipitation relationship
Keno District mill site (901m Elevation)	443	227	215	Calculated based on site elevation-precipitation relationship

These precipitation and evapotranspiration estimates have been compared to recent work done by Clearwater Consultants Ltd. (CCL, 2008) on behalf of Alexco to update the 1996 study on Hydrology for the Keno Hill Silver district (CCL, 2008). CCL found that using the latest site flow data, hydrologic inputs for their new site-wide water balance could be estimated using the original techniques presented in the 1996 Hydrology Study, provided the influences of adit flows on local hydrology were accounted for. A direct comparison between the annual net precipitation for the Keno District Site (209 mm) with the 2004-2007 MAR of the Christal Creek catchment area based on KV-7 flow data (221 mm) shows close agreement. Comparison between the estimated Bellekeno Mine Site annual net precipitation and MAR from the Lightning Creek catchment area above KV-41 shows a considerable difference (258 mm vs. 344 mm, respectively). This can be explained in the fact that the Bellekeno Mine site is quite low within the Lightning Creek catchment, and therefore receives below average precipitation for the catchment area.

6.2 Climate Monitoring Stations

As part of closure planning studies, a meteorological station was established on Galena Hill in summer 2007 by Alexco. The station measures air temperature, relative humidity, barometric pressure, rainfall, wind speed and direction, solar radiation, and soil temperature. As a condition of Type A water use licence QZ09-092, a second metrological station and snow course have been established at the Keno District mill site. The location of the mill site weather station is shown on Figure 2. A Yukon Government monitored snow

course station also exists in the area. These data will be used to update meteorological/hydrological information and water balances for the project area throughout operations and to better inform closure planning. This will include calculations of minimum and maximum for both wet and dry years.

7.0 NOISE IMPACTS AND SOUND MONITORING

Noise Impacts and sound monitoring are discussed in the Noise Abatement Plan submitted under QML-0009.

8.0 DUST ABATEMENT AND MONITORING

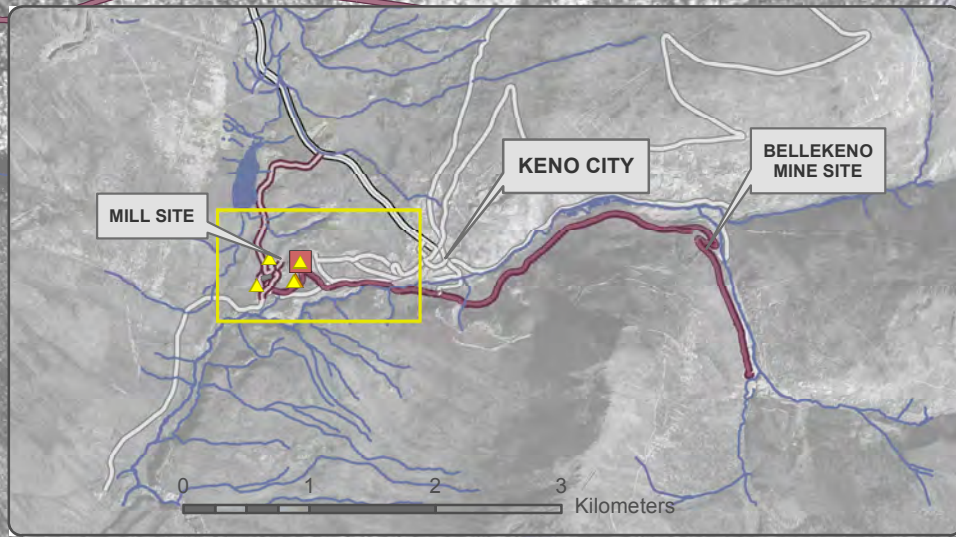
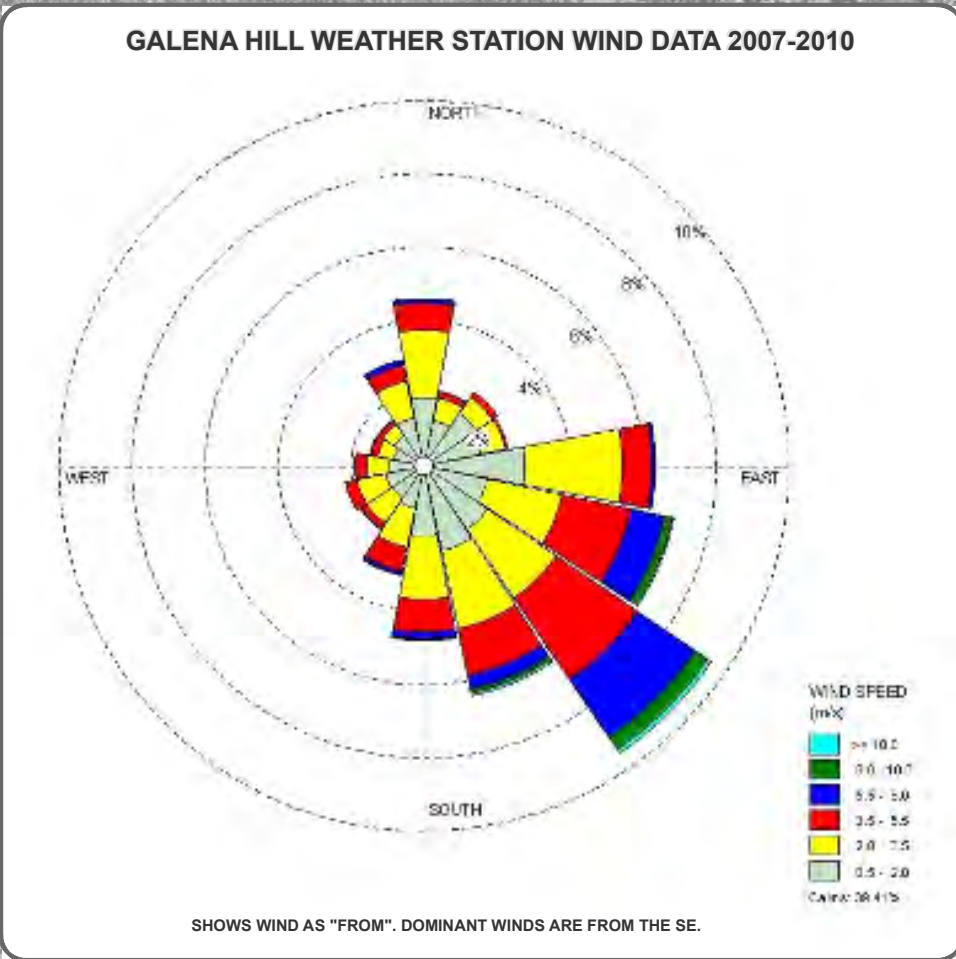
In accordance with Clause 69 of the Decision Document for the assessment for the Bellekeno Mine Project (YESAB File Number 2009-0030), dustfall monitoring was installed at two initial locations near the Keno District mill site. Bergerhoff dust monitoring gauges were selected as the appropriate instrumentation to carry out this program. The Bergerhoff deposit dust gauge is designed to measure dust deposition, which can be reported as a weight per unit area over unit time.

This section outlines the approach for dustfall monitoring for the Bellekeno Production Unit and surrounding areas.

Mill site layout and infrastructure and locations of Bergerhoff dust monitoring gauges currently in place at two locations at the edge of the mill site are shown on Figure 2.

8.1 Dust Modeling Synopsis

A dust modeling exercise using ISC3 modeling software using both simulated and real weather data from the Galena Hill weather station was undertaken by Alexco for the DSTF. The Gaussian plume model is used by this program. The results of the wind analysis predicted that any dust generated by the DSTF would rarely be transported towards Keno City. Results of the dust modeling using worst-case-scenario inputs predicted a maximum of 60 µg/m³ in Keno City, which is well below the BC objective of 150 µg/m³. The accuracy of the Gaussian model is noted to be within 20% for ground level emissions at distances less than 1 km. At distances greater than 1 km, the equation is estimated to be accurate within a factor of 2 (Reed, 2005). The dust modeling report formed Part III of the Dry Stack Tailings Facility Construction and Operation Plan and was submitted September 2010.



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

Main Map: 1:4,000 Inset Map: 1:60,000
(when printed on 11 x17 inch paper)

- ▲ Dust Monitor Station
- Weather Station
- Mill Access Road
- Haul Road
- Local Road



MONITORING AND SURVEILLANCE PLAN QML - 0009

**FIGURE 2
DUST MONITORING STATIONS**

DRAWN BY MD SEPTEMBER 2011 VERIFIED BY EA

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(Last edited by: jpan; 9/13/2011/14:39 PM)

Figure 3 Bergerhoff Deposit Dust Gauge

8.2 Potential Mill Site Dust Sources and Mitigative Measures

The single largest potential source of dust from a mining operation is considered to be windblown dust from tailings facilities. This has been a feature of slurry tailings deposits in past mining operations, where desiccated ‘beaches’ of tailings form above water line in large, valley fill tailings impoundments. The system proposed for the Bellekeno mill, however, is completely different from valley-fill slurry tailings deposits of the past. The Dry Stack technology results in a filtered, moist tailings deposit that is placed and compacted in lifts to achieve certain design compaction levels. Also, with the added feature of progressive construction and progressive reclamation, only a fraction of the total DSTF footprint will be exposed at any one time. As far as possible, each year’s dry stack after construction is covered with an evapotranspirative cover and revegetated.

Therefore, not only is the footprint minimized, but damp and compacted tails will not be subject to wind erosion. Should desiccation be observed in summer months, the Operation, Maintenance and Surveillance Manual for the Day Stack Tailings Facility submitted in September 2010 dictates procedures to be undertaken to maintain moist conditions prior to covering. These include rewetting with spray bars or trucked water.

A second potential source of dust at the mill site is from the ore crushers, conveyance equipment and fine ore and concentrate stockpiles. First quarter operations of the mill site have revealed that dust can be produced by the crushing operation during extremely cold weather (below -30 C) when most of the available moisture in the ore is frozen. Significant production of dust from crushing is generally not observed at warmer temperatures. Dust from crushing operations at cold temperatures will be controlled by installation of dust screens or temporary dust suppression structures around the crushing equipment. The fine ore stockpile is covered with a sprung structure, and no significant dusting from this pile has been observed. The ore loadout areas are sheltered within loadout bays in the mill building, and the ore loading area is covered by a sprung structure which is attached to the mill building. These structures will be effective in minimizing dust from the ore loadout area.

A third potential source of dust is from mill site traffic. This will be of primary concern in any prevailing dry periods during the summer. Traffic related dusting will be controlled on the mill site area roads by application of water as necessary and/or use of non-petroleum dust suppressants (e.g. Calcium Chloride). Under no circumstances will waste oil or other hydrocarbon product be used for dust suppression. Verification that dust control measures are effective is provided by the dust monitoring.

8.3 Seasonality of Sources

As discussed above, potential dust sources at the mill site have been identified as the Dry Stack Tailings Facility (DSTF), the tailings and concentrate loadout areas, the fine ore stockpile, the primary and secondary crushers, and fugitive dust from mill site area roads. Based on the dust modeling conducted and submitted as part of the DSTF Construction and Operation Plan and preliminary data collected to date, these potential dust sources are expected to be more likely to produce dust at different times of the year. Dust from crushing activity is most likely during periods of cold weather during the winter months, when natural water in ore is too frozen to provide natural dust suppression. Dust from other sources (DSTF, loadout areas, stockpiles, and roads) is considered more likely to be produced during the summer months during periods of dry weather.

8.4 Dust Monitoring

During the YESAA assessment, the issue of dust was highlighted by assessors and reflected in the YG Decision Document issued July 10, 2009. Clause 64 and clause 65 of the Decision Document call for dust monitoring to be conducted during operations as follows:

64. Monitoring dust conditions is an important step in controlling dust impacts. Simple TSP (dustfall) monitoring is a simple and inexpensive way to determine dust deposition at the sampling locations. This test can be done at the site by the proponent with little cost or training necessary.
65. If warranted by initial dustfall measurements indicating TSP concentrations in excess of 150 micrograms per cubic metre (the BC Air Quality Objectives and

Standards Level A criteria) at the fence line, the proponent shall conduct more sophisticated monitoring with high volume samplers and re-evaluate and improve dust suppression techniques to achieve the TSP objective.

It should be noted that TSP (total suspended particulate) monitoring is not the same as dustfall monitoring, which is a passive measurement of dust accumulation over time per unit area. The Decision Document suggests the use of BC Air Quality Objectives and Standards Level A criteria of $150 \mu\text{g}/\text{m}^3$ as a threshold for triggering phase two of the monitoring program. However, dustfall measurements (as suggested in the decision document for phase 1) will yield deposition rates (in $\text{mg}/\text{dm}^2/\text{mo}$) and will not be comparable to BC Air Quality Objectives and Standards.

Alexco believes that the intent of these clauses were to instate a two phase monitoring program in which dustfall monitoring is undertaken as the first phase, with a specified trigger upon which more sophisticated TSP monitoring would be deployed.

The Pollution Control Objectives for the Mining, Smelting and Related Industries of BC (1979), provide reasonable limits for dustfall (Phase 1) at the edge of the mill site. These parameters, which range from 1.7 to 2.9 $\text{mg}/(\text{dm}^2 \cdot \text{d})$, will be used as a trigger for phase two (TSP monitoring). If deposition rates measured at the edge of the mill site either exceed 1.7 $\text{mg}/\text{dm}^2 \cdot \text{d}$, Phase 2 of the monitoring plan will be undertaken.

8.5 Phase 1: Dustfall Monitoring

Two Bergerhoff gauges have been commissioned near the mill site. One gauge (DM-1) was installed in January, 2011 to the east of the DSTF between the mill site and Keno City. A second Bergerhoff gauge (DM-2) has been installed to the west of the mill facility and crushing facility and is located between the mill site and upper Christal Creek. The location for dust monitoring stations is shown on Figure 4.

In a meeting held between Alexco and representatives from YG Environment and YG Environmental Health, additional Bergerhoff gauges were recommended by YG Environment. Two additional dust monitoring gauges were installed by Alexco near the mill site in August, 2011. All dust monitoring locations are shown on Figure 2.

The dust monitoring station locations were selected based on results of Galena Hill Wind analysis, and the location of the most sensitive receiver (Keno City). Distance from potential dust sources was selected to be consistent with Clause 70 of the Decision Document, which states that TSP standards should be met at “the fence line”. Although there will not be a fence around the perimeter of the project, the locations are consistent with the approximate edge of the extent of the project area. DM-1 may need to be relocated slightly to the east as it lies within the final footprint of the dry stack tailings facility. However, this portion of the dry stack will be constructed as the final part of the pile construction and will not occur for several years.

8.6 Phase 1 Sampling Initial Results

Initial results of dust sampling between were taken at DM1 and DM2 for the time intervals March 6, 2011 until April 3, 2011, and between April 3, 2011 and May 10, 2011 are attached in an interpretive memo (Appendix D).

8.7 Phase 2: TSP Monitoring

Dust monitoring may be triggered to require more rigorous sampling at the site. Should the monitoring plan move into Phase 2, TSP dust monitoring equipment will be put in place, together with more rigorous dust suppression measures. Sampling equipment will consist of either a continuous duty, constant flow air monitoring system or a discrete sampler. It is anticipated that this type of equipment will require power at the site and will measure ambient concentrations (in $\mu\text{g}/\text{m}^3$). The objectives recommended during the assessment to which results from a continuous sampler were to be compared were the BC Air Quality Objectives and Standards Level A criteria of $150 \mu\text{g}/\text{m}^3$ averaged over 24 hours, or $60 \mu\text{g}/\text{m}^3$ for the annual geometric mean. Alexco is aware that Environment Yukon has recently set Ambient Air Quality Standards under the Environment Act. These standards for TSP are set at $120 \mu\text{g}/\text{m}^3$ for a 24-hour average, and $60 \mu\text{g}/\text{m}^3$ as an annual geometric mean. Should dust monitoring proceed to TSP monitoring, Alexco will compare its results to the Ambient Air Quality Standards under the Environment Act.

Should phase 2 be initiated, a single instrument will be installed at the primary receptor point (DM1 on Figure 1), and the Phase 1 instruments (Bergerhoff gauges) will be decommissioned), Once Phase 2 is initiated, the focus will be on ensuring that air quality (TSP) are maintained at or below the Ambient Air Quality Standards under the Yukon Environment Act through more rigorous and/or additional dust suppression measures.

8.7.1 Phase 2 Monitoring Schedule

Should a discrete sampler be used, the averaging period will correspond to the interval between filter changes, and with monthly filter changes, data will be comparable to annual objective. Filters will be sent to a certified laboratory for analysis.

8.8 Method of Analysis

Samples taken during Phase 1 testing will be subjected to the following procedure upon receipt by the laboratory:

Based on the outcome of the first round of dust monitoring (as described in Appendix D) the laboratory has been instructed to run dust samples for only TSS, and to keep the solids from the Total Solids and if enough sample is available (at least 1 gram) to proceed with an ICP metals analysis.

Dust will be recovered monthly from the filters and collection bottles and the rate of dust deposition will be calculated. Details on dust recovery techniques can be found in the

standard protocol developed for the Bergerhoff dust gauges (German Standard VDI 2119) which is provided as Appendix E.

8.9 Future Monitoring

Based on the results of the first round of dust monitoring under Phase 1 of the plan described herein, the following recommendations have been adopted for further dust monitoring:

- Continuation of the Phase 1 (dustfall) monitoring program as there were no exceedences of the trigger of 1.7 mg/(dm²*d) for the second phase (TSP) monitoring.
- Two additional monitoring Bergerhoff dust monitoring stations (shown as DM-3 and DM-4 on Figure 2) will be installed along the northwest and southeast margins of the mill site. These additional stations will provide additional confidence that windblown dust resulting from any predominant wind direction is adequately sampled.
- Only TSS will be measured for future dust samples by the laboratory, because of its more sensitive RDL.
- A sampling period length of approximately 1 month will be carried out during the spring and summer months as other potential dust sources are exposed.
- A longer sampling period (e.g. 60 days) during winter/spring months will be carried out in order to attempt to collect a greater (measurable) sample weight which will provide a greater margin above RDLs.
- Implementation of more sophisticated field sampling procedures (including the periodic addition of deionized water to sampling jars) will be implemented during the summer months in order to prevent potentially drying out of the sample jars, which could cause loss of sample. In winter, more frequent emptying of the sampling jars (in which subsamples would be held by Alexco and combined prior to sending to the lab) may be required as necessary in order to prevent overflowing of sample jars with snow, which could prevent proper sample collection.
- Continuation of pre-emptive and reactive dust control procedures as outlined in the DSTF Construction and Operation Plan, Traffic Management Plan, and Monitoring and Surveillance Plan is recommended to help ensure that fugitive dusting does not become an issue.

9.0 WASTE ROCK MONITORING

All waste rock management facilities are subject to monitoring for physical and geochemical stability (acid rock drainage or metal leaching). A complete Waste Rock Management Plan was attached to the Construction Site Plan Revision 1 as Appendix B and includes detailed descriptions of waste rock monitoring and mine wall testing.

10.0 ENVIRONMENTAL EFFECTS MONITORING (UNDER MMER)

The MMER, governed under the Fisheries Act, was annexed on June 6, 2002 and amended on October 2006. The Bellekeno mining operation is subject to these regulations, as effluent discharge exceeds 50 m³ /day, which authorizes the deposit of a deleterious substance (allow the deposit of an effluent) from the mining and milling operation according to the following categories and conditions (MMER 2002, Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring, June 2002):

10.1 Final Discharge Points

Bellekeno mine and mill operation will have two discharge sites into two different receiving waters (mine operation effluent discharges to Lightning Creek (KV-43); milling operation at the Keno District mill will discharge into Christal Creek and/or Christal Lake (KV-83).

The final monitoring location for KV-83 will require a year-round accessible site where an accurate flow measuring device, according to Environment Canada specifications, can be constructed (Guidance Documents for the Sampling and Analysis of Metal Mining Effluents, Environment Canada, April 2001). This will also serve as the location where effluent sampling and monitoring will occur.

10.2 Effluent Monitoring

Monitoring at the above sites for discharge and water quality is required on a weekly basis and will be triggered at each respective location when mine and or mill construction commenced. Acute lethal toxicity tests are required monthly. In addition to criteria specified in the Type A water license, effluent must meet the following criteria (MMER 2004, Metal Mining Effluent Regulations, subsections 34(2), 36(5) and 38(9) of the *Fisheries Act*):

The concentration of the deleterious substance in the effluent does not exceed authorized limits as shown in Table 3:

Table 3 MMER Standards

Deleterious Substance	Maximum Authorized Monthly Mean Concentration	Maximum Authorized Concentration in a Composite Sample	Maximum Authorized in a Grab Sample	Units
Arsenic	0.50	0.75	1.00	mg/l
Copper	0.30	0.45	0.60	mg/l
Cyanide	1.00	1.50	2.00	mg/l
Lead	0.20	0.30	0.40	mg/l
Nickel	0.50	0.75	1.00	mg/l
Zinc	0.50	0.75	1.00	mg/l
TSS	15.0	22.50	30.00	mg/l
Radium 226	0.37	0.74	1.11	Bq/l

*All concentrations are total values

The pH of the effluent is equal to or greater than 6.0 but is not greater than 9.5; and

The deleterious substance is not an acutely lethal effluent (trout and daphnia LT50)

10.3 Environmental Effects Monitoring (EEM) Program

An Environmental Effects Monitoring program is currently being developed with Environment Canada under the MMER for the Bellekeno operation. The sampling requirements under this program are as follows:

Part 1. Effluent and Water Quality Monitoring Studies

- a) Effluent Characterization: Quarterly sampling of extra parameters from final discharge point;
- b) Water Quality Monitoring: Quarterly sampling of sites within reference and exposure areas:
 - a. Reference Area: Water frequented by fish that is not exposed to effluent and that has fish habitat that, as far as is practicable is most similar to the exposure area.
 - b. Exposure Area: All fish habitat and waters frequented by fish that are exposed to effluent; and
- c) Sublethal Toxicity Testing: Semi-annual sampling required at each final discharge point and analysis of effects on reproduction or growth of a fish species, a plant species, an invertebrate species and an algal species as acceptable to MMER.

Part 2: Biological Monitoring Studies

A number of study cycles that each include:

- A study design (first study design to be submitted within 12 months of triggering MMER and includes a site characterization);
- Environment Canada and stakeholder review;
- A Field Sampling Program; and
- Submission of an Interpretive Report that indicates whether or not an effect is observed.

Within each cycle, studies are conducted to determine if the effluent is having an effect on the following biological components including:

- a) Fish Population: Studies conducted in exposure and reference areas
- b) Fish Tissue Studies: Only required if concentrations in effluent exceed is equal to or greater than 0.1 ug/l or ppb – as determined by the effluent characterization program)
- c) Benthic Invertebrate Community: Studies conducted in exposure and reference areas.

The first study cycle (Cycle 1) is 30 months in duration, and was submitted in September, 2011. The Bellekeno Mine Cycle 1 Study Design is attached as Appendix F. The subsequent cycles are 24-72 months in duration, depending on previous results (i.e. if an effect is indicated). A final cycle is required if notification of mine closure is issued. In order to avoid redundancy in sampling sites and monitoring programs, final discharge points for MMER will be considered final discharge points under the proposed water licence for the Bellekeno mine/mill development and operations. All requirements and reports and data for the MMER EEM studies will be provided to the Yukon Water Board.

10.4 Christal Lake Characterization Study

To document local environmental conditions in Christal Lake an initial Characterization study will be conducted. This study will fulfill the requirement of Clause 48 of Water Licence QZ09-092, which states:

“The Licensee shall conduct sediment and benthic invertebrate characterization studies in Christal Lake during the first full open water season after the license is issued. The studies shall involve the collection of lake sediments, phytoplankton, zooplankton and water quality. The Licensee shall provide the results of the study and interpretation to the Board by March 31, 2012”

The purpose of this study will be to document limnological characteristics of Christal Lake and will be undertaken during the first year of construction /operation. The program will involve the collection of lake sediments, phytoplankton, zooplankton and water quality using

recognized guidance protocols. The program will be conducted three times during the open water season for phytoplankton only and one time sampling for other parameters. The results of this study will be considered as part of the MMER EEM program and the continuation of the Christal Lake Study will be integrated into the MMER EEM program as required.

11.0 SPILL CONTINGENCY PLAN

A Spill Contingency Plan was developed under the current Water Licence QZ07-078 for the purpose of advanced exploration and preliminary development activities at the Bellekeno Mine and has been modified for active operations. The Spill Contingency Plan outlines that:

“The Licencee shall immediately contact the 24-hour Yukon Spill Report Centre, (867) 667-7244, and implement the Spill Contingency Plan should a spill or an unauthorized discharge occur. A detailed written report on any such event including, but not limited to, dates, quantities, parameters, causes and other relevant details and explanations, shall be submitted to the board not later than 10 days after the occurrence”;

“All personnel shall be trained in procedures to be followed and the equipment to be used in the containment of a spill”; and

“The Spill Contingency Plan shall be posted on site for the term of the Licence”.

For more details, see the Spill Contingency Plan and the Emergency Response Plan submitted for QML--0009. All incident reports including the occurrence of a spill, should it occur, will be forwarded to FNNND.

12.0 ADAPTIVE MANAGEMENT PLAN (AMP)

In accordance with Clause 90 of Water Licence QZ09-092, an Adaptive Management Plan was developed specifically for the Bellekeno Undertaking. This licence was based on the framework established by the District Wide Adaptive Management Plan but was customized for the specific activities and developments of the Bellekeno Undertaking. The Bellekeno Adaptive Management Plan is attached as Appendix G, and a summary is presented below.

12.1 AMP Objectives

An adaptive management plan (AMP) is a management tool designed to guide responses to unforeseen or contingency events respecting for example, water quality and quantity and physical conditions of site workings and infrastructure. The adaptive management approach provides for assessment of mitigation measures and their effectiveness, and guides the orderly implementation of responses.

Because it is difficult to predict the specific environmental condition that may arise which requires a response from management, the AMP does not necessarily provide specific detailed descriptions of responses to a situation. Rather, the AMP provides a range of possible responses to use as a guide to respond to specific environmental conditions encountered.

The AMP framework encompassing active Company management includes:

- routine inspection and environmental monitoring, maintenance and reclamation;
- routine assessment of monitoring and performance data;
- performance thresholds for implementation of appropriate levels of responses for planned contingency measures; and
- reporting of monitoring results and actions.

Results of the current monitoring programs are assessed on an ongoing basis to determine if any negative trends in water quality, quantity or other parameters are occurring. If the results indicate that there are no negative environmental impacts, then the frequency and length of monitoring and maintenance continues as usual. Adaptive management will be implemented to respond to negative trends or impacts (known as “events”) observed through the monitoring programs.

Management uses the information collected by the monitoring programs together with the suggested range of responses within the AMP to determine a suitable response for dealing with a given event.

A number of events have been identified which represent potential environmental conditions that would require a management response, if they were to occur. They include the following:

1. Change in Water Quality or Quantity
2. Non-AML Waste Rock Disposal Area(s) Seepage Exhibits AML
 - a. Waste Rock Disposal Area(s) (including where used for road and general construction) runoff trending to AML conditions
3. Sludge Storage Area Effectiveness Compromised
 - a. Seepage Observed Near Sludge Storage Area
 - b. Sludge Storage Area Approaching Capacity
4. Physical Instabilities
 - a. Area of Significant Subsidence is Observed
 - b. Rock Fall or Landslide Occurs Within a Monitored Area
 - c. Structure Failure or Portal Collapse
5. Site Security Compromised
 - a. Gate, Fence or Sign Damaged
6. Development of high pore pressures underneath the DSTF
7. Development of significant erosion of exposed DSTF surfaces

8. Development of erosion at the Flame and Moth Site discharge area
9. Transport of sediment from the Flame and Moth discharge area into Christal Creek
10. Development of large differential settlements at the DSTF
11. Development of large differential settlements along the conveyance flume from the DSTF to the Flame and Moth Site collection and sediment pond
12. Exceedence of recommended water quality standards in the receiving environment occurring irrespective of compliance with effluent discharge standards
13. Identification of groundwater quality impacts at the Flame and Moth or Bellekeno mill sites; and
14. Identification of water quality impacts to Keno City water wells.

The AMPs for each of these events are described individually in the Bellekeno Adaptive Management Program attached as Appendix F, while Table 4 provides a summary of the approach to AMP events. This table describes a narrative trigger, indicators and response thresholds, monitoring locations and parameters.

12.2 AMP Approach

For each AMP event a methodical approach is provided:

1. Description of the event and possible environmental consequences - Addresses issues or information that trigger the AMP;
2. Location of possible event occurrence – Identifies specific working site locations if applicable to event;
3. Monitoring requirements – Identifies the parameters to be monitored, frequency and means for monitoring each parameter;
4. Specific indicators and thresholds - Defines the conditions when management actions should be taken. There may be a series of indicators and staged thresholds for an individual event; and
5. Approach to responses –Description of the approach to responses including a simplified flow chart to guide the implementation process if any specific thresholds have been crossed.

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Table 4 Overall AMP Summary

EVENT	NARRATIVE TRIGGER	INDICATORS	THRESHOLDS	MONITORING LOCATIONS	MONITORING PARAMETERS
1. CHANGE IN WATER QUALITY OR QUANTITY					
a. Significant change in water quality of treatment plant discharge	<u>Water Treatment Facilities</u> Decline in effluent pH noted or effluent quality trending towards possible exceedence of standards or exceeds licenced standards.	pH, Total zinc, ammonia, TSS	Treated effluent: TSS>20 mg/L for three consecutive days; OR Total Zinc > 0.40 mg/L and pH <6.5 for three consecutive days; OR Ammonia > 4.0 mg/L and pH > 9.0 for three consecutive days; OR Effluent quality standards exceeded.	Water Treatment Facilities	Routine in-situ, on-site total zinc, external multi-element ICP, hardness, pH, conductivity, TSS, ammonia, LT50
b. Significant change in water quality of adit discharge	Significant decline in pH or increase in conductivity from mine adit discharge to treatment plant	pH, conductivity	Adit discharge pH more than 1 pH standard unit lower or conductivity 2X higher than historic average	KV-42 Bellekeno adit discharge	Same as indicators
b. Adit discharge quantity significantly increases	Observed or measured flows display a sustained and statistically significant increase over historical flow conditions	Flow	Increase of flow to greater than 95% Upper Confidence Level when compared to the average for the previous 24 months or 90% Licence flow discharge criteria exceeded	KV-43 Bellekeno treatment plant; KV-XX Mill sediment pond discharge treatment plant	same as indicators
2. WASTE ROCK SEEPAGE EXHIBITS AML					
a. Waste rock seepage or runoff trending to AML conditions	Seepages from waste rock disposal areas or from works constructed or upgraded with non AML material show significant decline in pH and/or an increase in conductivity OR approaching licenced discharge standards	pH, conductivity	Significant decline in pH between measurements or pH <6.0 and/or conductivity showing a significant increasing trend or >2000 µS/cm; OR indicators approaching licenced discharge standards	Waste rock disposal areas and works or features constructed from non-AML material	pH, conductivity, Routine multi-element ICP

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EVENT	NARRATIVE TRIGGER	INDICATORS	THRESHOLDS	MONITORING LOCATIONS	MONITORING PARAMETERS
3. SLUDGE STORAGE AREA EFFECTIVENESS COMPROMISED					
a. Seepage observed near sludge storage areas	Routine inspection of sludge storage area shows seepage	Total zinc, pH	pH >8.5 and total zinc > 1.0 mg/L	Valley Tailings sludge storage cell	Same as indicator
c. Sludge storage area approaching capacity	Sludge storage area approaching minimum freeboard of 1.0 meter below the decant point	Visual observation of freeboard	Freeboard is at 1.5 meter below decant point	Valley Tailings sludge storage cell	Same as indicator
4. PHYSICAL INSTABILITIES					
a. Area of significant surface subsidence has occurred	An observed subsidence has exposed an opening to surface or resulting in slope failure	Visible slope failure, ground subsidence or opening on surface	Opening to underground workings or area of subsidence effects public safety or down gradient environment	Bellekeno Mine Production Unit Area	same as indicators
b. Rock fall or landslide is observed that affects road right-of-way or intrudes into stream	An observed rock fall or landslide effects a road right-of-way, infrastructure or intrudes into stream	Mine source material movement	Source material effects road or stream	Bellekeno Mine Production Unit Area	same as indicators
5. SITE SECURITY COMPROMISED					
a. Security gate, fence, sign damaged	Public health and wildlife safety measure damaged or removed	Sign, fence, gates, locks	Security feature damaged, removed, or compromised	Bellekeno Mine Production Unit Area	same as indicators
6. DEVELOPMENT OF HIGH PORE PRESSURES UNDERNEATH THE DSTF					
a. High porewater pressure within groundwater monitoring wells in the DSTF	Porewater pressure is observed in groundwater monitoring wells in the DSTF	Porewater pressure	Tip @ 1.0m or 1.7m depth – Porewater pressure parameter (Ru) exceeds 0.15	Groundwater monitoring wells in the DSTF	same as indicators
7.0 DEVELOPMENT OF SIGNIFICANT EROSION OF EXPOSED DSTF SURFACES					

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EVENT	NARRATIVE TRIGGER	INDICATORS	THRESHOLDS	MONITORING LOCATIONS	MONITORING PARAMETERS
a. Area of significant erosion on exposed DSTF surface	An observed movement of tailings caused by erosion on surface	Visual inspection of tailings surface	Geotechnical engineer or operator inspection identifies adverse operating condition	DSTF	Same as indicators
8. DEVELOPMENT OF EROSION AT THE FLAME AND MOTH SITE DISCHARGE AREA					
To be developed once discharge system is designed					
9. TRANSPORT OF SEDIMENT FROM THE FLAME AND MOTH DISCHARGE AREA INTO CRISTAL CREEK					
To be developed once discharge system is designed					
10. DEVELOPMENT OF LARGE DIFFERENTIAL SETTLEMENTS AT THE DSTF					
a. Significant differential settlements are observed in the DSTF	An observation of significant differential settlements are observed at the DSTF	Displacement of survey monitors and slope indicators	Displacements greater than 25 mm in any direction	Survey monuments and slope inclinometers	Same as indicators
11. DEVELOPMENT OF LARGE DIFFERENTIAL SETTLEMENTS ALONG THE CONVEYANCE FLUME FROM THE DSTF TO THE FLAME AND MOTH SITE COLLECTION AND SEDIMENT POND					
a. Significant differential settlements are observed in along the conveyance flume	An observation of significant differential settlements are observed the conveyance flume	Displacement of survey monuments	Displacements greater than 25 mm in any direction	Survey monuments	Same as indicators
12. EXCEEDENCE OF RECOMMENDED WATER QUALITY STANDARDS IN THE RECEIVING ENVIRONMENT OCCURRING IRRESPECTIVE OF COMPLIANCE WITH EFFLUENT DISCHARGE STANDARDS					

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EVENT	NARRATIVE TRIGGER	INDICATORS	THRESHOLDS	MONITORING LOCATIONS	MONITORING PARAMETERS
a. Water quality standards are exceeded in the receiving environment even though authorized licenced discharges are within discharge limits	Receiving environment discharge standards exceed CCME and do not have a history of exceedence, and waste related to the Bellekeno undertaking are contributing greater than 10% of the mass load.	Licensed discharge parameters	Exceedence of CCME at a receiving environment monitoring station, no previous trend of exceedence, and Bellekeno undertaking contributes >10% of mass load	Receiving environment monitoring stations	Same as indicators
13. IDENTIFICATION OF GROUNDWATER QUALITY IMPACTS AT THE FLAME AND MOTH OR BELLEKENO MILL SITES					
a. A significant increasing trend is observed in groundwater near the Flame and Moth or Non-AML Waste Rock Disposal Area	Total zinc significantly exceeds baseline measurements for a given monitoring well, and exceeds licenced effluent discharge standards	Total Zn	Total zinc exceeds the highest baseline measurement by a factor of 2x, and exceeds licensed effluent discharge standards	Groundwater monitoring wells	Same as indicators
14. IDENTIFICATION OF WATER QUALITY IMPACTS TO KENO CITY WATER WELLS					
a. A significant increasing trend is observed in groundwater near the Flame and Moth or Non-AML Waste Rock Disposal Area	Total zinc significantly exceeds baseline measurements for a given monitoring well, and exceeds licenced effluent discharge standards	Total Zn	Total zinc exceeds the highest baseline measurement by a factor of 2x, and exceeds licensed effluent discharge standards	Groundwater monitoring wells	Same as indicators

13.0 RECLAMATION EFFECTIVENESS MONITORING PROGRAM

A reclamation effectiveness monitoring program will be designed to assess interim reclamation efforts at Bellekeno. Over time the assessment protocol of the monitoring program will evolve so post closure reclamation benchmarks are well defined, measurable and documented. A thorough effectiveness monitoring program will allow for quick recognition of restoration successes and needed improvements, so future reclamation planning and implementation can benefit from the monitoring results.

Progressive reclamation is limited to the dry stack tailings facility. Progressive reclamation will occur in a staged (possibly an annual) basis but has not yet commenced at the DSTF. After initiation of progressive reclamation, the reclamation effectiveness monitoring program will likewise occur in a staged fashion after reclamation at the DSTF has been initiated. Routine monitoring and surveying for a number of aspects of the DSTF including physical, chemical, geotechnical stability, effluent and seepage water quality are to be carried out under several monitoring and surveillance programs, including:

- QML-0009 Monitoring and Surveillance Plan (this plan)
- QML-0009 DSTF Construction and Operation Plan (especially DSTF Operations, Maintenance and Surveillance Manual)
- QZ09-092 Groundwater Monitoring Plan
- QZ09-092 Physical Inspections and Reporting Plan
- QZ09-092 Tailings Characterization Plan
- QZ09-092 Water Management Plan and Water Balance Report

Information collected during routine assessments under these monitoring plans will be used to help provide background information and aid in development of the effectiveness of progressive reclamation monitoring program. In addition, the following steps will be used to determine reclamation efficacy:

- 1) Initial targets and goals are outlined in the Progressive Reclamation section of the Decommissioning and Reclamation Plan and will be used in impact assessment in determining long-term impacts. These targets and goals will be refined based on development of objectives in the District-wide closure plan and will be well-defined, representative of success, unambiguous, and easily measured including percent vegetation cover, species composition, physical stability, cover integrity, dust control and water quality.
- 2) Refine objectives into metrics: As mentioned above, benchmark parameters should be easily measured. The sample size needed to adequately define condition will depend on the underlying variability in the parameter to be measured. Metrics for success, including water quality, have largely been

identified in water licence QZ09-092 but will be expanded with development of the District-wide closure plan.

- 3) Use Adaptive Management: During project construction and operations, adaptive management will be an element of reclamation success monitoring. If monitoring indicates a failure to meet benchmarks, reclamation procedures will be modified or new procedures adopted to compensate based on guidance from adaptive management principals. For example, monitoring may indicate that additional erosion or runoff control methods may be needed or that reseeding with a new mix of plant species required.

Success of implementation of final reclamation will be measured by the ability to achieve stated closure objectives in the Decommissioning and Reclamation Plan. As described above, objectives may in part be derived from development of site-wide closure in the Keno Hill District. Impacted watersheds for the Bellekeno project overlap with those of the District, and thus the some of the metrics used to measure success will necessarily be the same as those for District-wide closure.

14.0 REPORTING

Reporting on water quality monitoring and management issues will be directed to the Yukon Water Board (YWB) and YG EMR in accordance with the requirements of the Water Licence and Quartz Mining Licence. Monthly and annual reporting will be carried out during Bellekeno mine development activities and through the implementation of site decommissioning until it can be demonstrated through the monitoring results that the final closure reclamation objectives have been achieved.

Alexco also continues to liaise with the regulatory agencies, FNNND, the Mayo RRC and the local community on environmental issues relating to the Bellekeno mine/mill development and operation program. For example all monthly and annual reports are provided to FNNND.

15.0 REFERENCES

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