WOLVERINE MINE
RECLAMATION AND CLOSURE PLAN

VERSION 2015-06

Prepared for:

Yukon Government Department of Energy, Mines and Resources and

Yukon Water Board

Prepared by:

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In conjunction with

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Table of Contents

List of Figures

List of Tables

List of Photos

List of Appendices

1 INTRODUCTION

This document presents an updated Reclamation and Closure Plan (the Plan) for the Wolverine Mine, Yukon, owned and operated by Yukon Zinc Corporation, (YZC); replacing versions that were originally submitted in June 2006 (Version 2006-01) and updated in March 2008 (Version 2008-02), April 2010 (Version 2009-03), September 2012 (Version 2012-04), and July 2013 (Version 2013-05). The Plan incorporates requirements of Quartz Mining License QML-0006 and Type A Water Use Licence QZ04-065 for the mine site as a whole

As per QML-0006 Section 8.0 and QZ04-065 Part E, the Plan recognizes the current condition of the mine, which is non-operational, and in a state of temporary closure. As such, the Plan also addresses care and maintenance of the mine site during temporary closure, and provides an update to the decommissioning and reclamation upon final closure.

The decommissioning process outlined in the Plan assumes that the mine has not been operated since January 2015 and that a mechanical water treatment plant does not exist on the site, as it is not predicted to be required during temporary closure. Final closure, as defined in this Plan, is presumed to occur following an extended temporary closure period, and therefore presumes that the mechanical water treatment plant would not be built. However, if operations were to resume, then the presumption would be that an appropriately sized mechanical water treatment plant would be constructed as part of the mine re-start procedure.

This Plan has therefore been presented in three parts:

- Part I: Temporary Closure Plan
- Part II: Resuming Operations from Temporary Closure, and
- Part III: Reclamation and (Permanent) Closure Plan.

1.1 Terms of Reference

1.1.1 Glossary of Terms

For consistency in interpretation of the contents contained herein, the following terms are defined:

- **Decommissioning** - the period following the cessation of operations involving the removal of equipment from active service.
- **Temporary Closure** - unless otherwise agreed to in writing by the Chief, Department of Energy, Mines and Resources:
  - The cessation of development or production that extends for more than a continuous two week period; or
  - Any closure after the start-up date where no ore is mined, or ore or tailings milled for a period exceeding two consecutive months.
- **Closure or Permanent Closure**
  - The period in which decommissioning and reclamation activities are completed for the purpose of returning the mine site to pre-mining conditions (estimated to be a three year period for the Wolverine Mine to meet water discharge standards in the tailings facility). Monitoring frequency is quarterly for groundwater and surface water sampling during closure.
  - Where Temporary Closure exceeds three continuous years in duration.
  - **Post Closure** – The period following closure where all reclamation activities are complete and the monitoring schedule frequency is reduced to annual assessments.

1.1.2 Abbreviations and Acronyms

$ K	thousands of (2015) Canadian dollars
$ M/a	Millions of Canadian Dollars per year
$M	millions of (2015) Canadian dollars
CCAA	Companies' Creditors Arrangement Act
CLO	Concentrate Load-out
Cu	Copper
DMS	Dense media separation system
EMR	Yukon Government, Department of Energy, Mines and Resources
FOB	free-on-board
Km	kilometres
km/h	kilometres per hour
KVA	kilo volt amps (1000 volt amps)
kW	kilowatt
LFN	Liard First Nation
LOM	life of mine
LTF	Land treatment facility
m	metres
M tonnes	millions of tonnes
m^3/d	cubic metres per day
MAR	Main Access Ramp
masl	elevation, measured in metres above sea level
mm	millimetres
PAX	potassium amyl xanthate
Pb	Lead
PWC	Price Waterhouse Cooper
QML	Quartz Mining License
RCP	Reclamation and Closure Plan
RRDC	Ross River Dena Council
s.g.	specific gravity
SMBS	Sodium Metabisulphite
STP	Sewage treatment plant
t	metric tonnes
TCP	Temporary Closure Plan
tpd	metric tonnes per day
TSF	tailings storage facility
YWCHSB	Yukon's Worker's Compensation Health and Safety Board
YZC	Yukon Zinc Corporation
EBR	Electro-Biochemical Reactor
FBR	Fluidized Bed Bioreactor

1.1.3 Units

All units in this report are assumed to be metric unless specifically stated otherwise.

1.2 Project Description

1.2.1 Location and Access

The Wolverine Mine, owned and operated by Yukon Zinc Corporation (YZC), is a zinc-silver-copper-lead-gold underground mine, with on-site milling capacity of 1,700 tonnes per day (tpd) to produce copper, lead and zinc concentrates. The original estimated life-of-mine (LOM) was nine years, based on a 5.2 M tonne mineable reserve. YZC completed major site construction throughout 2009 and 2010. Mill commissioning commenced in 2011 and commercial production of 1,020 tpd or 60% of rate mill capacity over a 30-day period was achieved on March 1, 2012. Production first achieved 1,700 tpd in January 2013. Current Resources are considered sufficient to support a mine life of 3-4 years on re-start of operations, dependent on metals prices.

The Wolverine Mine is located in the south-eastern Yukon near the headwaters of the Wolverine Lake watershed within the Kaska Nation Traditional Territory (Figure 1-1). Site access is via air or over a 24 km long, all season access road, which connects with the Robert Campbell Highway at km 190.

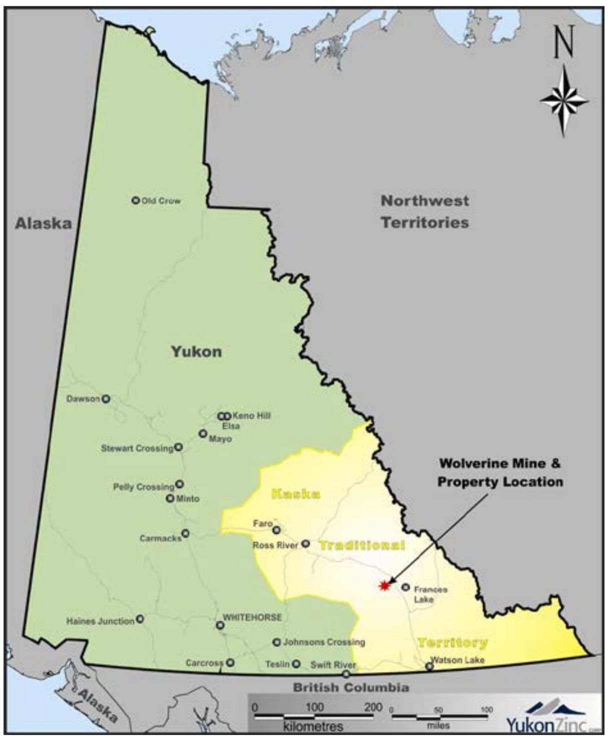


Figure 1-1: Location of the Wolverine Mine within the Yukon and Kaska Nation Traditional Territory

Exploration of the area commenced in the early 1970s, and in early 2005, a Type B Water Use Licence (QZ01-051) and a Mining Land Use Permit (LQ00140) were issued to allow for advanced exploration activities. Under these approvals, YZC completed test mining and detailed infill diamond drilling programs. Quartz Mining License QML-0006 and Type A Water Use Licence QZ04-065, were issued in December 2006 and October 2007, respectively, to allow for the development and operation of the mine.

The Wolverine Mine area climate is cold, with a mean daily summer temperature of 15°C and a mean daily winter temperature of -25°C. Precipitation falls fairly evenly throughout the year, predominantly as rain from May to September and snow for the balance of the year. The mean annual precipitation is 570 mm, with total snowfall of less than 2 m. Maximum wind speeds are less than 40 km/h and the annual average is 15 km/h. The project site elevation is approximately 1,350 masl.

The Wolverine Lake area is sparsely populated, and is used primarily for harvesting, gathering, and trapping by the Kaska First Nation bands from the Yukon, the Ross River Dena Council (RRDC) and the Liard First Nation (LFN). In July 2005, YZC signed a *Socio-Economic Participation Agreement* with the RRDC, on behalf of the Kaska Nation, that provides a basis for participation by all Kaska Nation members in project exploration and mine development and operations activities. This has and will include the review of environmental, social, and economic matters related to activities which support mine development, operation, and closure.

The Wolverine Mine has been operated and will be reclaimed in accordance with the *Kaska Socioeconomic Participation Agreement* and the *RRDC Traditional Knowledge Protocol Agreement* as well as the Terrestrial Performance Standards outlined in QML-0006 Schedule D (including terrain hazards, erosion control, re-vegetation, watercourses, contaminated soils, roads and trails, buildings and infrastructure, rock dumps, underground openings and workings, acid mine drainage concerns, TSF, and water control structures).

The original project timeline from construction through to post closure is provided in Table 1-1.

Table 1-1: Original Project Timetable

Project Year/Phase	Year(s)
Construction Phase	2009 to 2010
Production Ramp-Up	2011
Operations Phase	2012 - 2020
Year 1	2012
Year 2	2013
Year 3	2014
Year 4	Mining Halted
Year 5	2016
Year 6	2017
Year 7	2018
Year 8	2019
Year 9	2020
Permanent Closure Phase	2021 to 2023
Year 1 (Decommissioning)	2021
Year 2	2022
Year 3	2023
Post Closure Phase	2023-2029

Information pertaining to infrastructure and current activities for Wolverine Mine operations is provided below. For additional information, please refer to Wolverine Mine General Site Plan 2011-05 (August 2011).

1.2.2 Wolverine Mine Operations

Currently, the Wolverine Mine had been placed on Care and Maintenance, commencing in February 2015 and is therefore in a state of Temporary Closure as defined above. The mill and mine are no longer operational; however there is currently a Care and Maintenance Crew on site, to maintain the mill and mine integrity and continue environmental monitoring.

The Wolverine Mine was designed to operate 365 days per year, 24 hours per day at 1700 tpd of mill feed ore. The Mine has an existing underground mine with surface ramp access that extends from approximately 1,345 masl at the portal entrance to 1,115 masl at the current lowest elevation. The mine is accessed by a single main access ramp, and contains a ventilation raise that includes an evacuation route. A recent geotechnical survey of the main access ramp revealed a number of potential support failures to the ramp that will need to be addressed before the ramp can be used for underground access to the bottom of the mine.

Project manpower for normal operations is approximately 370 workers, working on a two-shift basis, with approximately 190 people on site at any one time.

Figure 1-2 illustrates the overall mine site layout, and Figure 1-3 and Figure 1-4 provide the layouts for the industrial complex and tailings facility areas, respectively. There are no significant changes to the general mine site infrastructure since the July 2013 update (i.e., RCP V2013-05).

The surface facilities and infrastructure for mine operations include the following:

- site access road;
- airstrip;
- fuel storage and dispensing;
- power generation and distribution;
- process buildings;
- assay laboratory;
- wet shotcrete plant;
- waste rock storage pads;
- tailings facility;
- truck shop;
- mining office complex;
- administration, first aid and mine rescue buildings, dry; and
- a camp.

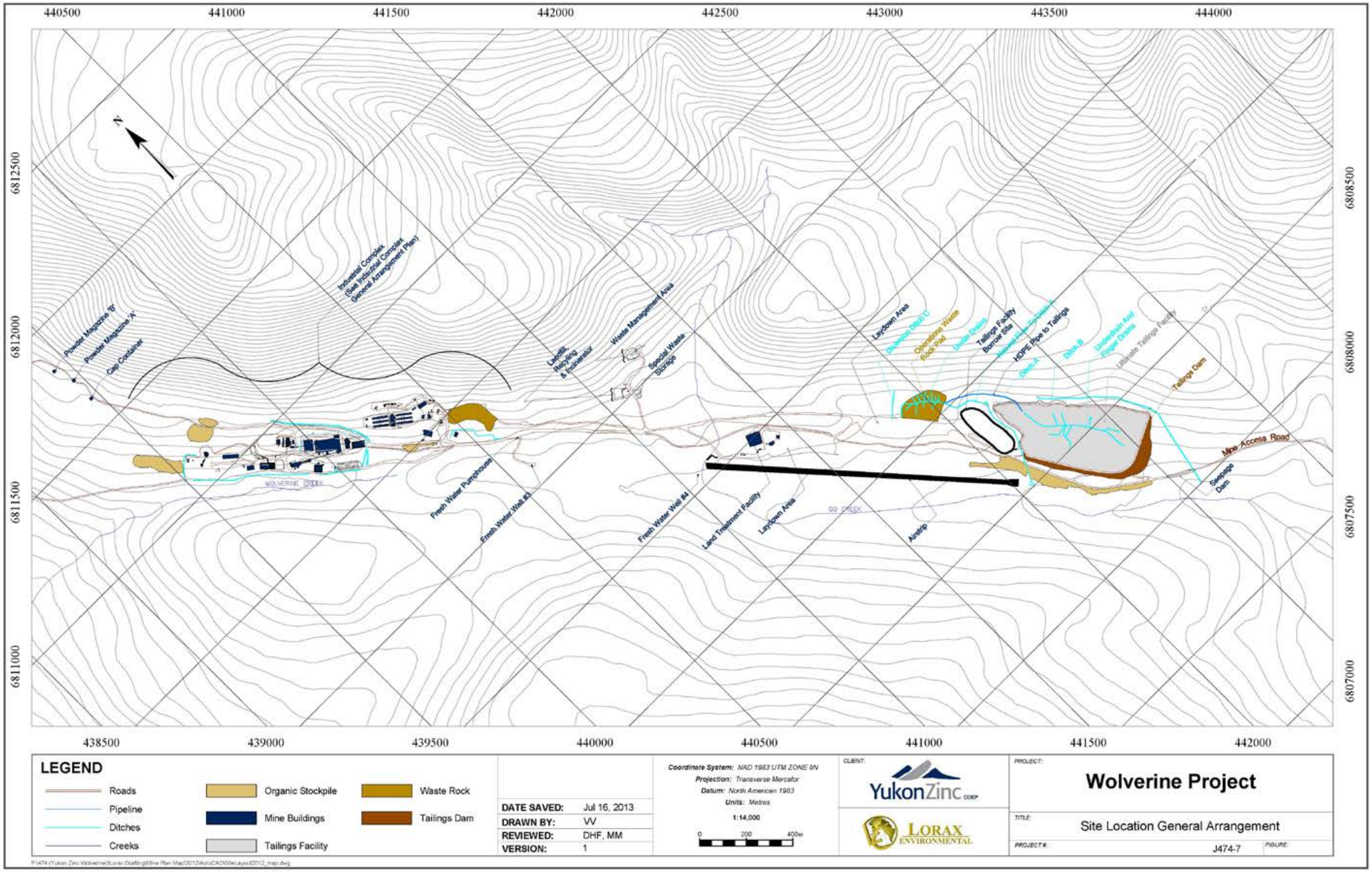


Figure 1-2: General Site Layout – Wolverine Mine Area

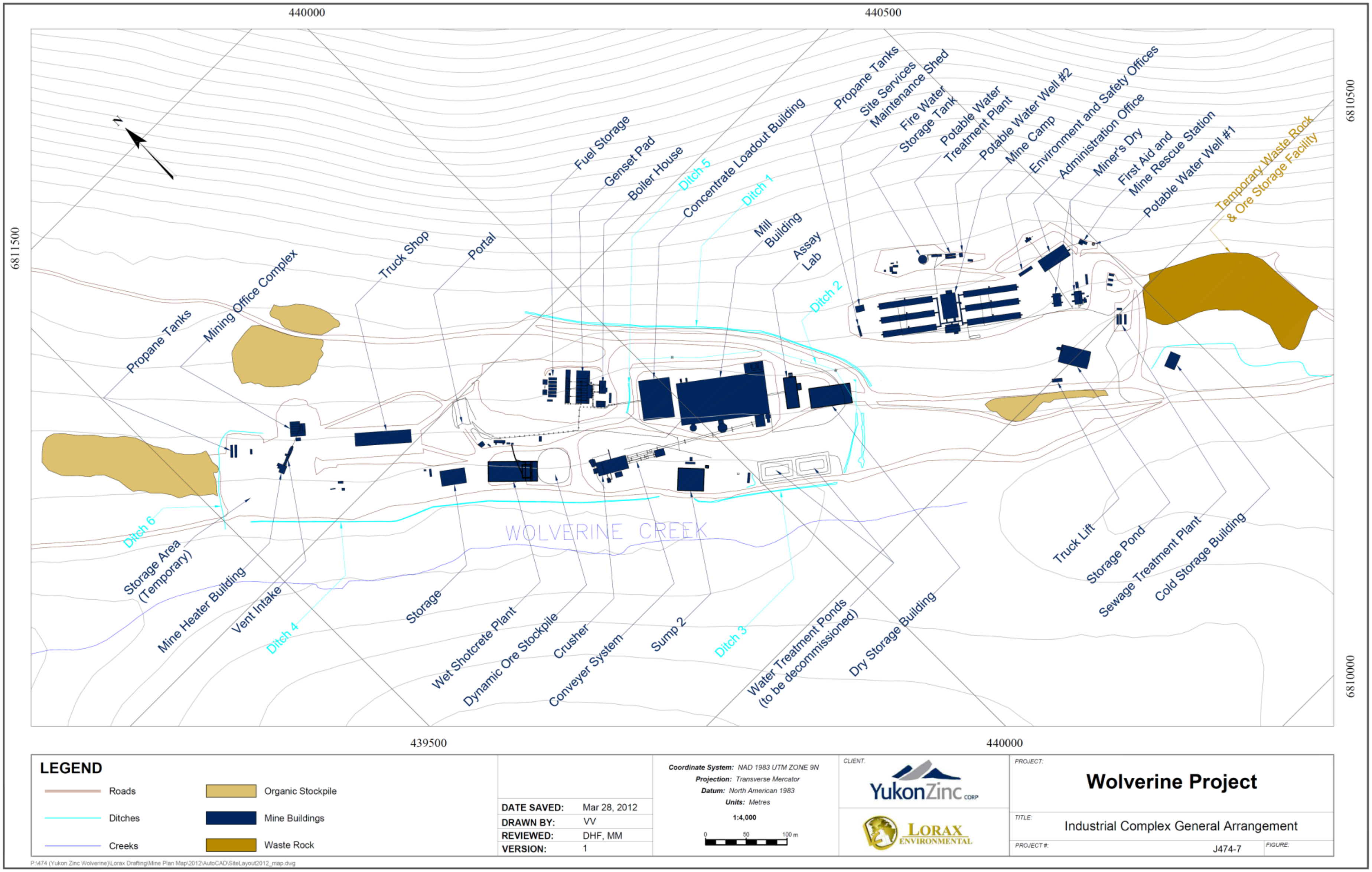


Figure 1-3: General Site Layout – Industrial Complex Area

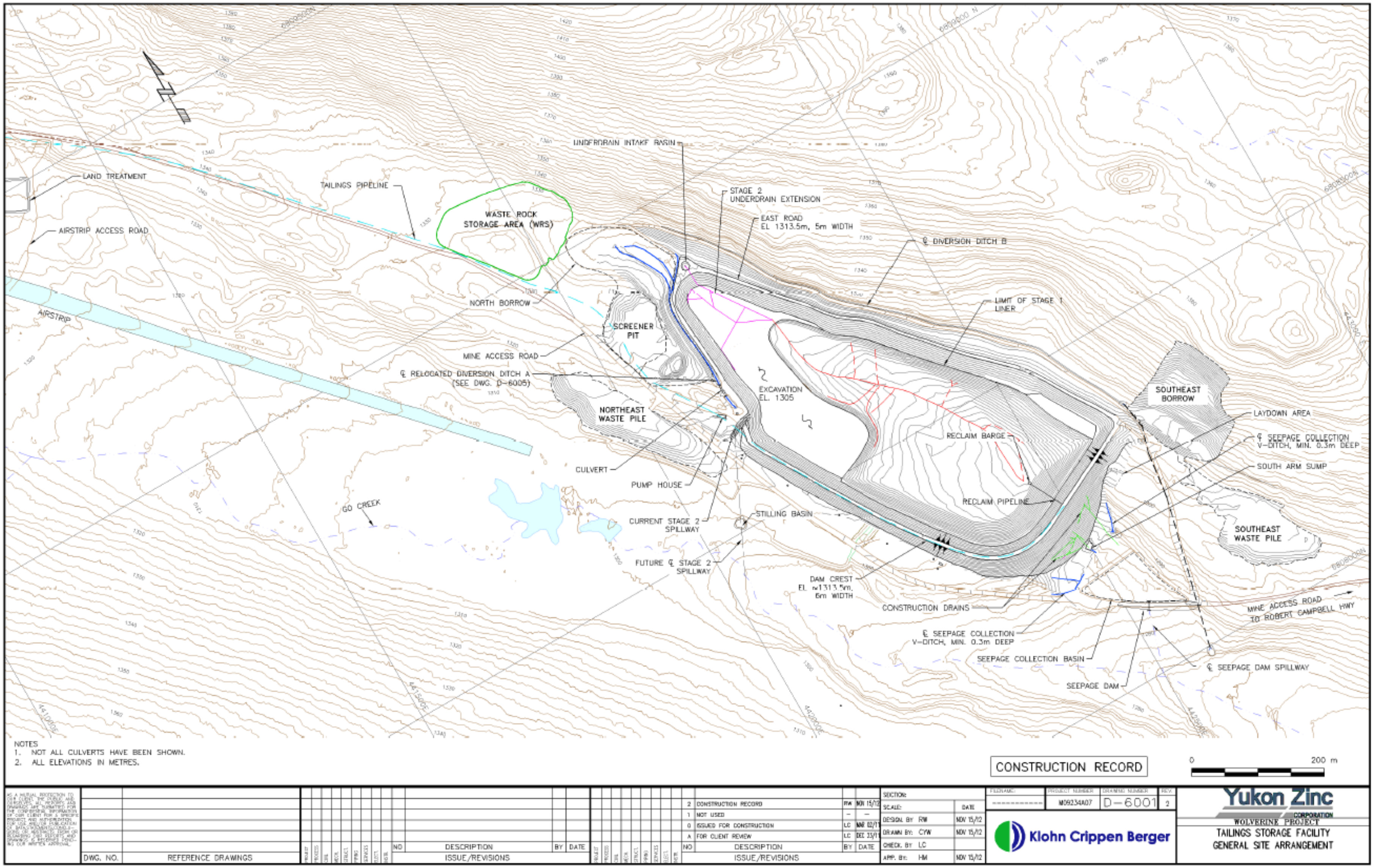


Figure 1-4: General Site Layout –Tailings Facility Area

The road is a private, single-lane gravel road with passing bays; has restricted access and is operated under radio control. The road can be used year-round, subject to snow clearing activities, with minimal load restrictions.

The on-site gravel airstrip is 1,340 m long, allowing a twin engine aircraft to land on the airstrip with a full passenger load. The airstrip is intended for restricted use only under Visual Flight Rules. It is maintained and used year-round.

Diesel fuel for the site power generators and associated operating equipment is supplied from six diesel fuel storage tanks (75,000 L capacity each) and an 8,500 L gasoline tank. Storage is based on two weeks of reserve during normal operations in the event of road problems and/or use restrictions. A fuel truck transports diesel fuel and lubricants to mobile equipment as required.

On-site power generation is provided by eight diesel generator sets, each rated 1,200 rpm, 1.26 MW continuous, 1.45 MW prime power generating at 4,160 V for a total installed generating capacity of 10.08 MW continuous, 11.60 MW prime power. In addition, a number of standby generators are present on site in varying capacities.

The process facilities consist of a crusher building, mill building and concentrate load-out building. Feed conveyors connect the crusher building to the mill and transport crushed ore to the rod and ball mills. Ancillary facilities include a wet shotcrete plant, assay laboratory, mining office complex, truck shop and camp.

Camp infrastructure at the Wolverine Mine consists of six, 41-man dormitories, a kitchen, recreation hall, administration office, first aid office, mine rescue station and dry facilities. Additional support infrastructure includes a maintenance workshop, training room, firewater tank, potable water treatment plant, communication station, and sewage treatment plant.

When the mine is operating, water from the underground workings and the tailings slurry from the milling process is pumped to the tailings facility, (TSF), then reclaimed water from the TSF is pumped back to the mill for process water use. At least half of the tailings solids produced by the mill were designated to be placed underground for paste backfill operations.

Waste rock from the mine is stored on two designated waste rock pads. The first pad, located southeast of the camp, was constructed in 2005 to hold development waste prior to operations and the second pad located north of the tailings facility was constructed in 2011. Additionally a further temporary waste rock pad is in use adjacent to the mine portal. Prior to the temporary shutdown, approximately 42,000 tonnes of ore were also stockpiled on surface in two additional temporary piles, adjacent to the crusher building and also close to the Portal entrance. This ore was expected to be fed to the crusher during normal operations. The waste in the temporary waste dump was planned to be returned underground.

Metal concentrates produced by the milling process were trucked south along the Robert Campbell Highway, through Watson Lake to the Stewart Bulk Terminal in Stewart, BC; for transportation via ocean freighter to various smelters in Asia.

The total tonnage mined from underground to-date is shown in Table 1-2. As can be seen, approximately 42,000 tonnes of ore is still stockpiled on surface near the mill.

Table 1-2: Annual Production to date

Year	Mined Ore (t)
2010	26,826
2011	142,315
2012	441,095
2013	505,942
2014	443,867
2015	35,207
Total	**1,595,253**
Stockpiled	41,848
Milled	***1,553,405***

1.2.3 Current Conditions

1.2.3.1 Corporate

On 27 January 2015 YZC announced through a press release that it was temporarily shutting down operations at the Wolverine Mine, due to unfavourable market conditions; putting the site in "Temporary Closure" according to the definitions in Section 1.2.1. A notice of change of operations was submitted to the Yukon Government to that effect. Most employees and contractors were laid off at this time and the mine was put into care and maintenance.

On 23 April 2015, YZC issued another press release announcing the re-structuring of the company under the Companies' Creditor Arrangement Act (CCAA). On 17 April 2015, the Supreme Court of British Columbia issued an Order authorizing YZC and PricewaterhouseCoopers Inc. (PWC) in its capacity as Court appointed Monitor of YZC, to carry out a sale and investment solicitation process and actively seek offers for an investment in YZC, or for the purchase of the YZC's assets or business. PWC Corporate Finance has also been appointed by the Court to assist the Monitor and the Company in the Solicitation Process. The Solicitation Process has commenced and YZC, the Monitor, and the Financial Advisor have already had discussions with several potential investors and purchasers. The intention is to identify an investor or purchaser that will preserve the Company's mining assets and, in due course, recommence mining activities at the Wolverine Mine. The solicitation period concluded on 8 June 2015 and the Monitor and YZC will report the outcome of the solicitation process to the Court on 14 August 2015.

A number of interested parties visited the site in May 2015 and reviewed the available data. After the court date on 14 August 2015, assuming a deal has been reached, it will likely take at least 6-8 weeks to close the arrangement and lift the CCAA order.

1.2.3.2 Wolverine Mine Site

All industrial activity has ceased at site:

- The underground mine is closed and gated;
- There are no industrial activities, or processes, occurring in the mill;
- No tailings are being added to the TSF; and
- No waste or ore is being created or added to existing waste piles.
- A 5-man crew is on-site to maintain the site and ensure environmental compliance.

2 PART I: TEMPORARY CLOSURE PLAN

This Part presents the Temporary Closure Plan (TCP) for the Wolverine Mine Site and represents the current program of work being carried out by YZC. As the site is currently in Temporary Closure, this section does not present a theoretical plan as an update to prior submissions, but instead reports on the progress of the recent, ongoing, and near-term temporary closure activities.

It should be noted that YZC's expenditures are closely controlled during this process by PWC as the Monitor for the CCAA process, as all funding has to be borrowed at premium rates and accounted for in detail. Despite this, YZC has managed to complete a significant amount of clean-up and closure work on site, as reported in the following sections. Costs for any outstanding and ongoing work beyond the end of June 2015 have been estimated and included in this TCP.

2.1 Personnel

Currently, 10 rotational workers have been retained at site to keep five workers on site at any given time. This crew is comprised of supervisors, operators, and maintenance staff.

Care and maintenance staff are to ensure that environmental compliance is maintained, and environmental data collection is completed. The company has retained the services of an experienced environmental consultant in Vancouver, with experience of the site, to ensure that all regulatory reports are appropriately submitted.

Over the longer term, it is proposed to reduce the site crew to 8 workers, with 4 workers on site at any time, to continue with the care and maintenance of the site and to continue a reduced environmental monitoring process, more suited to the Care and Maintenance status of the project. Any work outside the normal care and maintenance process will be contracted out.

2.2 Underground Mine

The mine de-watering system is not being run at present and the mine is passively flooding.

The only equipment left in the underground mine are the electrical transformers, switch gear and communications equipment, a single refuge station, plus some pumps and fans.

Mr. Woo Shin, P.Eng, a former YZC site geo-technical engineer, was retained in late April 2015 to conduct a geotechnical investigation of underground workings, to assess the stability of the main ramp and review the water inflow status, for the purpose of preparing a ramp rehabilitation plan and a mine de-watering plan. Woo Shin's 6 May 2015 report details proposed rehabilitation work in over 20 locations on the main ramp and associated infrastructure that must be completed before access can be established to the lower levels of the mine, to allow pumping to recommence.

The cost of performing this work includes:

Prepare equipment for program		0.25 $M
Rehab to 1170 masl		0.95 $M
Rehab to the bottom of the mine (1170 to 1115m asl)		2.06 $M
	Total	**3.26 $M**

The reason for the separation of work above and below the 1170 masl elevation is two-fold:

- The rehabilitation work for the MAR below the 1170 masl elevation is much more extensive and costly than that required above it. The main ramp between 1150 and 1145 masl is failing by caving upward and threatens to undermine the main ramp between 1170 and 1160 masl. This will require steel sets and concrete to maintain access through this part of the ramp. Replacing the complete ramp between 1170 and 1145 masl elevation, by driving a ramp bypass, is proposed as a potentially cheaper and safer solution than repairing the existing ramp.
- The main sump is located above this elevation on the 1200 Level, allowing staged pumping of the mine.

While continuous dewatering of the underground mine was originally included in previous versions of the temporary closure plan, YZC does not have the necessary funds to complete the reclamation work required to access the bottom of the mine and thus carry out this pumping work at present. Consequently, no underground rehabilitation work is proposed at this time and thus no underground access is currently proposed within this Plan; no further recovery of equipment stored underground will be carried out and no underground access, or work, is included in this TCP. To bar unlawful personnel from access the underground workings, access gates have been installed on the portal and locked, as was the manway ventilation raise door.

The underground geotechnical assessment estimated that the remaining capacity of the underground mine is 134,000 m^3 of free space, at the time of the report in May 2015. Concurrently, an estimate was made of the water inflow rate (150 m^3/d), resulting in a projected duration of 30 months to completely flood the mine to the portal elevation (October 2017).

2.3 Mill

2.3.1 Mill Decommissioning

A metallurgical and processing crew of ten mill workers and a metallurgical engineer was brought back into site on 14 May 2015, for three weeks, to secure the processing plant and remaining site reagents left on site. Their work was completed by 4 June 2015.

The work completed included the following:

- Clean up of the mill area and other safety-related jobs essential to good housekeeping;
- Wash down of all areas and sumps;
- Emptying the ball mill and rod mill of charge and jacking them onto their cradles and off their pinions;

- Emptying of all flotation cells;
- All pumps were split and left open as appropriate;
- Identified and segregated any equipment that requires warm storage for potential removal from site, or warm storage;
- Filled all gear boxes with oil for long term preservation;
- Emptied all reagent tanks, flushed any chemicals remaining in the reagent holding tanks to the TSF;
- Ensured that all stored reagents on site are appropriately identified and labelled, repackaged as required, and stored in a secure area (such as the CLO, or prepared lined storage areas); and
- Disposed of any other small amounts of reagents that could be effectively washed to the TSF.

2.3.2 Concentrate

At the beginning of June, 2015 there was approximately 2,400 tonnes of zinc concentrate in the Concentrate Load Out building (CLO), which was due to be shipped out from the CLO to the owner of the concentrate, Transamine. YZC has commenced loading this material into trucks using company equipment for shipment overseas during summer 2015. Once the CLO is clear of zinc concentrate, it will be swept and cleaned out, then used for secure storage of reagents as appropriate, as it is fully concreted and easy to clean up in the unlikely event of a spill.

There are also less than 20 bags of lead and copper concentrate left over from prior shipments. These have been re-bagged and stored in the CLO, pending possible sale.

2.3.3 Reagents

All reagents have been securely packaged and stored, such that they can be shipped to other operations for use elsewhere if possible, or retained on site for future use. Selling these reagents at a discount is not realistic, as most potential receivers are reluctant to take them to avoid disrupting their processes. Hence, they are being offered free-on-board (FOB) Wolverine site and the company is actively seeking willing recipients.

2.4 Special Waste Pad

The Special Waste Pad on site has been cleaned up and organised and dirty totes have been washed out and sent to the scrap pile. All other old barrels and scrap material are being collected around site and sorted appropriately.

2.5 Explosives

No explosives remain on site. The explosives magazines have been emptied, the explosives burned, and the licences returned to YWCHSB to be held for YZC. The magazines will be removed from site as back-haul transport going back to Whitehorse.

2.6 Power Generation

Under normal operating conditions, the power at site is provided by eight 3516B Caterpillar gensets. An average of 5,144 litres of fuel is consumed per day for the operation of one of these large generators, when used to heat and power the mine and mill complex; (25,700 litres was consumed over 5 days in March 2015 during the care and maintenance phase).

To reduce this fuel consumption, reduce the carbon footprint of the operation and move to more efficient generation of much lower amounts of power during the TCP, the site is now powered using an existing 350kW Caterpillar genset, along with an existing larger 500KW Caterpillar Standby set, to service the camp and the modest needs of any other facilities to be used on site, with a projected consumption of 768 litres of diesel per day. Using this much smaller generator, which is more than sufficient for all TCP activities, on-site storage (6 x 75,000 L tanks – 450,000 L) is sufficient to feed the smaller gensets as well as the mobile equipment throughout the 6-month winter period. With diesel stored on site in the main tanks, it will not be necessary to keep the access road open and maintained in the winter months to re-fuel the operation, further reducing the site maintenance requirements.

The eight primary generators will be mothballed during the 2015 summer season and the glycol loop will be emptied into storage tanks on site. On recommencement of operations, the glycol stored in the tanks will be re-conditioned and replaced within the glycol loop, which would be further extended to partially heat the mine air. The actual glycol itself will not freeze. As indicated by the manufacturer, the freezing point of the glycol in the system is – 62° F (- 52° C). The glycol line will also be isolated into short loops wherever possible, by closing all the system valves. Before re-commencement of operations, it will be necessary to go through this loop and replace all appropriate seals and remove any rust build up that may affect future operations.

The current power system and many of the mill pumps and processes are controlled by a DeltaV programmable control system. To enact these changes, the DeltaV will have to be disconnected, or power will have to be "back fed" from the smaller generators. All powered facilities required by the TCP will have to be converted to manual operations with all necessary interlocks, where appropriate.

2.7 Camp

Camp requirements for the TCP crew will be very modest in comparison to operations, with only four people on site most of the time. Accordingly, parts of the main kitchen and mess hall have been converted into office space for the winter and the office building shut down. Living accommodation will be provided in one half of Bunkhouse #3. All remaining bunkhouses and buildings are being winterised and shut down.

2.8 Site Access Road

The reduced freight requirements of the TCP, particularly the reduced diesel consumption, allow for seasonal operation of the access road, eliminating the need for winter road maintenance.

If any optional program is enacted which requires the operation of the large gensets during the winter months, the quantity of diesel consumed could not be able to be stockpiled for winter operations in the existing fuel farm. In this case, year-round operation of the access road would be necessary, assuming such operations are to be carried out in the winter season.

2.9 Tailings Storage Facility (TSF)

The total tailings placed in the TSF, derived from operational records, are shown in Table 2-1.

Table 2-1: Milling Product Totals, including tailings placed in the TSF (tonnes)

Year	Milled	Concentrate	Paste	Tailings
2011	153,352	26,723	0	126,629
2012	428,955	82,486	86,506	259,963
2013	519,625	112,629	146,903	260,093
2014	431,879	100,952	134,502	196,425
2015	19,594	6,095	2,927	10,572
Total	**1,553,405**	**328,885**	**370,838**	**853,682**

The specific gravity of waste material mined from underground is 2.83 t/m³, thus the solids volume of tailings placed in the TSF is 301,654 m^3. The current total volume of the TSF is estimated at 1,013,455 m^3, indicating that the total volume of water in the TSF is 711,801 m^3. This water would be a combination of pore water within the settled tailings and free water above it.

The “as built” pond capacity of the TSF facility is estimated to be 1,378,100 m³ to the minimum compliant freeboard (1 m below spillway) and 1,552,600 m³ to the spillway. The remaining capacity within the TSF is therefore estimated to be 399,100 m³ to the minimum compliant freeboard and 539,200 m³ to the spillway.

The average inflow rate into TSF was estimated as follows:

1. *Seepage Pond below TSF*
   Collected snowmelt is generally noted in the seepage pond from April through June. Once spring melt is concluded, there is little to no flow recorded in the seepage pond, indicating negligible seepage through the TSF embankment. Therefore, seasonal flow from the seepage pond to the TSF is ~87 m^3/yr, or the annualized flow rate is ~0.24 m^3/d. *Note that this water is of good quality and could be discharged to the environment as part of the long-term water management plan.*

2. *Waste Pad #2*
   A 4" pipe is installed from the Waste Pad #2 to the TSF. Although no historical recordings of flow rate were made due to lack of access to the bottom end of the pipe to perform a flow test, an average flow rate of 7.5 m^3/d can be assumed during the spring season due to run-off.
3. *Sump #2*
   There is no inflow of underground water to the sump as a result of underground operations being suspended. The pump to the TSF will therefore only be run to move the water from the surface run off into the sump. Based on prior years, this averages 48 m^3/d. Note that this water could be bypassed around the sprung structure over this sump, reducing flows to the TSF, as part of the long-term water management plan.
4. *Sewage Treatment Plant*
   The average flow of treated sewage treatment plant effluent to the TSF from the STP is 21.7 m^3/d. This flow rate will reduce markedly during care and maintenance with the greatly reduced level of staff on site and the discontinued use of the sewage treatment plant.
5. *Land Treatment Facility*
   The average inflow from the LTF to the TSF is 9.8 m^3/d.
6. *Precipitation and Evaporation*
   The total surface area of the TSF on the "as-built" drawing is 138,487 m^2, measured on the top of the embankment. The average annual precipitation at site is 0.57 m with an average evaporation rate of 0.24 m, resulting in a net gain of 0.33 m per year. This results in a total gain of 45,700 m^3 into the TSF over the year; an average inflow of 125 m^3/d.

The total average inflow to the pond is thus estimated to be 212 m^3/d. Table 2-2 shows that at this fill rate, the TSF has sufficient capacity to store the required water for the duration of this TCP (a minimum of 1 ½ years).

Table 2-2: Capacity of TSF

Fill To	Volume (m3)			Inflow Rate (m3/d)	Duration (mos)
	Start	End	Change		
Max Freeboard	1,013,455	1,431,401	417,946	212	66
Spillway	1,431,401	1,552,605	121,204	212	19
				Total	**85**

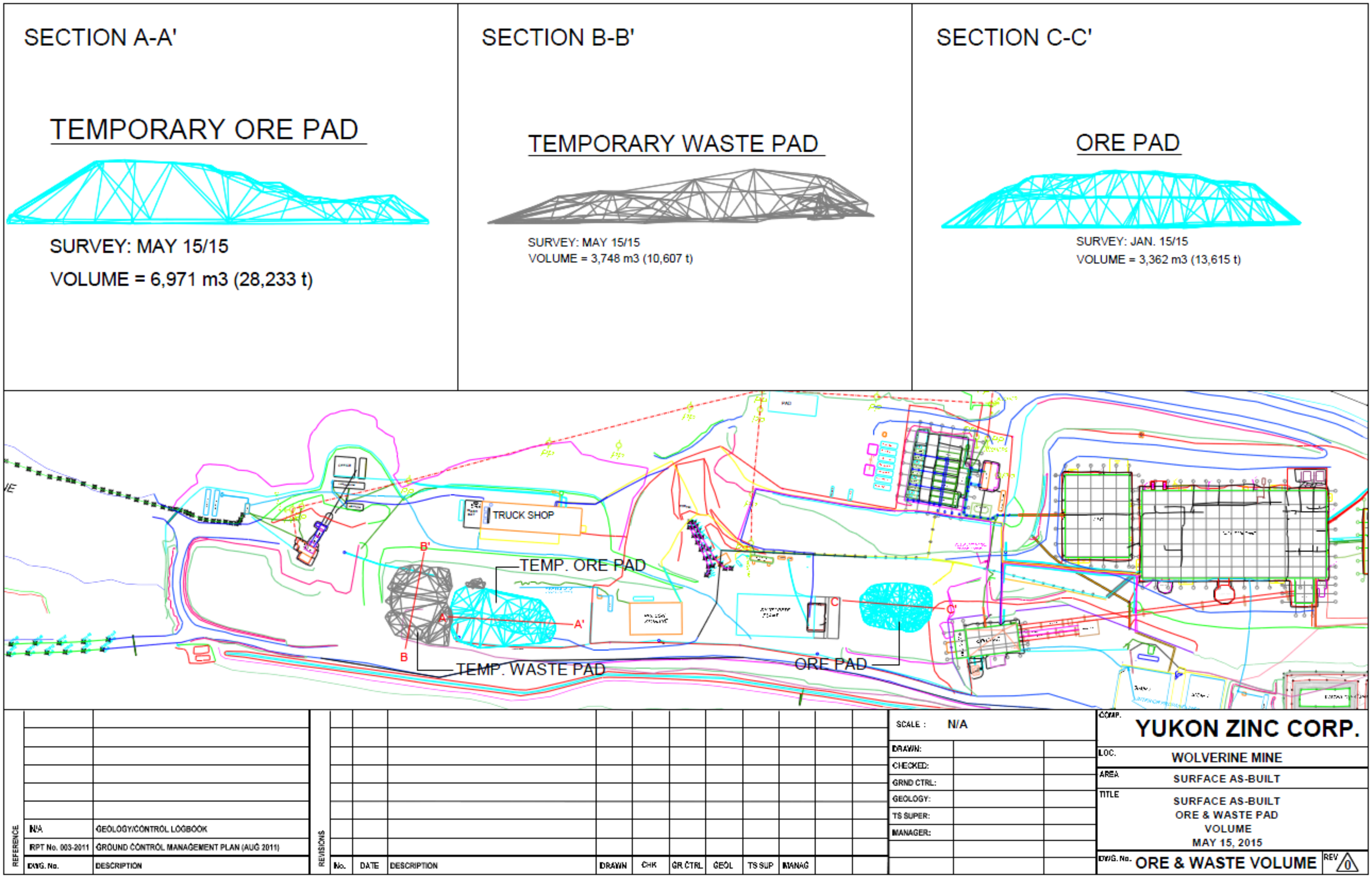
A bathymetric survey of the TSF has also been completed to confirm tailings depth and location. A minor slump exists under the liner, on the north inside slope of the TSF. Klohn Crippen, the engineer of record for the TSF has evaluated the slump, during a visit to the minesite in early July 2015 to complete the TSF inspection and also to complete the annual Earth Structures Surveys and a report is pending. This Report will be completed before the end of July 2015.

2.10 Temporary Waste and Ore Dumps

There are two temporary ore piles and one waste pile that are not on liners at present (see Figure 2-1):

- A 28,300 tonne ore pile and 10,600 tonne waste pile located adjacent to the Portal; and
- A 13,600 tonne ore pile located immediately north of the crusher building.

YZC will move these piles to the Waste Dump #2 above the TSF, using mine staff and equipment to load into contracted truck haulage, commencing mid July 2015.


SECTION A-A'
TEMPORARY ORE PAD
SURVEY: MAY 15/15
VOLUME = 6,971 m3 (28,233 t)
SECTION B-B'
TEMPORARY WASTE PAD
SURVEY: MAY 15/15
VOLUME = 3,748 m3 (10,607 t)
SECTION C-C'
ORE PAD
SURVEY: JAN. 15/15
VOLUME = 3,362 m3 (13,615 t)
TRUCK SHOP
TEMP. ORE PAD
TEMP. WASTE PAD
ORE PAD
A
A'
B
B'
C
C'
REFERENCE
N/A
GEOLOGY/CONTROL LOGBOOK
RPT No. 003-2011
GROUND CONTROL MANAGEMENT PLAN (AUG 2011)
DWG. No.
DESCRIPTION
REVISIONS
No.
DATE
DESCRIPTION
DRAWN
CHK
GR CTRL
GEOL
TS SUP
MANAG
SCALE : N/A
DRAWN:
CHECKED:
GRND CTRL:
GEOLOGY:
TS SUPER:
MANAGER:
COMP.
YUKON ZINC CORP.
LOC.
WOLVERINE MINE
AREA
SURFACE AS-BUILT
TITLE
SURFACE AS-BUILT
ORE & WASTE PAD
VOLUME
MAY 15, 2015
DWG. No.
ORE & WASTE VOLUME
REV
0

2.11 Experimental Water Treatment systems

The single biggest concern during Care and Maintenance and any subsequent closure of metal mines is protection of the receiving environment through water collection and treatment; in particular the removal of contaminants from contact water to permissible discharge concentrations. At the Wolverine Mine the contaminant of most concern in the water for potential discharge is selenium.

Two passive water treatment systems have been currently assumed for this TCP, based on the current Care and Maintenance status of the operation. These two methods would be:

1. Microbial reduction stimulation and ferric sulphate treatment within the TSF, and
2. Biopass treatment systems for potentially contaminated groundwater, waste rock seepage and TSF spillway overflow.

While considerable research has been undertaken on both systems, they will have to be developed further for application to this TCP. As such, the current Care and Maintenance period presents a unique opportunity to further develop passive water treatment systems on the Wolverine site.

An inexpensive passive system of water treatment to reduce selenium has been proposed by EMR, to be developed and employed in the TSF using Ferric Sulphate. Details are presented in the Permanent Reclamation and Closure Plan (RCP), Section 4.2.1.

In addition there has been a program of experimental testwork led by Yukon College to develop a biological remediation process to “fix” metals from solution. This system is based around the encouragement of microbes that occur naturally in the waters of Wolverine Creek to consume and fix the selenium, copper and other minerals from the water. This program, loosely described as a Biopass, is described in detail in Section 4.2.2.

The temporary closure of mining operations, while maintaining staff on site, would allow for the completion of a number of field trials on a variety of experimental Biopass systems at very low cost, using mine staff and equipment. Within this Plan three different Biopass systems are proposed and YZC would be prepared to commence trials on all three systems as part of the Care and Maintenance process.

Ditch style Biopass operation could be established in late summer 2015. This Biopass system is proposed to be established below current sources of contaminated surface water, such as Waste Pile #1, the seepage pond below the TSF and/or Sump #2. The first such installation would be aimed at extending the work of the Yukon College on development of the Wolverine Creek specific Biopass system. Similarly, a pond style Biopass system is also considered for installation at the waste rock and ore storage pad, and could be trialed in 2015.

Finally, the Biopass system using containment structures is proposed to be constructed in 2016. This system would be constructed from existing rigid vessels (e.g., large reagent plastic totes), and the top cut off to allow filling and monitoring. This style of construction will mimic the type of vessel used in the testwork by Yukon College in 2013/14 (Janin, 2014; Janin & Harrington, 2015). The top the tote would be replaced to prevent precipitation infiltration. The influent and effluent sides would be perforated to allow water to enter and exit the vessel, with geotextile filter fabric to retain the multi-media and activated carbon within the vessel. A geotextile filter fabric wall would also be installed between the multi-media and activated carbon sections of the Biopass. The use of large reagent totes would also allow for subsequent additional Biopasses to be added in a reactive train, if required.

2.12 Environmental Monitoring

To reflect the complete lack of industrial activity on site, YZC proposes a reduced sampling program from that described in the previous Reclamation and Closure Plan V2013-05, as shown in Table 2-3. Quarterly sampling is proposed for those sites easily accessed year round, and seasonal sampling for those sites only accessed via the access road, which will be closed in winter.

Table 2-3: Proposed Surface Sampling Program During TCP

Station Number	Watershed	Sampling Frequency	
		RCP V2013-05	RCP V2015-06
T1	TSF	Monthly	Quarterly
W82	Wolverine Creek	Monthly	Quarterly
W9		Monthly	Quarterly
L1	Little Wolverine Lake	Monthly	-
W31	Go Creek	Monthly	Quarterly
W80		Monthly	Quarterly
W22	Money Creek	Monthly	Seasonally
W71	Access Road Route	Monthly	Seasonally
W72		Monthly	Seasonally
W73		Monthly	Seasonally

Groundwater quality monitoring will also be conducted quarterly, at stations outlined in Table 2-4, which is consistent with the RCP V2013-05.

Table 2-4: Proposed Groundwater Sampling Program During TCP

Groundwater Station	Location	Sampling Frequency
W05-1A, 1B	Airstrip North	Quarterly
MW05-2A, 2B	Tailings Facility – Southwest	Quarterly
MW05-3A, 3B	Mine	Quarterly
MW05-4A, 4B	Mine	Quarterly
MW05-5A. 5B	Mine	Quarterly
MW05-6A, 6B	Airstrip East	Quarterly
MW05-7B	Mine	Quarterly
MW06-8S, 8M, 8D	Mine	Quarterly
MW06-9S, 9M	Mine	Quarterly
MW06-10S, 10M, 10D	Mine	Quarterly
MW06-11S	Mine	Quarterly
MW06-12S	Mine	Quarterly
MW08-13	Tailings Facility - West	Quarterly

2.13 Temporary Closure Cost Estimate

2.13.1 Cost Estimate

Temporary closure costs have been prepared from first principles, using existing data from site operations, vendor quotations, and several assumptions that are specified in this section. These have been detailed for the first five years of closure, and are summarized in Table 2-5. The detailed breakdown is shown in Table 2-6.

Table 2-5: Summary of Annual Temporary Closure Costs (thousands of dollars)

Description		2015*	2016	2017	2018	2019	2020
Minimum Requirements		1,335	1,912	1,822	1,822	1,703	1,703
Optional Work Programs			564	30	20	20	20
Seasonal Fuel Adjustment		128	-6	6	13	-3	-5
Contingency	30%	439	741	558	556	516	516
Annual Total		**1,902**	**3,210**	**2,416**	**2,411**	**2,237**	**2,235**
CUMULATIVE TOTAL		**1,902**	**5,112**	**7,528**	**9,940**	**12,177**	**14,412**

*July – December only.

This estimate includes the following activities:

- A minimum crew is maintained at site, with additional training as required to fulfill all functions, such as first aid and environmental monitoring. Rotations are assumed to be 21 days in and 21 days out.
- Minimal power requirements, allowing for the use of smaller gensets and a corresponding significant reduction in diesel consumption starting in July 2015.
- All temporary ore and waste stockpiles are moved to Waste Pad # 2 in July and August 2015.
- Waste Pad #1, a lined facility located near the mill, is left as-is during the TCP. Contact water continues to be collected in the sump, and transported and stored in the TSF.
- The main site access road is operated six months per year, nominally from May to October. The project is operated on a “fly in-fly out” basis from November to April. The airstrip and local site roads will be maintained year-round.
- The underground mine is allowed to flood and hydraulic plugs are installed in the main access ramp (MAR) and vent raise as late as possible, nominally September 2016. Although the mine has adequate storage capacity to extend past this date prior to water coming to surface, the plugs must be installed while the access road is open to deliver supplies, especially fuel, steel and cement, for this program.
- The TSF will continue to maintain a positive water balance, receiving an average of 212 m^3/day of contact water. It has sufficient storage beyond the five years of this TCP and at this rate would not be completely filled until 2022.
- An inexpensive batch water treatment system is proposed to be developed and employed in the TSF using ferric sulphate. Details are presented in the Reclamation and Closure Plan (RCP – Section 4.2).
- A separate ditch style Biopass could be developed below the TSF seepage pond to handle seepage pond water, prior to discharge to the environment.
- Additionally a series of experimental Biopass systems are proposed to be developed in Year 2 of this plan (2016); potentially sited below the current sources of contaminated surface water, such as Waste

Pile#1 and Sump#2. The first such installations would be aimed at extending the work of Yukon College on development of the Wolverine Creek specific Biopass System.

On the above basis and as costed below, the TCP costs an average of 2.6 $M/a over the six years considered (2015 to 2020). Annual TCP costs extending beyond 2020 would be expected to remain flat at approximately 2.4 $M/a, the same as the final two years shown in Table 2-5.

2.13.2 Basis of Costing

The following sections describe the assumptions used to estimate costs for manpower, equipment, and supplies for each of the options considered.

2.13.2.1 Manpower

The proposed TCP assumes a full time staff of eight workers in total, on two four-person rotating crews working three weeks “on” followed by three weeks “off”. As such, there are only four full time workers on site at any given time. Occasionally a work plan will require additional temporary assistance, primarily for equipment maintenance and operation. In this case, additional specialist operators and mechanics have been assumed depending on the optional programs enacted. These have been included at the current YZC staff rates, plus 30% for short term contracts, assuming that prior workers are brought back to perform these duties.

Costing for all underground work was assumed to be conducted by an outside contractor, as was the case during operations. Historic rates from Procon were assumed for all underground work with a premium of +30% added.

Support costs for all YZC personnel have been estimated at approximately $116 per worker day. This is based on the cost of commercial travel, charter flights, grocery flights, and allows a camp support cost of $75 per worker day. Support costs for underground workers are estimated to be $152/day, based on the higher commercial flight costs, as the workers are not usually from Western Canada.

2.13.2.2 Equipment Operation

Most equipment proposed to be used for the work outlined in the TCP exists on site and is owned by YZC. Ownership costs have therefore not been included except in the case where the equipment is under lease, in which case an additional rental price was included to honour the lease for the duration of the work. Hourly operating costs were derived by determining the rated hourly fuel consumption of the relevant equipment and multiplying by a fuel supply rate of $1.09 per litre (which includes a 10% premium on diesel prices at the end of June, 2015). Additional charges were then estimated by scaling for parts and maintenance costs based on data from another operation.

Rates for contractor equipment were derived from an independent quotation from a contractor to a regular favourable client in BC. These rates include the equipment and its operator. As these were preferred rates, a premium of 30% was added to reflect the mine’s remote location in Yukon.

2.13.2.3 Supplies

All supplies were included at current supplied price, plus a 30% premium to reflect the lower consumption and desirability of the client to local vendors.

One exception is fuel. The most recent fuel price, derived from vendor invoices, is $0.99 per litre. A +10% premium was assumed for fuel supply, resulting in an assumed price of $1.09 per litre for diesel. A price of $0.90 was assumed for propane, with the same +10% premium applied, resulting in a price of $0.99 per litre.

Fuel for the TCP is planned to be stockpiled on site in the existing fuel tank farm during the six months of road operations for subsequent consumption through the winter months. This results in a “seasonal fuel adjustment” in the Budget, as shown in Table 2-5.

An inventory of current supplies was undertaken at site and the requirements needed to complete the programs were calculated using the available material on site, plus the estimated costs for additional purchased support supplies to meet the overall program proposed.

2.13.2.4 Contingency and Premiums

To accurately represent the costs to company going forward, premiums have been applied to most cost elements as follows:

- Manpower: A premium of +30% has been applied to all contractor rates. An annual retention bonus of one month’s salary is assumed for all staff, applied to the month of October.
- Supplies: A premium of +30% is applied to most supplies costs, +10% for fuel
- Equipment: A premium of +30% has been applied to all equipment rental and parts replacement costs.
- Added to these premiums, a contingency of 30% has been applied to all costs.

Table 2-6: Detailed Temporary Closure Plan Costs by Year (thousands of dollars)

COST BUILDUP							2015	2016	2017	2018	2019	2020
C&M Personnel												
Role	**#/day**	**rotation**	**Payroll**	**$/day ea**	**Support $/d**	**$/mo**						
3 Supervisor	1	3wk in/3wk out	2	700	174.07	26,222	184	341	315	315	315	315
1 Mechanic	1	3wk in/3wk out	2	715	174.07	26,672	187	347	320	320	320	320
5 Electrician	1	3wk in/3wk out	2	667	174.07	25,245	177	328	303	303	303	303
6 Enviro Tech	1	3wk in/3wk out	2	578	174.07	22,562	158	293	271	271	271	271
Power Generation												
	Fuel, l/d	**Fuel Price, $/l**	**Cost, $/d**	**$/mo**	**O&M$ (5%)**							
Large Genset (CAT 3516B)	5,144	1.09	5,893	176,801	8,840	185,641	560	12	12	12	12	12
Convert Power for Small Genset						30,000	50	-	-	-	-	-
Small Genset (350 kW 3PH 600 V)	768	1.09	880	26,397	1,320	27,717	75	299	299	299	333	333
Backup Genset (JD 300 KVA)	786	1.09	825	24,747	1,237	25,985	8	31	31	31	-	-
Annual Maintenance	2 workers	14 days	12 h/shift	1,200 $/shift		33,600	17	17	17	17	-	-
Mobile Equipment for Site Maintenance - Assume Road is Closed Oct - March, C&M Staff Operate Equipment On Site												
ID# Description	**h/a**	**$/h**	**Usage**									
1 Excavator	100	60	repair roads, clear culverts			6,013 $/a	2	6	6	6	6	6
2 Art. Truck	20	63	misc haulage			1,264 $/a	1	1	1	1	1	1
3 Dozer	30	86	road maintenance			2,583 $/a	2	3	3	3	3	3
4 FEL	192	68	snow removal, load sand truck			13,132 $/a	6	13	13	13	13	13
7 Grader	600	70	grade runway, snow removal			41,748 $/a	21	42	42	42	42	42
8 Vacuum Truck	384	52	transfer sump water			19,888 $/a	12	20	20	20	20	20
9 Sand Truck	96	52	sand site roads			4,972 $/a	2	5	5	5	5	5
10 Pick Up Trucks	2,160	19	site travel - assume 3 trucks + ambulance			41,894 $/a	21	42	42	42	42	42
11 Quad	48	19	site travel for env. sampling			933 $/a	1	1	1	1	1	1
12 Snow Machine	48	19	site travel for env. sampling			933 $/a	0	1	1	1	1	1
Annual Maintenance	2 workers	28 days	12 h/shift	1,200 $/shift		67,200	67	67	67	67	-	-
Haul Ore and Waste Stockpiles to Waste Pad				122,452		122,452	122	-	-	-	-	-
Other												
Environmental Monitoring		surface water assays		45 per year	420 $ea	18,900 $/a	10	19	19	19	19	19
		groundwater assays		36 per year	290 $ea	10,440 $/a	5	10	10	10	10	10
		bathymetric survey of ponc		1 per year	5000 $ea	5,000 $/a	5	5	5	5	5	5
Training and Certification		allowance				20,000 $/a	10	20	20	20	-	-
Spill Kits				12 per year	500 $ea	6,000 $/a	3	6	6	6	6	6
Environmental Reports		by off site consultant		12 per year	3,000 $/mo	36,000 $/a	18	36	36	36	36	36
WTP Research		by off site consultant				30,000 $/a	-	-	-	-	-	-
Annual Tailings Dam Inspection		by independent engineer		1 per year	10,000 $ea	10,000 $/a	30	30	30	30	30	30
Propane for camp		20 litres/worker day		2,970 $/mo		35,640 $/a	21	36	36	36	36	36
Misc Supplies and services				12 per year	1,000 $/mo	12,000 $/a	6	12	12	12	12	12
Internet				12 mos	1,000 $/mo	12,000	6	12	12	12	12	12
Install Mine Plugs			Portal			186,700	-	187	-	-	-	-
			Raise			131,600	-	132	-	-	-	-
Install Biopass System							-	-	-	-	-	-
Passive Water Treatment of TSF				research			-	10	10	-	-	-
				application			20	10	10	10	10	10
				sampling			3	10	10	10	10	10
Fuel Adjustment							160	-38	6	13	-3	-5
						Subtotal	1,968	2,366	1,991	1,988	1,871	1,869
					30%	***Contingency***	*590*	*710*	*597*	*596*	*561*	*561*
						TOTAL	**2,558**	**3,075**	**2,589**	**2,584**	**2,432**	**2,429**
						Cumulative TOTAL	**2,558**	**5,634**	**8,222**	**10,806**	**13,238**	**15,667**

3 PART II: RESUMING OPERATIONS FROM TEMPORARY CLOSURE

The resumption of mining and milling operations at Wolverine will require a significant improvement in metal prices, plus time and additional expenditure. The following is a brief discussion of work that must be performed, area-by-area, prior to any resumption of operations. This is not an exclusive list of requirements to re-start operations, but highlights the improvements that are necessary to make any future resumption of operations successful.

3.1 Underground Mine

3.1.1 Main Ramp De-watering and Rehabilitation

Currently, the mine is passively filling with groundwater discharge and there are no near-term plans to resume underground pumping operations. It is therefore assumed that the mine will be in a flooded state when operations are resumed. An extensive de-watering program will thus be required prior to resuming mining operations.

In April 2015, an experienced professional geotechnical engineer completed a comprehensive inspection of the Main Access Ramp (MAR), and other parts of the mine. Over twenty locations on the ramp and associated infrastructure were identified in the Underground Inspection Report as requiring rehabilitation work (see Section 2.2). In addition to these areas, other areas of concern will become apparent on re-entry, as the mine undergoes a cycle of saturation and drainage.

Because of the nature of the host rocks, dewatering of the mine will have to be completed in a progressive and staged manner, as follows:

- Pump a segment out;
- Assess the stability of the back and walls;
- Conduct any necessary rehabilitation and support work; and
- Advance the pumps.

This work will have to be done under the direction of a registered geotechnical engineer and with active ground control work crews and equipment.

3.1.2 Mine Plan

The current Reserve projects only two to three more years of operations, in the absence of further drilling to identify more Resources and raise the confidence in these Resources to Reserve status. Thus advance drilling work will form a part of any re-opening process. The mine life may also be extended by drilling of potential mineralisation on adjacent claims. As a consequence, any plan to re-develop the mine will also need to address the opportunities to improve Resource to Reserve status, plus extend and increase known Resources.

To do this, first it will be necessary to more accurately define Resources and Reserves within the current mine envelope through a program of close spaced definition drilling from underground, prior to mining any zone. This may require a hangingwall or footwall drift to provide appropriate drill platforms. Exploration drilling should also be carried out, both from surface and underground, to extend mining zones outside the currently known resources and thus extend mine life. The most likely way to further prolong operations is to acquire the down-dip extension of the orebody that runs off the current YZC claims. These claims are currently owned by others.

Before resuming mining operations and after demonstrating additional resources, a Comprehensive Mine Plan will have to be prepared, including Resource and Reserve re-estimations; followed by an economic evaluation of the proposed operation, leading to re-financing of the mine start up.

This comprehensive mine plan will also need to address and correct several deficiencies in prior operations, including the following:

- Mining operations must be supported by more closely spaced diamond drilling to control and direct underground mining.
- The mining drift widths should be re-evaluated. Stability is not a function of mining width, but of the square of the mining width. A 6 m mining width would therefore require 225% more support to stabilize than a 4 m wide heading ($6^2/4^2 = 2.25$).
- A reduction in mining width will necessitate a re-evaluation of the mining fleet, particularly the bolting units. Because of time delays between now and resumption of mining at Wolverine, it is unlikely that the current mining equipment will be available and operationally ready for any resumption of mining. The operation should therefore view start up as an opportunity to replace current models with units that are rationalized to smaller, more controllable mining widths.
- Disposing of waste material underground will also require mining trucks and/or scoops, to be fitted with ejector buckets for bucket tipping of waste returned to underground and to avoid over-height drifts.

Previously, because of poor contractor equipment availability, YZC purchased the mining equipment for the operation and it is not considered realistic to expect a contractor to have the right equipment for this work. As a consequence, the extensive use of a mining contractor should be discontinued and replaced by more cost-effective owner employed work crews. Philosophically, while contractors are often used for capital development programs, they are generally not used for ongoing operations because of their premium price, and future operations should follow this pattern.

A significant proportion of the remaining Reserve underground is below backfilled sill drifts for the level above and as such, much of this high-grade ore Reserve abuts zones filled with lightly cemented mill tailings. The strength and quality of any paste fill from the sill level above, that will be exposed while mining the residual ore below, will require a clear understanding and may require some form of additional support to allow successful mining. The development of the mining method for these sill remnants and the support of the mining drive against areas of paste fill will be crucial to the mine plan.

Any future mine plan would benefit enormously from the incorporation of a dense media separation system (DMS) in the mill, as it would allow the mining of narrow high-grade intersections of ore that would normally result in heavily diluted headings, or tipping of the complete round to waste. DMS plants typically reject 30-40% of the feed while losing 3-5% of the contained metals. Prior testwork on Wolverine ore indicated up to 30% rejection of material fed to the DMS.

The use of DMS would have a number of additional benefits, including the raising of head grades to the mill, the reduction in the amount of carbonaceous material reporting to the float circuits, reduction of tailings volumes, since the DMS rejects are pumped underground with the paste fill, levelling of the grades fed to the mill and the ability to take low grade material and turn it into more economical feed to the mill. Additionally the DMS can be used to process the surface waste dumps, providing they contain some ore and effectively act as a mechanism to get this additional waste back underground as part of the paste fill.

3.2 Processing Plant

The processing plant (mill) has been prepared for a long-term suspension of operations. Readying it to operate once again would require a methodical program of re-commissioning of all equipment. At present, all gearboxes have been topped off with oil. These will have to be drained and refilled with new oil. The mills will have to be returned to their pinions. All lines will have to be reconnected and all pumps re-assembled. The DeltaV system will have to be updated and re-commissioned. All reagents will have to be topped up and replaced where appropriate.

To improve the economics of the operation, a dense media separation plant (DMS) should be added to the processing plant. A DMS plant separates out the mill feed based on the specific gravity (s.g.) of the individual rocks in the mill feed. The Wolverine Mine has a significant difference in s.g. between ore at ~3.7 t/m^3 and waste rock at 2.7 t/m^3. A dense media plant can be used at a separating density of approximately 3.0 t/m^3, splitting the difference between ore and waste, causing the waste to float and the ore to sink.

The type of DMS selected has to consider the softness of the carbonaceous argillites and as such would most likely be a bath, or drum type system. The scrubbing action of the pumps in any cyclone based system will result in the excessive generation of fines during the DMS process and as such will lead to this fine material getting into the medium and across to the float circuits, defeating part of the reason for installing the DMS plant. This is the main reason why, subject to testwork, a bath style plant would be preferred.

The DMS process generally improves milling operations substantially, for the following reasons:

- The ore fed to the flotation circuits in the mill is higher grade. Higher grade usually results in higher recovery overall.
- Grade fluctuations in the mill are damped. The mine regularly extracted ore that is massively diluted, but too valuable to throw away. Pulses of such material result in big swings in head grades, negatively impacting recoveries.
- The effect of “other material”, such as shotcrete, which introduces lime in the shotcrete cement into the feed to flotation affecting (raising) the flotation pH, is greatly reduced.
- A significant percentage of the carbonaceous argillites are rejected within the DMS process, improving recovery and reducing reagent consumption.
- Fewer reagents are required, as a significant portion of the mill feed (30 to 40%) does not pass on from the DMS to the flotation circuit. Also, assuming the DMS operation is efficient, the use of carbon depressants in the flotation circuit can be reduced or avoided.

- Power requirements for the milling operations are greatly decreased, as waste rock is rejected by the DMS, prior to the grinding mills. As the site operates with costly diesel-generated power, this is a significant cost consideration.

Use of a DMS on the front end of the mill, post the crushing circuit, will allow the Mill to operate more independently of the mine. Current considerations for a re-start plan are for a mining operation producing at 1,200 tpd, 350 days per year. The mill, subject to testwork, could however operate about half of this time, with planned maintenance during the shut down periods. The existing crushing plant on the front end of the mill, can easily handle 2-2,500 tpd from stockpiled ore. This would then feed to a 2,500 tpd DMS plant and associated fines treatment system. The DMS system would then feed the grinding and flotation circuit operating at 1,700 tpd on washed, separated, higher-grade ore post the DMS system. The grinding mills, flotation circuit and associated filtration and pumping equipment are adequately sized to handle the product from the DMS plant. This area would thus require no major changes.

The paste backfill system would similarly have to be operated only when the mill was operating. This will require scheduling of underground crews and also of mill crews accordingly, but will result in significant operational savings.

3.3 Power Generation

In order to resume operations, the large gensets would have to be brought back into operation. Six of these gensets are in good working order. One requires limited repairs and one is stripped for a major rebuild. While it is possible that a mill with a DMS plant will operate on only six sets, it would obviously be preferable to have all eight sets operating. Additionally, the use of the large gensets allows the DeltaV system to be reconnected to control the site. Because of the fuel consumption characteristics of the large gensets, the access road would have to be operated year-round during milling operations to provide the necessary quantity of diesel for operations.

3.4 Mine Waste Disposal

The DMS plant will generate a considerable quantity of crushed washed waste rock for disposal, (approximately 30 to 40% of the mill feed). As this material will be a fairly small size, say minus ¾ inch, it should be possible to mix it with the paste tailings and pump it underground as fill.

The DMS also provides an opportunity to dispose of some or all of the waste stored on the temporary waste pad (Waste Pad #1) by returning it underground as backfill. The stored waste on Waste Pad #1 should therefore be run through the crusher and DMS plant during commissioning and disposed of underground as waste fill, or incorporated into the paste fill. It is likely that the low-grade mineralization in this material will be sufficient to pay the cost of crushing and DMS processing.

3.5 Water Treatment

3.5.1 Mechanical Water Treatment Plant

The primary concern for water treatment at the Wolverine Mine is selenium. All other elements can be treated using standard and relatively inexpensive methods. A series of passive treatment systems are intended to be developed and employed during temporary closure to treat all water on site, based on the Biopass concept as developed by Yukon College, that will likely result in the compliant release of much of the currently stored water in the TSF and any longer term seepage from the underground workings. However, a passive system cannot be employed for operations, due to the volumes of water to be treated. As such, an active mechanical water treatment plant will be required for ongoing operations.

A considerable amount of research has been undertaken for YZC by a variety of specialists, aimed at treating mine contact water, primarily for the purpose of removing selenium. Two similar mechanical processes have been investigated: Electro-Biochemical Reactor (EBR) and Fluidized Bed Bioreactor (FBR). A report was generated by Envirogen Technologies of Kingwood, TX in July 2014, to present these two mechanical options.

Both systems require three pre-treatment steps: passing the water through an equalization basin to reduce fluctuations in the TSF wastewater chemistry and settlement of entrained solids; filtration to screen small stones, grit, and debris; and passing the water through heat exchangers to recover heat from the treated effluent water.

The EBR system consists of an anaerobic reactor pre-treatment vessel followed by two EBR vessels and one anaerobic post-treatment vessel. The FBR system consists of one anaerobic bioreactor, one fluidized bed bioreactor, followed by a solids separation tank. The settling tank supernatant then enters a membrane tank with four submerged ultra-filtration membrane cassettes for filtration of the water, removing the reduced elemental selenium from the treated water.

Envirogen has provided a preliminary engineering report for both systems (July 2014) that specifies the capital and operating costs for the two systems, estimated for a plant to treat the mine and mill operating at 100% of name plate capacity, or 1,700 tpd. The costs of the two systems are very similar at $11.9 M for the EBR system and $11.6 M for the FBR system. Annual operating costs for the EBR system are less, estimated at $552 K/a versus $900 K/a for the FBR system. This is largely due to increased labour requirements for disposal of residual solids.

Envirogen also provided a schedule for the construction and installation of the plant, which is estimated to be 32 months from inception to operations. The first twelve line items of the schedule (10 months), involving the pilot plant and bench scale testwork, have already been completed. The schedule shows that the plant could be mechanically complete in 19 months and would require an additional 4 months for commissioning prior to full operations.

It is postulated that a smaller plant would be suitable for ongoing operations, perhaps at 50% capacity according to the following rationale:

- The proposed resumption of operations at the Wolverine mine, as contemplated above, would be at a greatly reduced mining rate of 1,200 tpd. This will reduce the volume of water to be treated.
- Water in the current TSF, which contains selenium, will be passively treated during the TCP period; thus the bulk of the contained water could be released from the pond prior to the resumption of operations, generating additional storage capacity within the TSF, such that during resumption of operations, treatment would not be required to keep pace with operations.
- Ongoing passive treatment of some of the surface water flows will mean that less water reports to the TSF for subsequent treatment from these sources.
- The treatment plant can also be run year-round rather than for 7 months of the year as currently specified. This would require heating the water, which can be achieved using excess heat from the current generating plant via an extension of the glycol loop. This will require additional testwork, however, the heat recovery system within the mechanical treatment plant is anticipated by Envirogen to be very efficient, resulting in very little added heat requirement for the feed water.
- Finally, if the initial plant as constructed is built to half the expected final capacity, it will be a simple matter to construct a second similar plant, in the event that the single smaller plant capacity is found to be insufficient.

3.5.2 Passive Treatment During Operations

As stated, a passive water treatment system will not meet the ongoing needs of operations. However, the high cost of the mechanical treatment plant prompts the consideration to construct another water-only pond and use it to batch treat water prior to release. A trade-off evaluation would have to be done, but given the high costs, long scheduling timeframes, and uncertainties associated with the mechanical treatment plant, this is may well be a viable alternative and is worthy of further investigation

4 PART III: RECLAMATION AND CLOSURE PLAN (RCP)

4.1 Significant Modifications to Version 2013-05

There are two significant items in which current short-term closure activities have deviated from the previous Reclamation and Closure Plan (V2013-05):

1. The mine waste stored on surface has not been returned underground as backfill; and
2. An active water treatment plant was not installed.

This Reclamation and Closure Plan (RCP) has been prepared to accommodate these realities, with the following significant changes:

- Most of the waste rock in the Temporary Waste Pile #1 will be retained at its current location. As part of the proposed RCP, it will be reshaped with more stable slope angles and the excess material will be hauled to Waste Pile #2 for permanent disposal. The waste will then be capped with glacial till material and topsoil then seeded and a Biopass will be installed to treat seepage into the existing sump.
- Assuming no further mining operations on the site, the TSF will be treated using a batch system, by stimulating sulphate and selenium reducing microbes through creation of a reducing environment within the TSF through nutrient addition and then by adding a coagulant such as ferric sulphate to precipitate metals out of solution. A Biopass system will then be installed downstream of the TSF to passively treat water released to the environment from the existing spillway.

4.2 Water Treatment Options

The single biggest concern during closure is protection of the receiving environment through water collection and treatment; in particular the removal of metal contaminants, specifically selenium, from contact water to permissible discharge concentrations. Two water treatment systems are currently assumed for this RCP, based on the current Care and Maintenance status of the operation. These two systems would be:

- Reducing environment and ferric sulphate treatment within the TSF; and
- Biopass treatment systems for potentially contaminated groundwater, waste rock seepage and TSF spillway overflow.

While considerable research has been undertaken on both systems, they will have to be developed further for application to this RCP. These two systems are detailed below.

There is no plan to construct an active mechanical water treatment plant within this RCP as it simply deals with reclamation and closure, following on from only those activities outlined in the Temporary Closure Plan (Section 2).

4.2.1 Ferric Sulphate and Microbial Stimulation

To promote microbial treatment of the tailings supernatant during the winter, organic amendments (e.g. methanol) and nutrients would be introduced to the pond to foster a more reducing environment, which will promote the conversion of selenate to the more reactive selenite, and allow subsequent biological reduction of the selenite to elemental selenium, which will precipitate out of solution. Reducing conditions in the sub-ice pond would also promote the activity of sulphate reducing bacteria, which will result in the co-precipitation of other metals of concern (e.g., copper, cadmium and zinc).

The on-site stock of SMBS (sodium meta-bisulphide) is suggested as a suitable agent to add to the pond for this purpose. Ideally these agents would be introduced just prior to ice-up to allow the reducing agents to fully develop in an oxygen-poor environment under the ice.

Once the ice has melted from the tailings storage facility in the spring, a batch treatment of the water collected in the tailings storage facility using ferric sulphate is proposed. Ferric sulphate is a primary coagulant that complexes with metal ions. The flocs (clumps of fine solids bound together in the form of a sludge), formed by the iron complexes also assist in adsorbing other contaminants. The sludge produced from ferric sulphate treatment is a stable red sludge, retaining the metal contaminants bound in the sludge, and which will settle under water, on the interface between the existing settled tailings and the supernatant water in the tailings storage facility.

Treatment using ferric sulphate would require re-circulation of the pond water, with injection of ferric sulphate into the returning water, until the entire water volume has been treated. The water would then be left to settle out, and the metals coagulate into flocs and settle out of the water column onto the tailings below. The supernatant water would then be able to be discharged to the environment, following confirmation that the water meets discharge objectives. The ferric sulphate treatment would be able to be repeated until the desired water quality is achieved.

Ferric sulphate was successfully used to treat the underground discharge in the 2006-2009 care and maintenance program at the Wolverine Mine, when batch treatment of water with ferric sulphate was successful in achieving the discharge criteria in the Type A Water Use Licence QZ04-065 for discharge to Go Creek.

Note that this system is not currently considered as a viable option for the re-start of mining and milling operations, when a mechanical treatment system is expected to be required to treat the extra volume of water from processing and underground pumping. Batch treatment with ferric sulphate requires that the pond be kept still, rather than allowed to recirculate through ongoing milling operations. Such a batch treatment process could however be employed as a final closure option.

4.2.2 Proposed Biopass Treatment Systems

Biopass treatment systems are the term used to describe a passive treatment channel, typically containing organic based biological material, which promotes the development of microbes that fix and precipitate the metals in the water passing through the Biopass system. Biopass systems can also contain chemical treatment materials, such as limestone, activated carbon or other absorptive materials. Chemical treatment passive systems may also called "permeable reactive barriers". Biological systems generally utilize naturally occurring microbes to precipitate metals as metal sulphides and thus dissolved selenium (selenate) is reduced to solid phase elemental selenium through microbial reduction. Chemical, lime based systems utilize lime to neutralize acidity and treat mine water drainage, while activated carbon is an absorptive mechanism to remove contaminants suspended in the effluent.

For the Wolverine Mine closure systems, the proposed Biopass systems include:

1. A biological, carbon based treatment system installed in Wolverine Creek to intercept potentially contaminated groundwater, which has potentially come from contact within the workings from the closed and plugged mine.
2. A biological, carbon based treatment system installed in the seepage sump at the Waste Pile #1.
3. A chemical, absorptive based treatment system installed in the Go Creek drainage to intercept and polish TSF overflow prior to discharge to Go Creek.

These systems, as well as the testwork previously conducted, are described below.

4.2.2.1 Wolverine Creek Biopass

The proposed Biopass system will be constructed in the Wolverine Creek channel along the stretch of creek that is known to contain higher metal concentrations (e.g. 400 m long) and could potentially receive groundwater with high selenium and other metal concentrations derived from seepage water from the Wolverine underground workings (Figure 4-1 and Figure 4-2). Un-impacted water in Wolverine Creek, upstream of the Biopass channel, will be diverted along the western margin of Wolverine Creek in a lined channel and re-introduced into Wolverine Creek in the lower reach that is not adversely affected by poor quality groundwater.

The Biopass will be approximately 2.5 m deep and 3 m wide and will collect groundwater that naturally discharges to Wolverine Creek (Figure 4-2). Deep groundwater that does not enter into Wolverine Creek will flow towards Little Wolverine Lake where no impacts to water quality are predicted to occur. The proposed excavated channel that intercepts groundwater will be filled with an organic substrate and amendments to support the locally generated sulphate reducing bacteria and micro-organisms that will reduce dissolved selenium to solid phase elemental selenium.

A gravel layer (0.15 m) will cover the organic substrate to facilitate (lateral) drainage of the upward flowing treated water. The drainage layer will be sealed at the top by an impermeable geomembrane liner to limit exchange of water and gas with the overlying cover (0.25 m) of topsoil to protect the liner. Rainfall and surface runoff that infiltrates into the cover layer will be collected in lateral sand drains to prevent water saturation of the topsoil cover.

The groundwater that discharges into the more permeable organic substrate will be biologically treated while moving in a down-slope direction. Collected groundwater will flow upwards and through the organic substrate where treatment will occur. Before joining the non-diverted section of Wolverine Creek, the

Biopass system will merge into a French drain, that discharges into Wolverine Creek. While the water exiting from the Biopass system is expected to be depleted of oxygen, this water will be subsequently combined with the diverted well- oxygenated water from upper Wolverine Creek. Moreover, this combined flow will then traverse steep terrain for approximately 1000 m before reaching the mouth of Wolverine Creek and, as such, is expected to be fully oxygenated by the time it reaches this fish-bearing reach.

The groundwater discharge rates that can be treated within the Biopass will depend on the porosity of the organic substrate layer and the total length of the Biopass. For example, by using a Biopass with a total length of 400 m, it will be possible to treat groundwater at discharge rates of approximately 2 L/s. Groundwater discharge rates in the treatment area are expected to be on the order of 0.5 L/s to 1 L/s, following installation of the hydraulic plugs in the portal.

The Wolverine Creek Biopass organic substrate content will be based on the laboratory testwork conducted to date (see Section 4.2.2.4), and future smaller trial Biopass systems as described elsewhere, and should incorporate a latent carbon source (e.g., wood chips and/or alfalfa) and a source of zero-valent iron (e.g., steel wool), which was found to drastically improve the selenium removal. While additional selenium and arsenic removal was noted in prior testwork through the use of ethanol to the bioreactor test systems, there was no significant change in the removal of other metals. It is therefore suggested that since ethanol drips are easily added to the Biopass system, these should not be installed on start up, but can be considered as an potential improvement should monitoring of the Biopass systems indicate further improvements in microbe activity (stimulated by feeding with ethanol), are required.

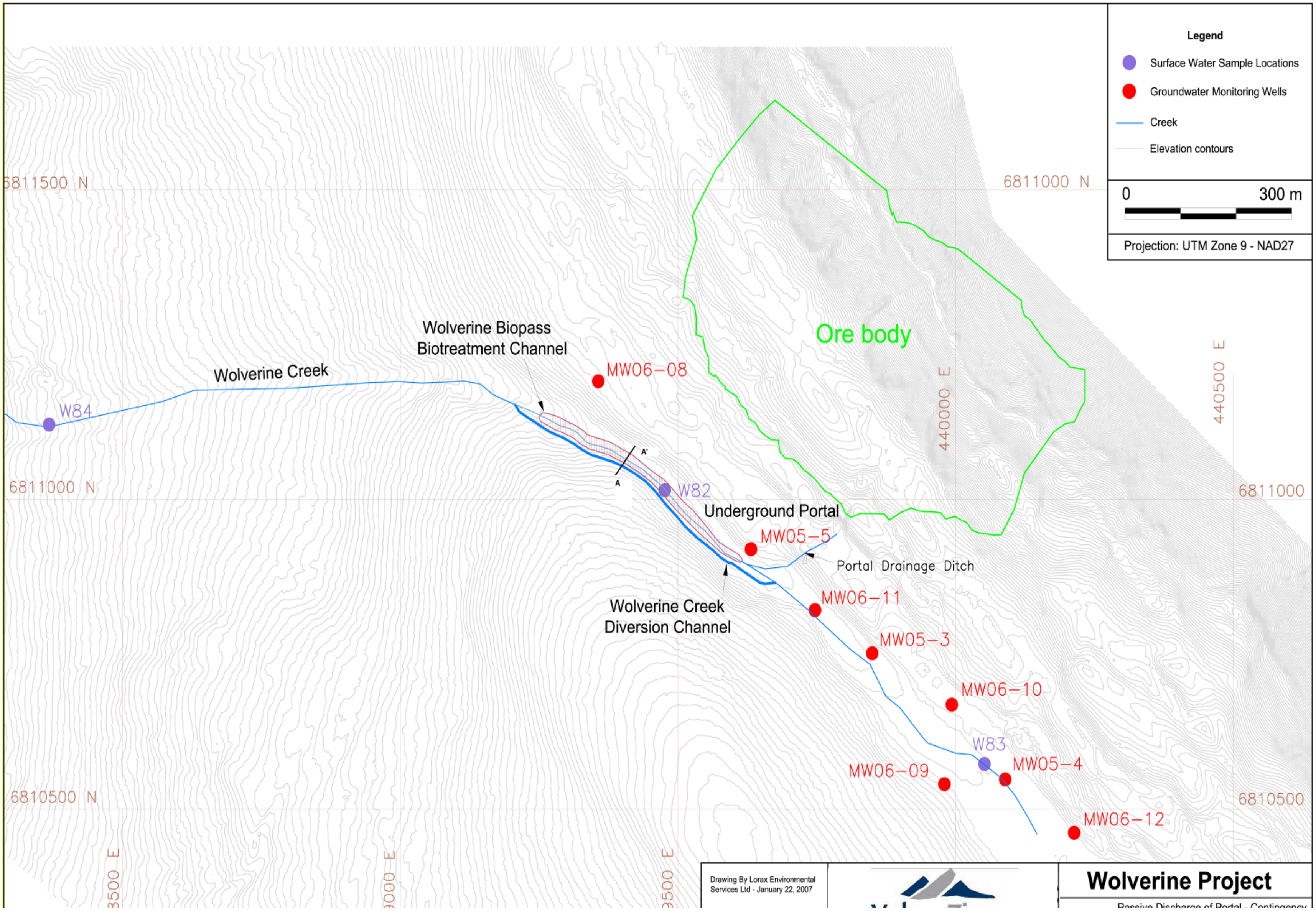

Legend
Surface Water Sample Locations
Groundwater Monitoring Wells
Creek
Elevation contours
0
300 m
Projection: UTM Zone 9 - NAD27
6811500 N
6811000 N
6811000
6810500 N
6810500
440000 E
440500 E
Ore body
Wolverine Biopass
Biotreatment Channel
Wolverine Creek
W84
W82
W83
MW06−08
Underground Portal
MW05−5
Portal Drainage Ditch
MW06−11
MW05−3
MW06−10
MW05−4
MW06−09
MW06−12
Wolverine Creek
Diversion Channel
A'
A
Drawing By Lorax Environmental Services Ltd - January 22, 2007
Wolverine Project

Figure 4-1: Location of Wolverine Biopass System and Diversion Channel

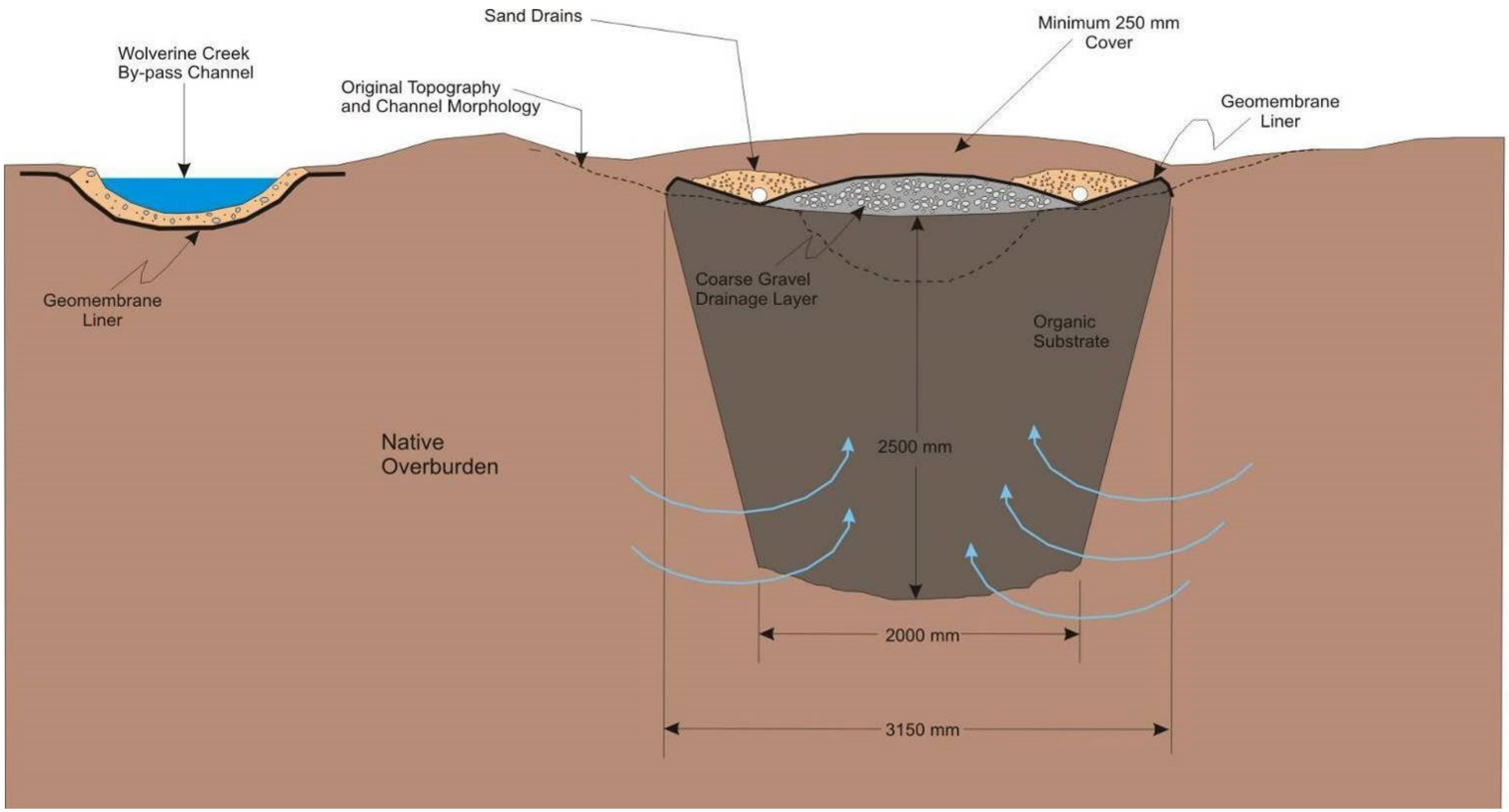


Figure 4-2: Cross-Section along Wolverine Creek Illustrating Biopass Design and Diversion Channel

4.2.2.2 Waste Pile #1 Biopass

Waste Pile #1 (*Temporary Waste Rock and Ore Storage Facility* on Figure 1-3) was originally constructed in 2005 to contain ore and waste rock excavated from a bulk sample excavated from the mine. It is a lined facility whose seepage discharges to a sump at the south-east corner. Seepage collected in the sump is moved, via water truck, to the TSF as required. Water quality has been monitored in the sump as a condition of the Type B Water Use Licence (QZ01-051 – now expired). Summary statistics of water quality collected from 2012 – 2014 is provided in Table 4-1. Water chemistry in the sump is typically in exceedance of the Type A Water Use Licence QZ04-065 allowable discharge limits for cadmium, selenium and zinc. All these metals can be readily treated with a Biopass system, by co-precipitation of sulphides formed by sulphate reducing bacteria, or, by selenium reducing bacteria, under oxygen depleted systems.

Table 4-1: Water Quality of Waste Pad#1 Seepage Water (2012 to 2014)

Parameter	A Licence QZ04-065 ADL*	MIN	MEDIAN	MAX	MEAN
Ammonial Nitrogen	**5**	0.010	0.084	1.750	0.337
Total Arsenic	**0.05**	0.00030	0.00134	0.01900	0.00204
Total Cadmium	**0.002**	**0.0041**	**0.0182**	**0.0536**	**0.0182**
Total Copper	**0.015**	0.0059	0.0152	**0.3330**	**0.0287**
Total Lead	**0.02**	0.00187	0.00756	**0.36400**	0.02285
Total Nickel	**0.5**	0.003	0.079	0.233	0.100
Total Selenium	**0.02**	0.0190	**0.0547**	**0.1330**	**0.0668**
Total Zinc	**0.5**	**0.71**	**1.92**	**5.86**	**2.19**

*ADL = Allowable discharge limit for discharge to Go Creek

The proposed re-contouring and subsequent covering of the waste pile with glacial till is expected to minimize the infiltration of precipitation into and through the waste pile, and subsequent seepage collected in the sump. For seepage collected in the sump, a biological Biopass system (similar to that proposed for Wolverine Creek), is proposed (Figure 4-3). The Biopass system will be constructed below Waste Pile #1 and will be filled with organic substrate, mixed with creek substrate excavated from Wolverine Creek, to act as an inoculum for microbes, as well as organic carbon amendments and gravel to support the sulphate reducing bacteria and micro-organisms that reduce dissolved selenium to solid phase elemental selenium. A gravel layer (0.15 m) will cover the organic substrate to facilitate (lateral) drainage of the upward flowing treated water. The drainage layer will again be sealed at the top by an impermeable geomembrane liner to limit exchange of water and gas with the overlying cover of topsoil to protect the liner. Rainfall and snowmelt that infiltrates into the cover layer will be shed off the sides of the sump.

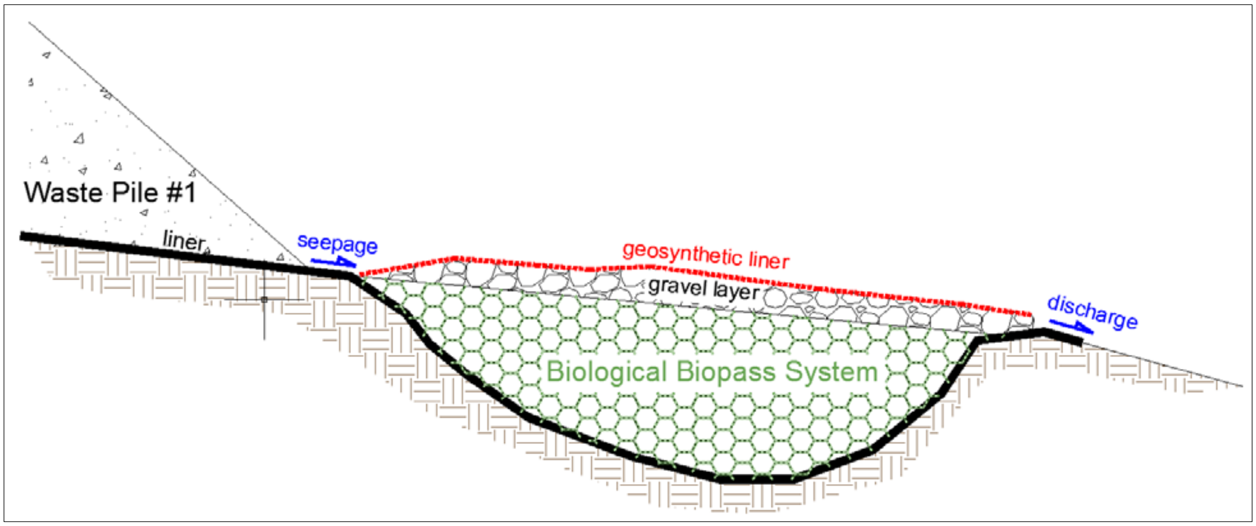


Figure 4-3: Proposed Waste Pile #1 Biopass System (not to scale)

4.2.2.3 TSF Overflow Biopass

Following seasonal treatment of the water stored in the TSF with ferric sulphate (Section 4.2.1), the water will overflow the TSF into the constructed spillway (spillway invert elevation 1,311.5 m), and subsequently into Go Creek during the summer months. Due to the uncontrolled nature of the discharge, a Biopass is proposed to be installed in the receiving channel to treat this discharge prior to entering Go Creek (see Figure 4-4).

The TSF Biopass is proposed to contain an initial filter material following by activated carbon. An activated carbon plant was installed during the care and maintenance program in 2005, which included a multi-media filtration system. It is proposed that the TSF Biopass utilize the existing multi-media and activated carbon previously brought to site, for the activated carbon active treatment plant, in a passive reactor configuration, as shown in Figure 4-5.

Materials existing on-site can be used to build the TSF Biopass below the TSF spillway channel. The Biopass may be constructed from existing rigid vessels (e.g., large reagent plastic totes), and the top cut off to allow filling and monitoring. The top should be replaced to prevent precipitation infiltration. The influent and effluent sides would be perforated to allow water to enter and exit the vessel, with geotextile filter fabric to retain the multi-media and activated carbon within the vessel. A geotextile filter fabric wall would also be installed between the multi-media and activated carbon sections of the Biopass. The use of large reagent totes would also allow for subsequent additional Biopasses to be added in a reactive train, if required.

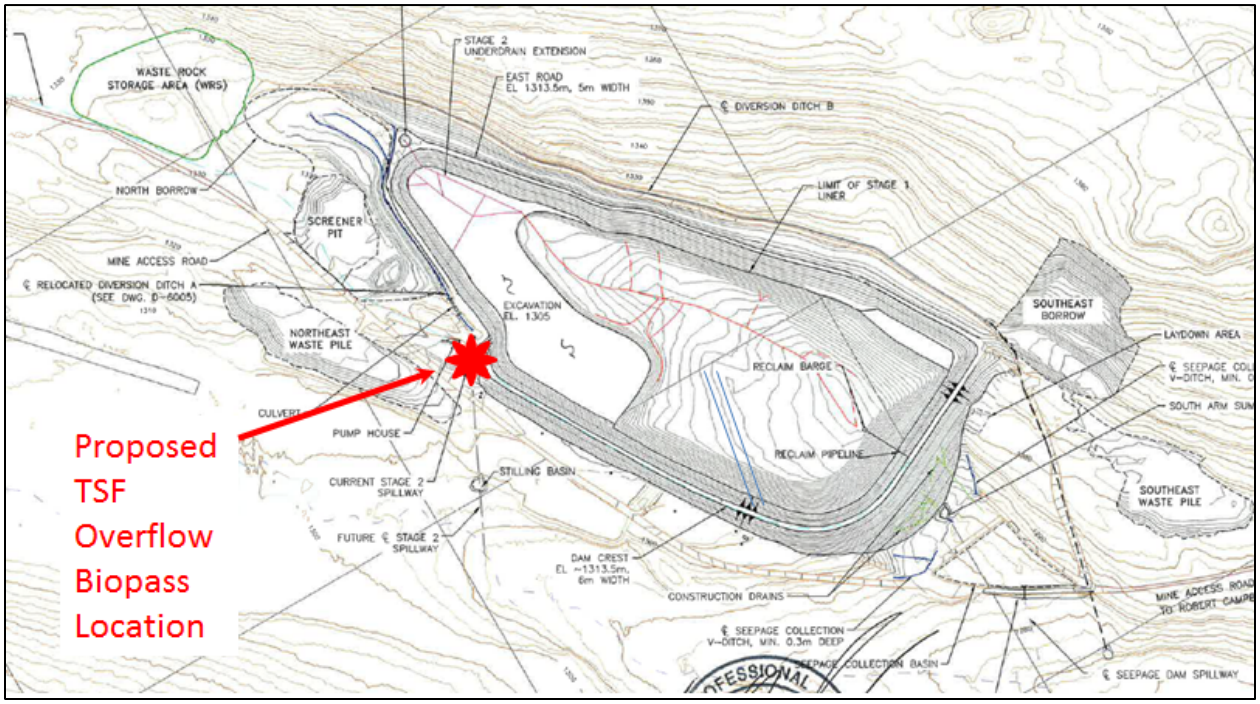


Figure 4-4: Location of Proposed TSF Overflow Biopass

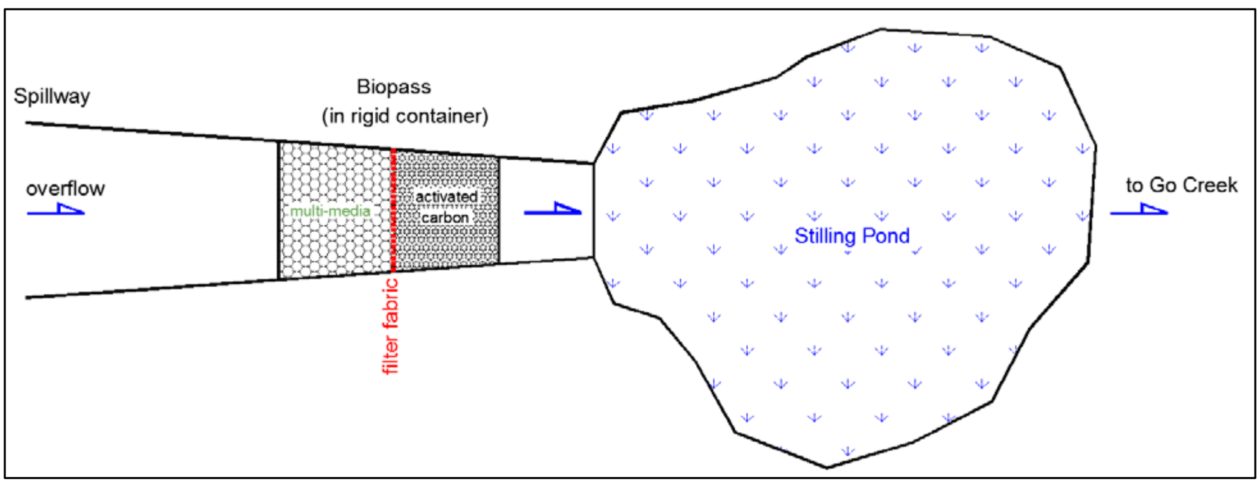


Figure 4-5: Proposed TSF Biopass System (not to scale)

4.2.2.4 Pilot Research and Testing

The biological Biopass concept is based around the use of microbes found within the Wolverine Creek system which either incorporate metals into their cell structure, or use the compounds as carbon or electrons donors, resulting in the metals being removed from solution in contaminated effluent streams. Due to the high incidence of metals in the Wolverine Mine area, the microbes found in the area are naturally predisposed to utilize these metals in their cellular processes. The Biopass process aims to provide the conditions necessary for these microbes to replicate and thus more readily remove contaminants from the contact water.

As the Wolverine Creek Biopass system was part of the initial proposed Reclamation and Closure plan, testwork has been ongoing since 2012 to define the design components of the Biopass system. This development and testing of the Biopass system was completed as part of a Royal Roads University Master of Science thesis in early 2012. Five columns were filled with varying compositions of gravel and Wolverine Creek substrate organics, and were un-amended (control column) or amended with manure, sewage sludge, zero-valent iron, or wood chips and alfalfa.

Selenium, sulphate and the other deleterious elements were significantly lowered within the control column and by the columns amended with sewage sludge. Sewage sludge greatly increased the rate at which the columns became reducing, thereby increasing sulphide precipitation and cadmium and zinc co-precipitation. The addition of zero-valent iron increased the sulphate and selenium removal to almost 100%. The addition of wood chips and alfalfa did not appear to greatly influence the removal mechanisms in the columns, but could affect the long-term success of a treatment system.

Subsequently, in December 2013, testwork was initiated at the Yukon College, as part of the work by the Industrial Research Chair, to further the design of a Biopass system, aimed at treating underground mine water from the active mine at Wolverine. Four bioreactors were prepared using sediment from Wolverine Creek, incubated and then fed continuously with dewatering effluent from the Wolverine Mine (Photo 4-1).

Different solid supports were compared (C5, C6: gravel/sand, C7: gravel/sand/ wood/lime and C8: gravel/sand/biochar), as well as ethanol addition (C5: without ethanol and C6, C7 & C8: with ethanol) to assess the role of ethanol in supporting microbe growth. Residence time was set at 69 days to mimic residence time expected in a proposed Biopass system (assuming underground water flow of 0.5 L/s). The reactors were setup in December 19, 2013 with incubation (no flow) until January 23, 2014.

Influent to the reactors was provided from underground mine dewatering from Sump 2. Ethanol was added to the influent to columns C6, C7 & C8 to enhance electron availability to the sulphate reducing bacteria. The effluent coming out of each reactor was collected in 2L jars over 1 week, every week for measurements of pH, total and dissolved metals and sulfate.

Photo 4-1: Experimental Bioreactor Set Up at Yukon College

The columns were run through December 2014, and the results are presented in Figure 4-6 through Figure 4-10 below, compared to the allowable discharge concentrations for discharge to Wolverine Creek from Type A Water Use Licence QZ04-065 (note logarithmic scale).

Initially, clogging of the tubing feeding in the reactors created some issues and prevented comparison between the C5-C6 reactors, however, this issue was fixed, and results for C5 and C6 are presented after 100 days, in the figures below.

Due to the variability in the influent concentrations, the cadmium, copper and zinc concentrations were also highly variable. Concentrations in the column effluents were comparable between the five treatments, indicating relatively little impact on removal from column amendments. All four columns were effective at achieving the discharge limits for cadmium, selenium and zinc and while none of the columns achieved the discharge limit for arsenic; however the ethanol-biochar column (C8) was most effective in this regard. The ethanol-biochar column was also most effective at removing selenium, with concentrations less than the detectable limit (0.7 µg/L) in many instances.

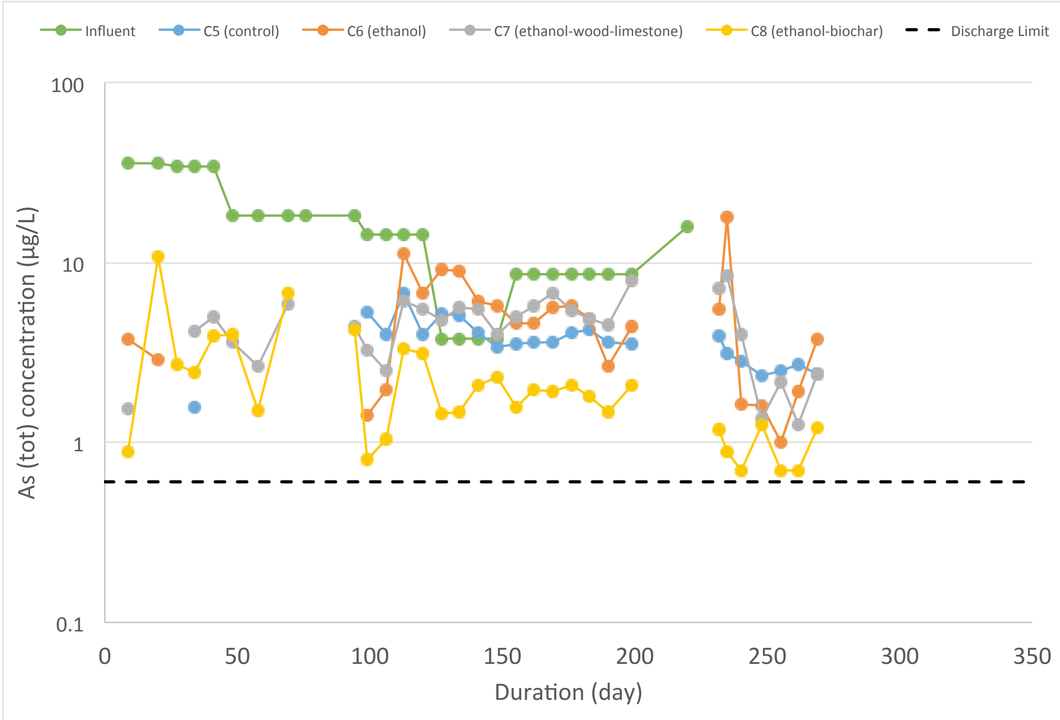


Figure 4-6: Total Arsenic Concentrations in 2014 Laboratory Bioreactors

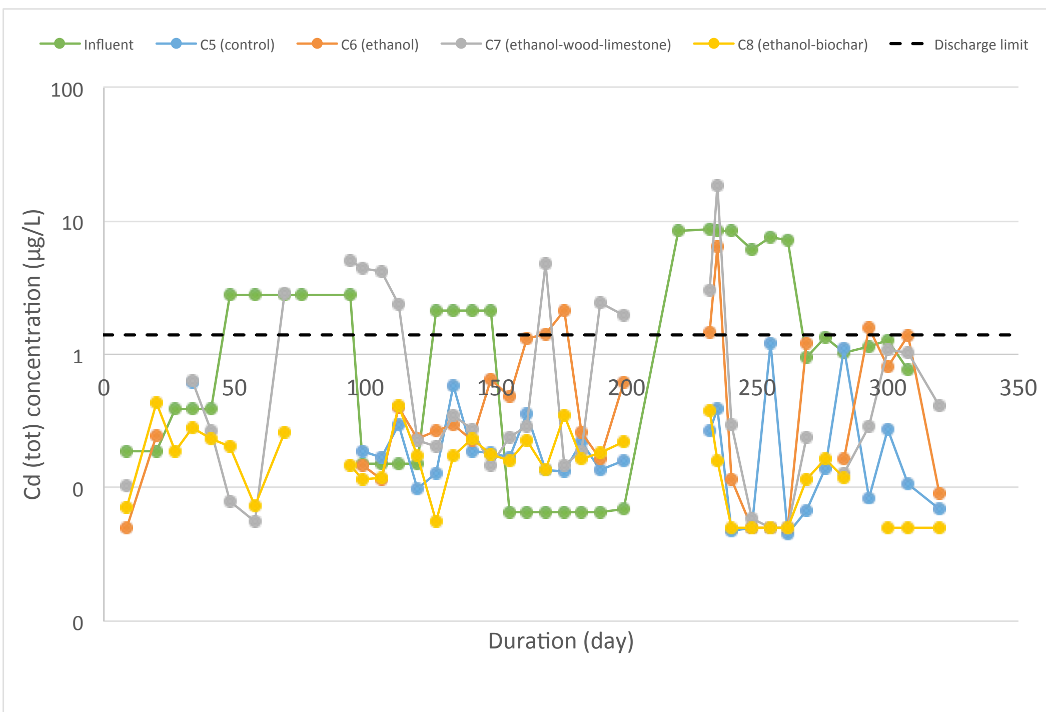


Figure 4-7: Total Cadmium Concentrations in 2014 Laboratory Bioreactors

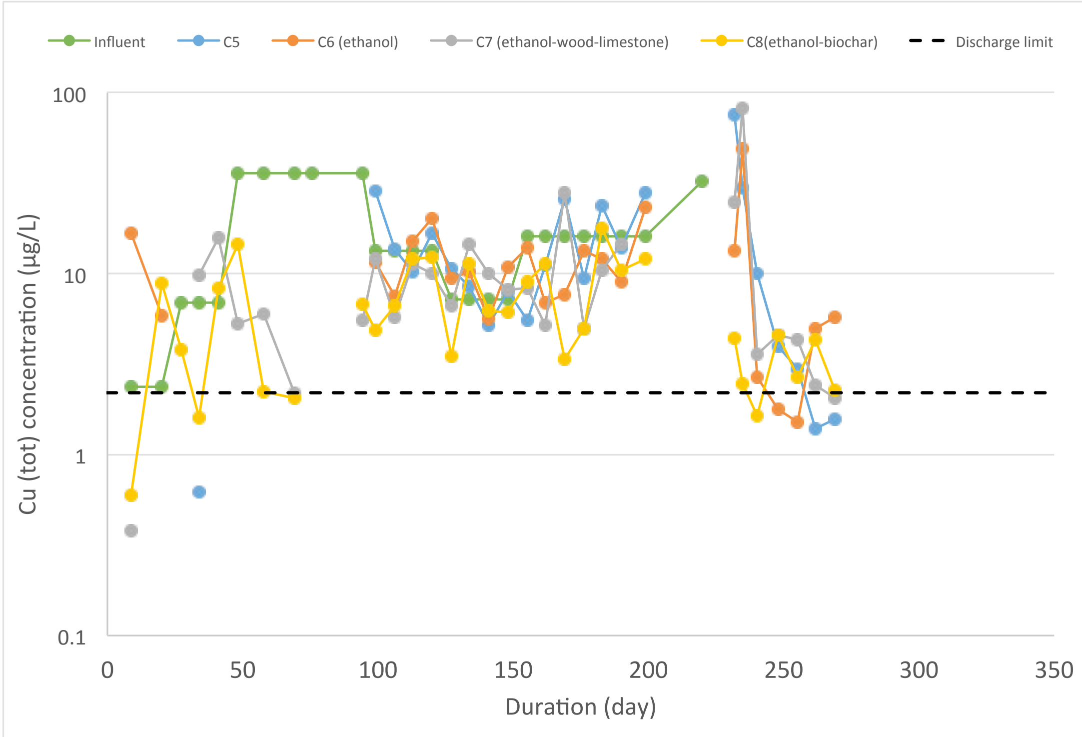


Figure 4-8: Total Copper Concentrations in 2014 Laboratory Bioreactors

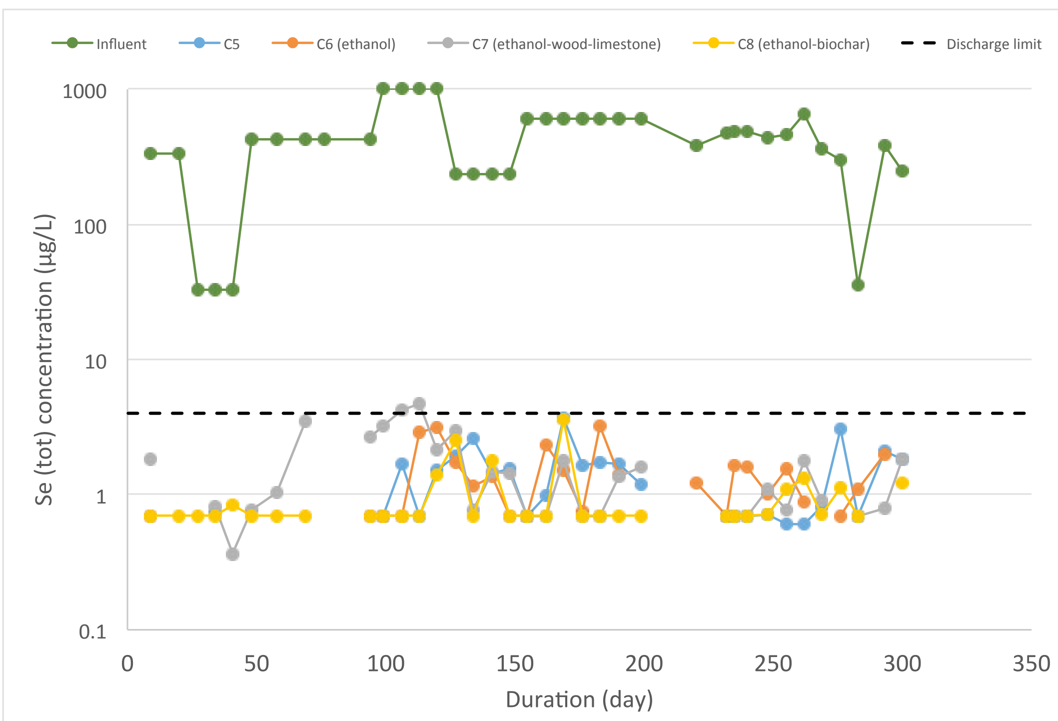


Figure 4-9: Total Selenium Concentrations in 2014 Laboratory Bioreactors

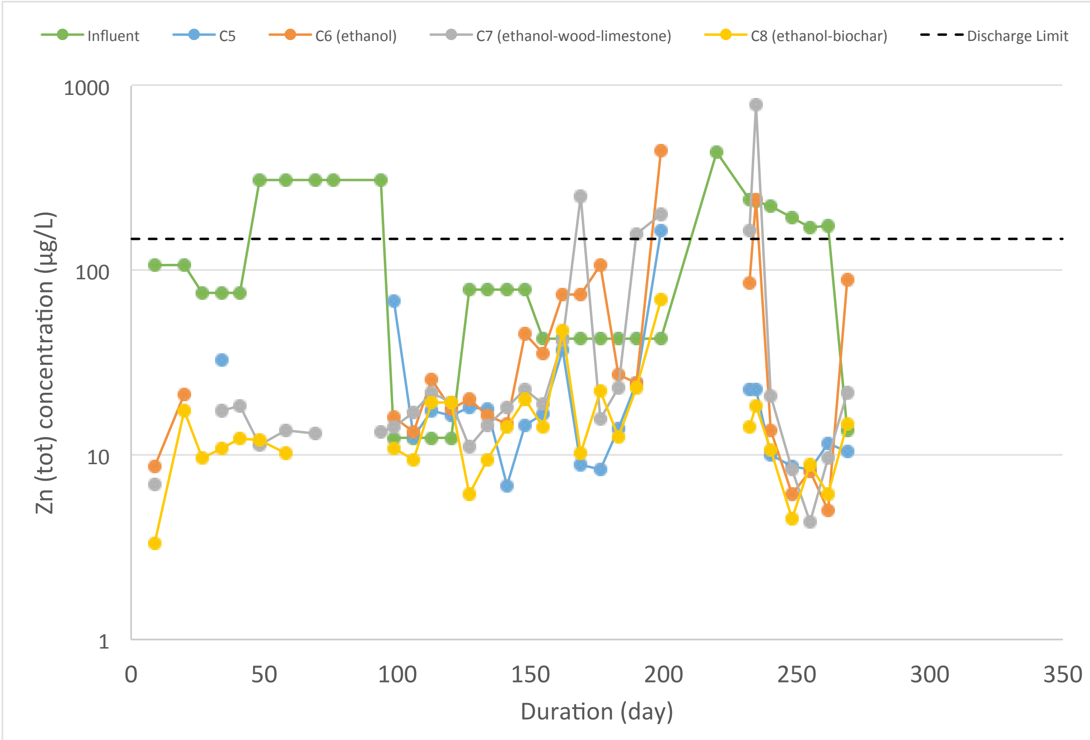


Figure 4-10: Total Zinc Concentrations in Bioreactors C5, C6, C7 & C8

These results indicate that while ethanol addition may enhance microbial activity (and hence metal co-precipitation), it is not necessary to meet the discharge objectives. Additionally, the inclusion of carbon amendments (wood) and sources of alkalinity (limestone) did not significantly change the quality of the effluent over the duration of the experiment (~320 days).

4.3 Re-vegetation

The primary objectives of land reclamation and re-vegetation at the closed mine is to provide short and long-term erosion control, to ensure land use is compatible with surrounding lands, and to leave the area as a self-supporting ecosystem.

An estimate for the sites to be re-vegetated (i.e., seeded and fertilized) was provided in Appendix A of the RCP 2013-05, and is summarized in Table 4-2. A total of ~70 ha is required to be re-vegetated. To determine the appropriate re-vegetation components (e.g., ground preparation, seed mix, fertilizer requirements, etc.) a reclamation research program was initiated.

Table 4-2: Mine Components and Quantity of Re-vegetation Required

Component	Quantity (ha)
Reclaim seepage recovery dam	0.8
Tailings pipeline	0.9
Reclaim pipelines	0.9
Coarse/inert material stockpile	2
Industrial complex and office buildings	14.5
Site diversions	0.5
Water supply wells	0.1
Camp and facilities	2.8
Explosive magazines	0.1
Landfill and landfarm area	1.4
All Weather Access Road	31.2
Stockpile footprints	2.4
Mine site road	7
Total	**63.8 ha**

To date, in areas of disturbance, stockpile areas and along the access road, YZC has used a ‘Roadside Reclamation’ custom seed mix. This mix, originating from western Canada, the Yukon and/or Alaska, contains 40% Violet wheat grass (Agropyron violaceum), 25% Arctic Red Fescue (*Festuca saximontana*), 20% Sheep Fescue (*Festuca ovina*), 10% Slender wheat grass (*Agoropyron paucifloru*), and 5% Tickle Grass (*Agrostis scabra*). The mix was specified to meet the following purity and germination requirements:

- Species must not exceed the following limits for noxious weeds per 25 grams: 0 primary, 5 secondary, 25 total and 0 sweet clover; and
- Minimum percent of pure living seed must be 70%.

4.4 Underground Mine

4.4.1 Hydraulic Plugs

The primary concern for the underground mine on closure is twofold:

1. To prevent access to the mine by people or wildlife; and
2. To inhibit, or eliminate groundwater discharge from the mine into the receiving environment.

The mine has two openings to surface that need to be sealed using hydraulic pressure bulkheads: the main portal and the ventilation raise. This section details the methodology that will be used to seal the two openings. It is largely a duplicate of the work performed by Asterisk Mining Services Ltd. for the report entitled *Environmental Risk Assessment, Yukon Zinc Corporation Wolverine Mine, Temporary Closure, 4 June 2015* and is used with the permission of Lorax Environmental Services Ltd.

4.4.1.1 Portal

The location selected for the hydraulic bulkhead in the ramp will be an area of competent ground as close to the portal as possible.

A channel of about 1 m width and 0.3 m depth will be excavated around the perimeter of the bulkhead location on all four sides (back, floor, left wall, right wall) using a jackhammer or other suitable tool. Two or three rows of 25mm rebar will be installed as pins at a fairly tight spacing (nominally 0.5 m) inside the channels. These pins will be resin-grouted, but will extend into the drift approximately 1 m rather than be installed flush to the face. The will be anchored approximately 1m into the solid rock.

Two or three square grid lattices of criss-crossed 25mm rebar will be constructed and placed in center of the bulkhead. Each lattice will be constructed of vertical and horizontal 25mm rebar attached to each other with wire at approximately 0.3 m spacing in both vertical and horizontal directions in the lattices. The entire lattice will be attached to the 25mm rebar pins that project from the wall.

Wooden forms will be erected on either side of the lattice reinforcements and ~ 40 MPa concrete will be poured between the forms, totally encapsulating the steel reinforced lattices and the rebar pins projecting from the drift walls, back, and floor. The final upper portion of the pour will have to be filled using a stiff mixture of sprayed shotcrete to completely fill the void between the bulkhead and the rock of the channelled slot.

After the installation is complete, the location will be pressure grouted by drilling an array of holes up, down, and in both walls around the bulkhead site. Cement grout will be forced into each hole by a high-pressure pump, filling the cracks and voids in the host rock of the immediate area.

This conceptual design is shown as Figure 4-11.

The ramp uphill of the bulkhead will be filled with waste to the collar. The final opening will be closed, covered with overburden, contoured, and reclaimed.

4.4.1.2 Raise

The hydraulic bulkhead for the raise will be constructed in much the same way as for the ramp, but at a horizontal orientation rather than vertical. It will not be adequate to seal the raise at the collar in overburden material – the hydraulic bulkhead will have to be installed inside the raise in solid rock to assure a strong seal and prevent water from flowing around the bulkhead through overburden.

Bullhorns will be installed into the four walls of the raise and timbers will be mounted between bullhorns for support. A plywood floor will be built atop the timbers, which will be sealed completely by shotcrete.

Using the plywood as a working platform, the same methodology will be employed by drilling and installing multiple rows of 25 mm rebar pins in the solid rock that stick out at least 1m from the rock surface into the raise. Again, multiple steel lattices of criss-crossing 25mm rebar will be constructed and attached to the rows of pins. Concrete will then be poured onto the plywood floor, encapsulating the rebar pins and lattices.

While working in the raise will be more difficult than in the drift, it will be much easier to establish water-tight seal with the raise walls then in the drift, eliminating the need to excavate the key slots used for the ramp bulkhead.

This conceptual design is shown as Figure 4-12.

After curing, the hydraulic seal would be covered with earth fill, re-contoured, and reclaimed.

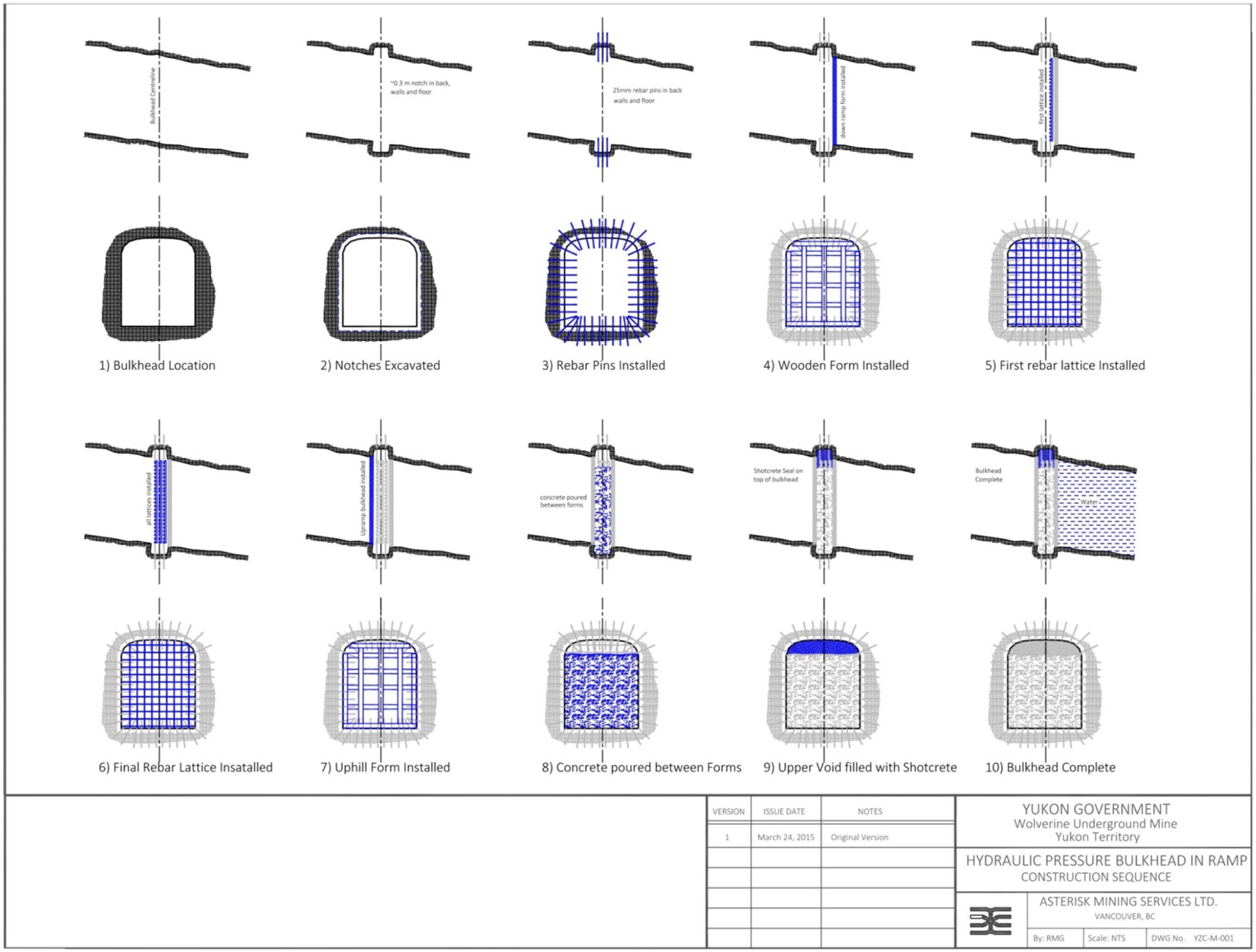


Figure 4-11: Conceptual Design for Hydraulic Pressure Bulkhead in Main Ramp (Used with permission from Lorax Environmental Services Ltd.)

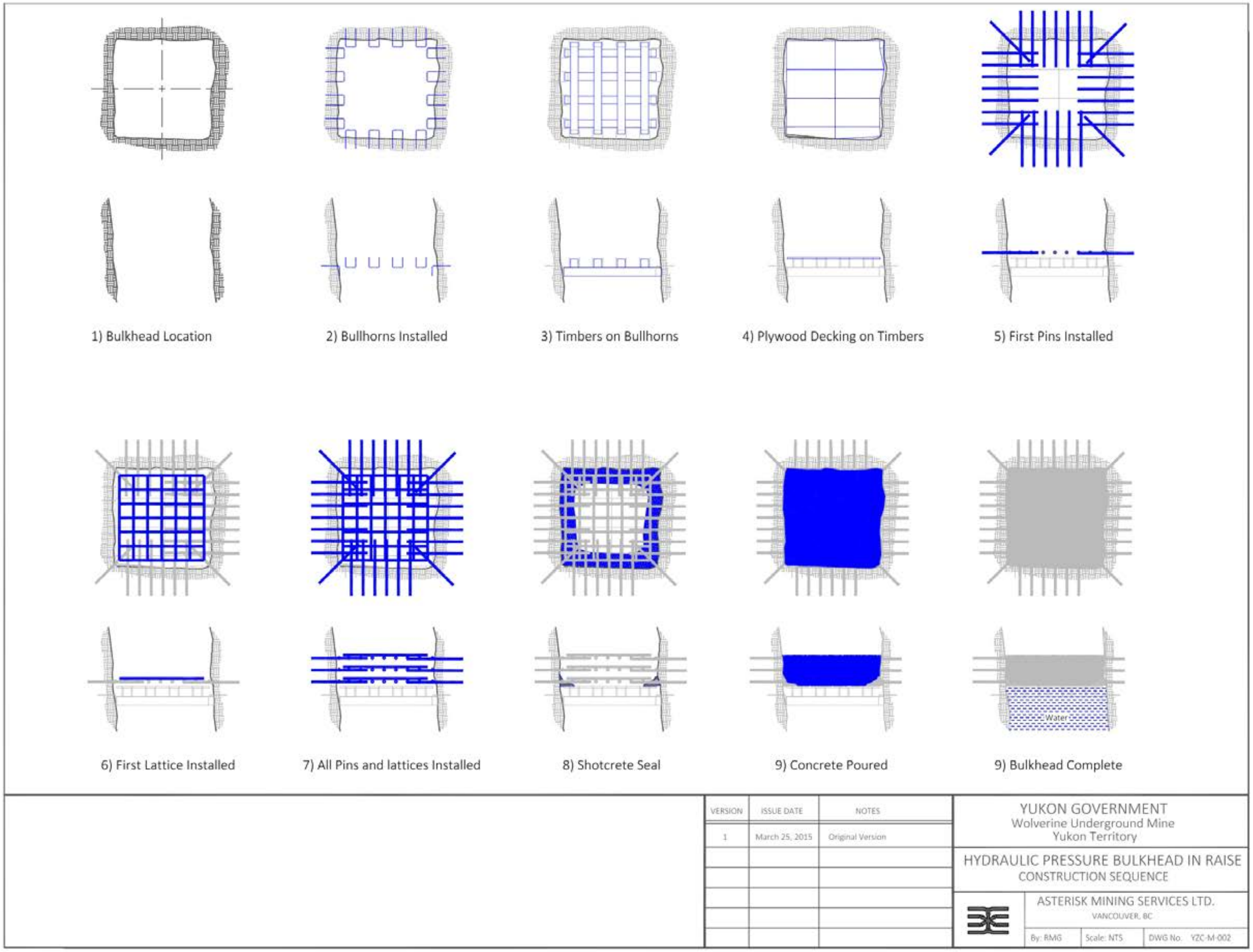


Figure 4-12: Conceptual Design of Hydraulic Pressure Bulkhead in Vent Raise (Used with Permission from Lorax Environmental Services Ltd.)

4.4.2 Underground Mine Water Quality Predictions

The quality of groundwater following the flooding of mine workings has been an important focus of the Wolverine Mine. AMEC Earth & Environmental (AMEC) developed an underground water quality model utilizing the static and kinetic geochemical testing database for mine rock types at Wolverine. The primary objective has been to develop predictions of water quality of flooded mine workings at closure. A detailed assessment and prediction was included in Appendix B of the Wolverine Mine Reclamation and Closure Plan V2008-02, and annual updates on humidity cells testing of mine rock, ore, neutralization potential depleted ore, dense media separation float and cemented paste backfill are provided in Wolverine Mine Monitoring and Surveillance Plan annual reports.

Groundwater recharge rates (e.g., discharge into the underground mine) have been monitored throughout the mine life. The average daily underground recharge rates for 2006 – 2010 are provided in Figure 4-13, and the average daily inflow rates on a monthly basis for 2009 – 2014 are provided in Figure 4-14. The average recharge rate, including service water and drainage from paste fill etc., in 2014 was 311 m^3/day, which is comparable to those in 2012 and 2013, 316 m^3/day and 290 m^3/day, respectively. With no further development, or mining work underground, it is expected that mine groundwater recharge will reduce to rates measured during the early part of 2015 and reported in the 6 May 2015 ground control and pumping report by Woo Shin P. Eng. These rates were approximated to 150 m^3/day. These rates are comparable to those seen between 2006 and 2009. As the mine fills closer to the surface portal entrance, the reduction in hydraulic head should further reduce these volumes.

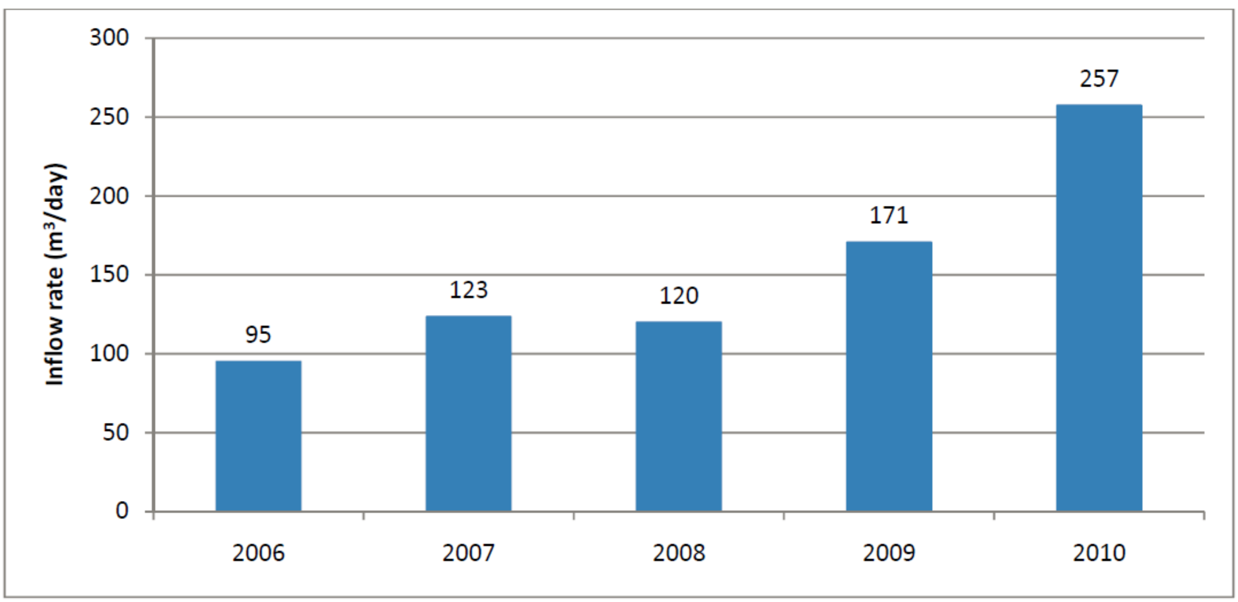


Figure 4-13: Daily Average Underground Recharge Rates, 2006 to 2010

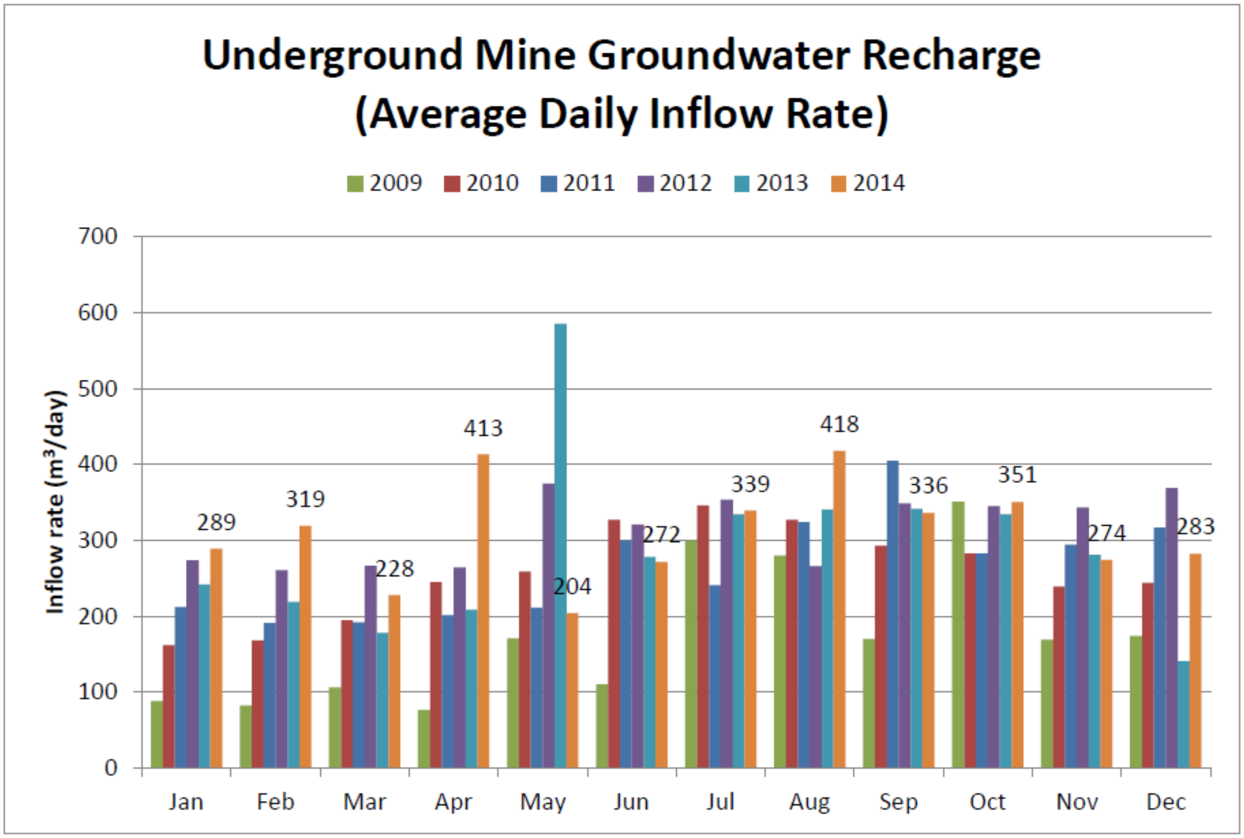


Figure 4-14: Daily Average Underground Recharge Rates, 2009 to 2014

Underground mine water quality has also been monitored since initial construction in 2005. The water quality in the underground mine for copper, selenium and zinc is shown in Figure 4-15 for samples taken 2006-2014, inclusively. It should be noted that metals content in the water is generally a composite of dissolved metals in the water and suspended solids in the water. For the purposes of closure one can assume that the suspended solids portion of such metals contamination will not be present as there is no underground activity to stimulate the generation of suspended solids within the drainage water. There was a marked increase in metal concentrations during preproduction development and during mine production (note exponential concentration scale). These periods are characterized by high suspended solids due to activities in the underground, and the use of shotcrete to reinforce the walls of the underground mine, resulting in higher total metal concentrations.

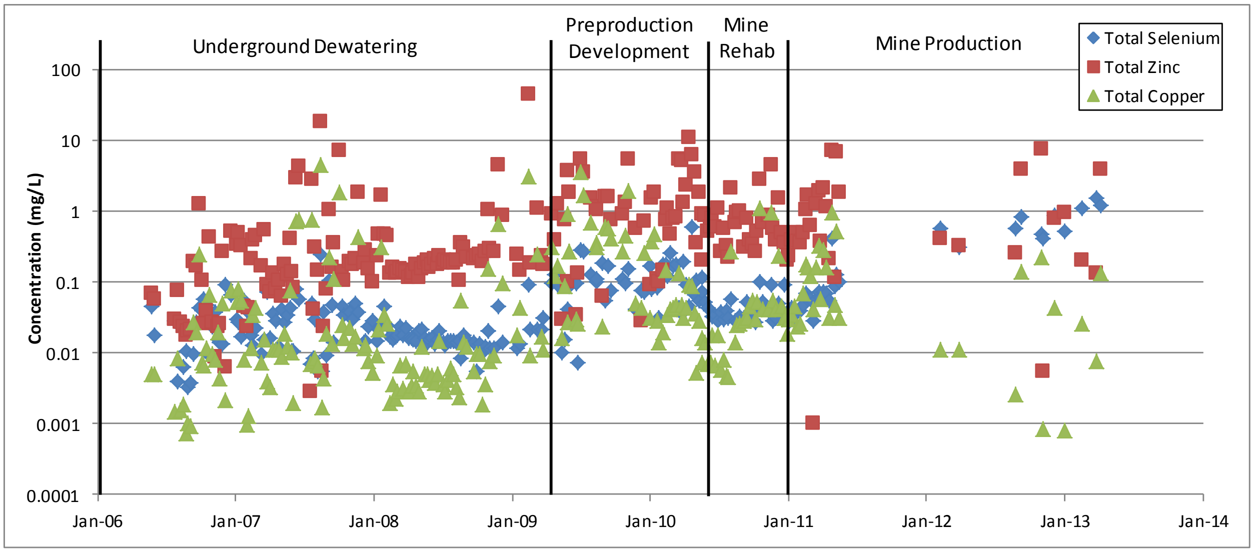


Figure 4-15: Underground Mine Total Cu, Se, and Zn Concentrations, 2006 to 2014

Therefore, water quality results following the commencement of preproduction development (April 2009) are not likely to be representative of underground water quality during closure. Water chemistry during the dewatering period (May 2006 – April 2009) are considered to be more representative of underground water during closure, and summary statistics for the underground dewatering period is provided in Table 4-3. Summary statistics are compared to the estimates of chemical composition of the groundwater following flooding of the mine workings prepared by the geochemical equilibrium model MINTEQ for the purposes of mine licensing developed by AMEC.

For the MINTEQ model, estimates of the accumulated weathering products on the mine surfaces were based on the humidity cell tests with mine rock, ore and paste backfill. Measured release rates from humidity cells with the six major rock types were used for non-ore bearing rock surfaces to develop mass loading estimates.

Mass loadings to the total water volume in the flooded mine were estimated by scaling mass loadings (mg/m^2/wk) derived from humidity cell tests to the estimated surface area exposed in the flooded mine. The weathering products were assumed to accumulate on the mine surfaces throughout the mine operation without losses due to ongoing leaching. The water quality of the mine water was estimated by dissolving the total mass (mg) of accumulated weathering products in the total volume of groundwater (L) that was predicted to flood the mine.

Table 4-3: Underground Mine Water Quality Statistics (2006 – 2008; n=123)

Parameter (mg/L)	A Licence QZ04-065 ADL*	MIN	MEAN	MEDIAN	MAX	MINTEQ Predicted Concentrations
Total Suspended Solids	**15**	1.5	**102.2**	**17.3**	**3630.0**	-
Ammonial Nitrogen	**5**	0.0025	0.0692	0.0336	0.3115	-
Total Arsenic	**0.05**	0.00046	0.01093	0.00238	**0.45100**	0.06
Total Cadmium	**0.002**	0.00002	**0.00893**	0.00140	**0.43300**	0.24
Total Copper	**0.015**	0.001	**0.128**	0.009	**4.600**	0.033
Total Lead	**0.02**	0.0006	**0.1890**	**0.0339**	**7.9100**	0.12
Total Nickel	**0.5**	0.00025	0.00657	0.00228	0.10800	0.016
Total Selenium	**0.02**	0.0034	**0.0281**	0.0180	**0.2520**	0.38
Total Zinc	**0.5**	0.003	**0.924**	**0.176**	**45.400**	7.7

*ADL – Allowable discharge limits for discharge to Go Creek

As shown in Table 4-3, the actual mean mine water quality has much lower concentrations of parameters of concern than predicted by the MINTEQ model, except for the mean copper concentration, which is an order of magnitude greater than those predicted. However, the mean underground mine water is in exceedance of discharge standards for TSS, cadmium, copper, lead, selenium and zinc.

Total metal concentrations are frequently tied to TSS concentrations (as shown in Figure 4-16), and the mine dewatering activities may have artificially increased metal concentrations, which would not evident during closure. Therefore, metal concentrations in the underground mine during closure when there is no underground activity, may be lower again than those provided in Table 4-3.

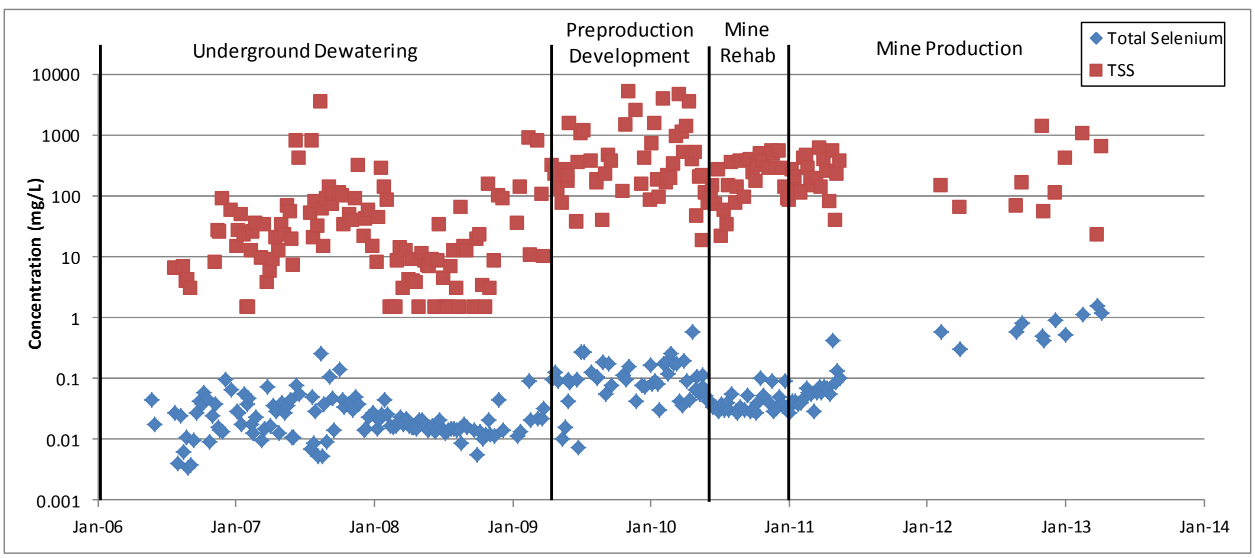


Figure 4-16: Underground Mine TSS and Total Se Concnetrations, 2006 to 2014

4.4.3 Reclamation

Limited residual reclamation activity will be required in the areas immediately adjacent to the mine workings and the portal apron. Soil placement and reseeding of these areas are largely addressed as part of the industrial complex reclamation. Minor reclamation and re-vegetation along the discharge channel corridor from the portal to the Biopass will be completed.

4.5 Infrastructure

The objective of closure will be to ensure public health and safety, stabilize the site, restore aesthetics, and restore disturbed lands to landforms similar to pre-mining development.

4.5.1 Processing Plant and Other Buildings

All materials from the industrial complex buildings will be completely removed with the exception of concrete foundations, which will be buried in situ.

Equipment with marketable value will be sold, and the remaining assets will be disposed of through demolition and salvage contracts. In the event that it is uneconomical to remove non-hazardous materials from the site, such material will be buried in the landfill.

Following demolition and dismantling of the industrial complex area, approximately 22 ha of area will require soil placement and reseeding. Closure costing has assumed re-contouring of the area followed by placement of 250 mm of salvaged topsoil recovered from nearby stockpiles.

4.5.2 Camp

Portions of the modular camp facilities will be progressively removed and sold as onsite personnel requirements decrease. Facilities will remain for care and maintenance staff and for reclamation and monitoring crews until all closure objectives have been met.

Once all closure activities have been completed, remaining modular structures will be removed and sold. Sewage treatment facilities will also be decommissioned and salvageable material removed from site. The water supply wells will be decommissioned once the potable water treatment and camp facilities are no longer required. The pump houses and the buried distribution system will be removed for salvage or, if deemed appropriate, the distribution system will remain buried in situ to minimize subsequent surface disturbance associated with removal. Water wells will be backfilled throughout their entire length with a combination of concrete and grout, and the top 5 m will be completely cemented.

Following decommissioning, the camp area will be re-contoured, soil growth medium will be placed and the area seeded.

4.5.3 Power Generation Infrastructure

All gensets will be de-activated, packaged, and transported off the property for sale. Distribution power lines will be re-spooled and sold as scrap. Power poles and distribution lines to other facilities will be salvaged or buried in the landfill. For any poles that are treated with a preservative such as creosote, the contaminated portion of the poles will be disposed of in accordance with Yukon Special Waste Regulations.

The glycol loop will be emptied and the glycol will be transported offsite for permanent disposal or recycling.

4.5.4 Explosives and Magazines

All unused explosives and detonation devices have been destroyed under the TCP. All magazines have been, or will be returned to the explosives supplier.

4.5.5 Fuel Storage Tank Area

Fuels and lubricants required during the three-year closure phase will only be ordered on an as-needed basis with the objective of reducing the inventory of remaining fuels during decommissioning. Fuels remaining at the end of the active closure phase will be either returned to the original supplier or sold to a third party user. All tanks will be emptied of their contents in accordance with the Yukon Environment Act. Excess fuel storage tanks will be hauled away for resale or salvage.

Propane tanks used for underground heating will be removed for resale or salvage by a qualified contractor, once underground operations cease. Associated fuel delivery lines will be removed and disposed of in an appropriate manner.

4.5.6 Equipment

All fixed and mobile equipment with marketable value will be removed and sold. All fixed materials currently underground inside the mine will be left in place. Equipment that cannot be sold or is deemed to be hazardous will be disposed of in a proper manner.

4.5.7 Industrial Reagents and Hazardous Products

All reagents and chemicals currently on site have been placed in the CLO, or other lined storage, under the TCP. Any chemicals that remain and are not necessary for the RCP will be disposed of in an appropriate manner.

4.5.8 Water Management Structures

4.5.8.1 Ditches

Drainage structures within the industrial complex area (Collection Ditches 2, 3 and 5) consist of geomembrane-lined open channels to transport storm water to a collection pond (Sump #2) prior to being pumped to the TSF. The Collection Ditches and Sump #2 will be decommissioned following the removal of all industrial complex structures. Liners will be removed and the ditches and sump backfilled with coarse material. Drainage will be allowed to flow naturally back to the receiving environment.

Ditch 1 upslope of the industrial complex, which is used to divert non-contact surface runoff around the area, will be decommissioned once infrastructure footprints and collection ditches have been reclaimed.

Diversion Ditches A and B (see Figure 1-4) and up-gradient under-drains will be decommissioned and clean runoff will be permitted to enter directly into the tailings impoundment to facilitate the replacement of tailings-affected water with clean runoff. Ditches will be backfilled and re-contoured consistent with the original topography. Disturbed areas along the ditch alignments will be re-vegetated.

4.5.8.2 Pipelines

Once the mill is no longer operational, the tailings and water reclaim pipelines will be dismantled and disposed of in the tailings impoundment or in the landfill area prior to capping. The tailings line and the reclaim pipeline will be removed and disposed of in one of the waste dumps, prior to capping, once water treatment is no longer required (Year 3 of closure). The pipeline corridor will be seeded as barren ground is exposed with pipeline removal.

4.5.9 Miscellaneous Materials

All salvageable material will be sold and removed from the site. Material that has no scrap value will be disposed of in the landfill site. Materials will be examined to ensure that all hazardous materials have been removed for proper disposal.

4.6 Waste

4.6.1 Mine Waste Piles

There are two lined waste pads on site containing waste rock generated from underground mining:

- Waste Pad #1, located south of the camp, which contains 91,000 m³ of waste (see Photo 4-2); and
- Waste Pad #2 located north of the TSF, which contains an additional 22,000 m³ of waste (see Photo 4-3). As part of the TCP, it is intended to increase the tonnage on this pad by moving the temporary waste pile at the mine portal and the two temporary ore piles up to this pad. It is therefore presumed that this will be the location for this additional material.

See Figure 1-3 for the location of Waste Pile #1 (labelled “Temporary Waste Rock and Ore Storage Facility”) and Figure 1-4 for the location of Waste Pile #2 (labelled “Operations Waste Rock Pile”).

Waste Pile #1 is too steep for long-term stability and reclamation (estimated at 30°). It will be re-contoured to a more stable slope angle of 3:1 by removing approximately 38,700 m³ of waste (43% of the pile) and hauling the excess material to Waste Pad #2. Waste pad #1 will then be covered with a 1 m layer of glacial till type material to seal the top of the dump.

Leached water from Waste Pad #1 currently drains into a sump that is emptied by water truck in the spring, with the water hauled to the TSF. The proposed glacial till cover layer will be compacted and is expected to seal the waste pile to stop ongoing leaching. The plan to permanently decommission this waste pad includes installing a Biopass system in the current waste pad sump as a contingency measure (Section 4.2.2.2)

Waste Pad #2 free drains by gravity into the TSF. It will also be capped with 1 m of compacted glacial till to prevent water from leaching through the waste.

The waste piles will be seeded to complete reclamation.

Photo 4-2: Waste Pad #1, East of the Camp (July 12, 2013)

Photo 4-3: Waste Pad #2 North of the TSF

4.6.2 Landfill and Waste Storage Areas

Decommissioning and demolition activities will generate some non-hazardous waste material that will be disposed of in the landfill area. Waste that cannot be buried in the landfill will be temporarily stored at the solid waste or special waste storage areas prior to transportation for disposal offsite. At the end of closure activities, the landfill and storage areas will be covered with a 250 mm thick compacted layer of glacial till and graded to encourage the shedding of water. The sites will then be seeded.

4.6.3 Land Treatment Facility

Soils present in the land treatment facility during the final year of operation will be tested to determine if material is acceptable for use in reclamation programs around the industrial complex. Depending on the level of contamination, contaminated soils excavated during decommissioning may be placed in the land treatment facility for remediation for subsequent use in reclamation activities in the closure phase (see Figure 1-2). If the various soils are found to contain residual contamination that does not permit use in reclamation, they will be hauled off site to an approved facility.

4.7 Access Road

The access road will be decommissioned on closure, which will include the following tasks:

- Remove all culverts and drainage structures offsite for permanent disposal at an appropriate location.
- Trenches resulting from the removal of culverts will be swaled, or contoured, to match the surrounding terrain. Where warranted due to fine grain soils, erosion protection will be installed within the remaining swales, to a point where the reclaimed watercourse meets with its original path in undisturbed soil.
- The Bunker Creek Bridge at km 10 will be removed, and the abutments will be excavated to the level of the rip-rap placed during construction.
- In smaller cuts and fills, ditches will be filled in, and the soils shaped to match the surrounding topography. Where ditches are to be left intact (in some steeper sections) existing ditch erosion protection may be left in place.
- In large cuts and fills, the embankment or excavation footprint will be reshaped to a lesser extent, but all slopes will be flattened or rounded to better suit the surrounding terrain.
- Organic stripping materials placed at the toe of fills during the original construction phase, will be re-contoured along the downhill side to act as a sediment filter, and to re-establish vegetation.
- Surfaces with less than 25% slope will be scarified to better receive seeding.
- Re-contour staging areas and roadside stockpiles.
- Install a permanent boundary at the access off the highway to discourage casual access.
- All remaining borrow sources will be stabilized and contoured to prevent surface erosion, then seeded as per the guidelines developed from the Reclamation Research Program.

Once all decommissioning activities have been completed and use of the access road is no longer required, a permanent barricade will be installed near km 14. This location has been selected on a 10% ascending gradient, some 3 km north of the glacio-fluvial plateau that separates the upper Money Creek and Go Creek drainages. The location will deny access to highway vehicles, all-terrain vehicles and snowmobiles, should they proceed along the reclaimed road corridor from the highway.

4.8 Tailings Storage Facility

The TSF currently stores 854,000 tonnes of tailings (see Figure 4-17), approximately 41% of its design capacity of 2.1 M tonnes. It also contains 712,000 m³ of contact water, largely process effluent from the grinding and flotation circuits that has been regularly re-cycled through the process plant.

The tailings comprise a sand-silt mixture with a relatively low permeability. Static testing (acid base accounting) of composite tailings samples indicated that the tailings contain significant quantities of sulphide-sulphur and lesser quantities of neutralization potential. As such, Wolverine tailings are characterized as potentially acid generating (PAG). Kinetic testing of two tailings samples in laboratory humidity cells, overseen by Marsland Environmental Associates, ceased in February 2012 after operating for over 340 weeks each. Humidity cell tests have indicated that the onset of acid generation in lab conditions could take five years for the diluted ore tailings sample, the most representative sample of actual Wolverine tailings. Laboratory humidity cells are accelerated weathering tests with conditions that are notably different than the conditions found in the tailings facility; nevertheless, for closure planning purposes, tailings are assumed to be potentially acid generating. Closure mitigation strategies have focused on eliminating the potential for tailings oxidation within the impoundment.

To prevent oxidation of the tailings solids and subsequent acid generation, the TSF has been constructed as a water retaining structure underlain with an impermeable liner. This will maintain the tailings in a saturated condition and under water cover, both during operations and at closure, and will eliminate the potential for acid drainage from the facility. Moreover, the liner also greatly reduces the potential for seepage of tailings water and the concomitant potential for groundwater contamination occurring both during operations, closure and at post-closure. The TSF closure strategy involves the retention of a minimum cover of 4 metres of water over the tailings in situ in the pond.

Assuming the Tailings pond is filled to capacity, the original proposal was to close the TSF as a saturated deposit with a combined cover of at least 1.5 m over the tailings consisting of the approximately 1.0 m of material and 0.5 m of water (see Figure 4-18; note vertical scale = 5x horizontal scale). This assumes that it will be filled to its maximum capacity of 2.1 M tonnes with future processing.

A recent bathymetric survey of the facility demonstrates that were the TSF to be permanently closed at this time then such a methodology cannot be employed due to the excessive depth of water in the pond – up to 10 m in depth (see Figure 4-19).

Because the TSF is fully constructed, but is nowhere near full, the current elevation of the tailings/supernatant interface, in the pond, when combined with the elevation of the permanent spillway will mean that the total water cover over the tailings when the TSF fills with water to discharge level will be at a minimum of 1 m, and up to 14 m in depth of water. This depth of water will be sufficient to prevent wave action reaching down to the deposited tailings in the pond and thus stirring sediment.

In the event that subsequent mining and milling activities result in more tailings being deposited in the pond, thus reducing this water cover to below 1 m from the final tailings elevation to the base of spillway, then YZC proposes placement of an inert cover material over any tailings solids with less than 1 m cover of water to reduce the potential for remobilization and re-suspension of tailings solids from wind induced wave action. To ensure that wave action cannot disturb previously placed tailings with less than 1 m of water cover, it is proposed to place coarse inert material (CIM) over such tailings if required. The borrow location for this CIM will be evaluated and full acid rock drainage testing (e.g. acid-base accounting and shake flask testing) will be performed to confirm there is no potential for acid generation and/or metal leaching from the CIM material.

4.8.1 Seepage Recovery Dam

Once the tailings impoundment water quality is of acceptable discharge water quality, the seepage recovery dam will be decommissioned in conjunction with access road closure activities as the dam is formed by a section of the road.

4.8.2 Spillway

The spillway on the tailings impoundment will not be removed at closure as this structure serves as the natural overflow of the impoundment once tailings water is of acceptable quality for direct discharge. Rip rap will be placed as appropriate on the spillway and its runoff to prevent erosion of the TSF embankment. Routine inspection of the spillway will be required to ensure that the structure can freely transport water.

4.8.3 Climate Change

The potential effects of climate change have been evaluated and duly considered in the design and closure management of the tailings impoundment. Wide-ranging precipitation conditions (e.g. 100-year dry and 100-year wet) were evaluated in water balance modeling for the facility in support of this plan. Continued monitoring of site meteorological conditions (e.g. precipitation and evaporation) will also provide the necessary supporting data to ensure all tailings design criteria for extreme events, including climate change, are adequate and comprehensive.

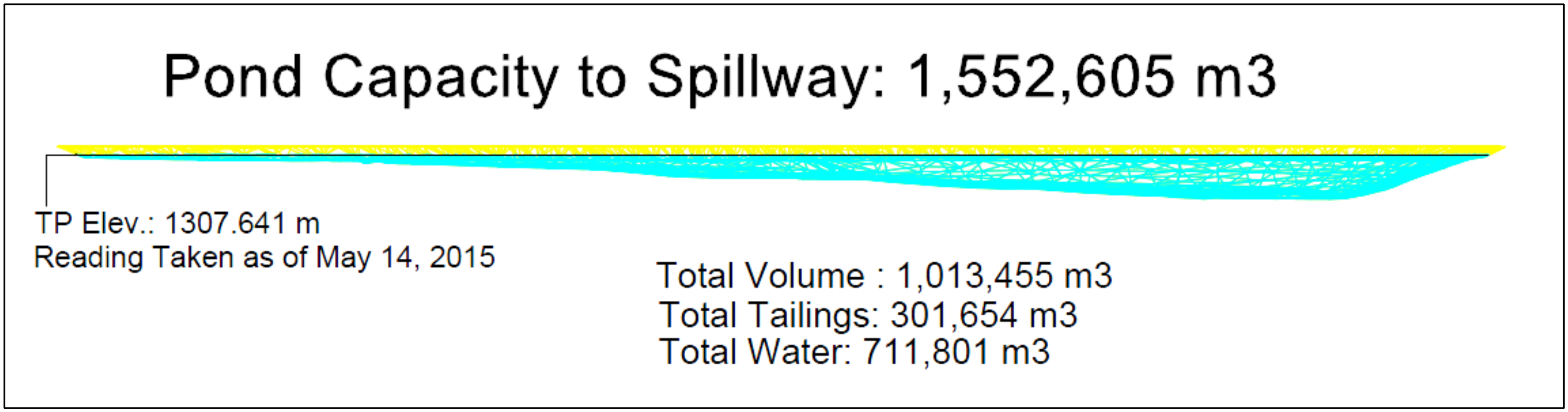
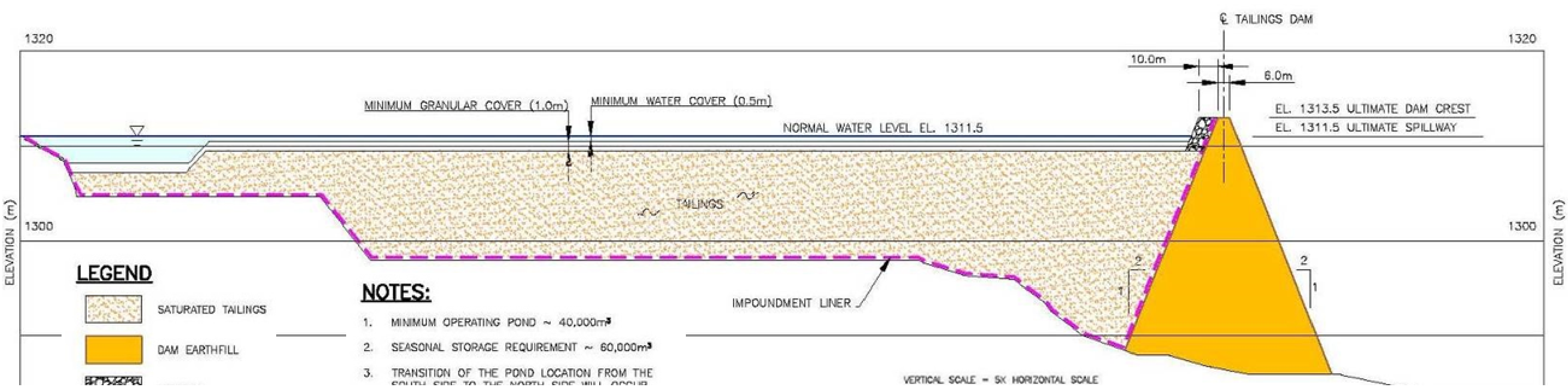


Figure 4-17: Current Volume in Tailings Storage Facility



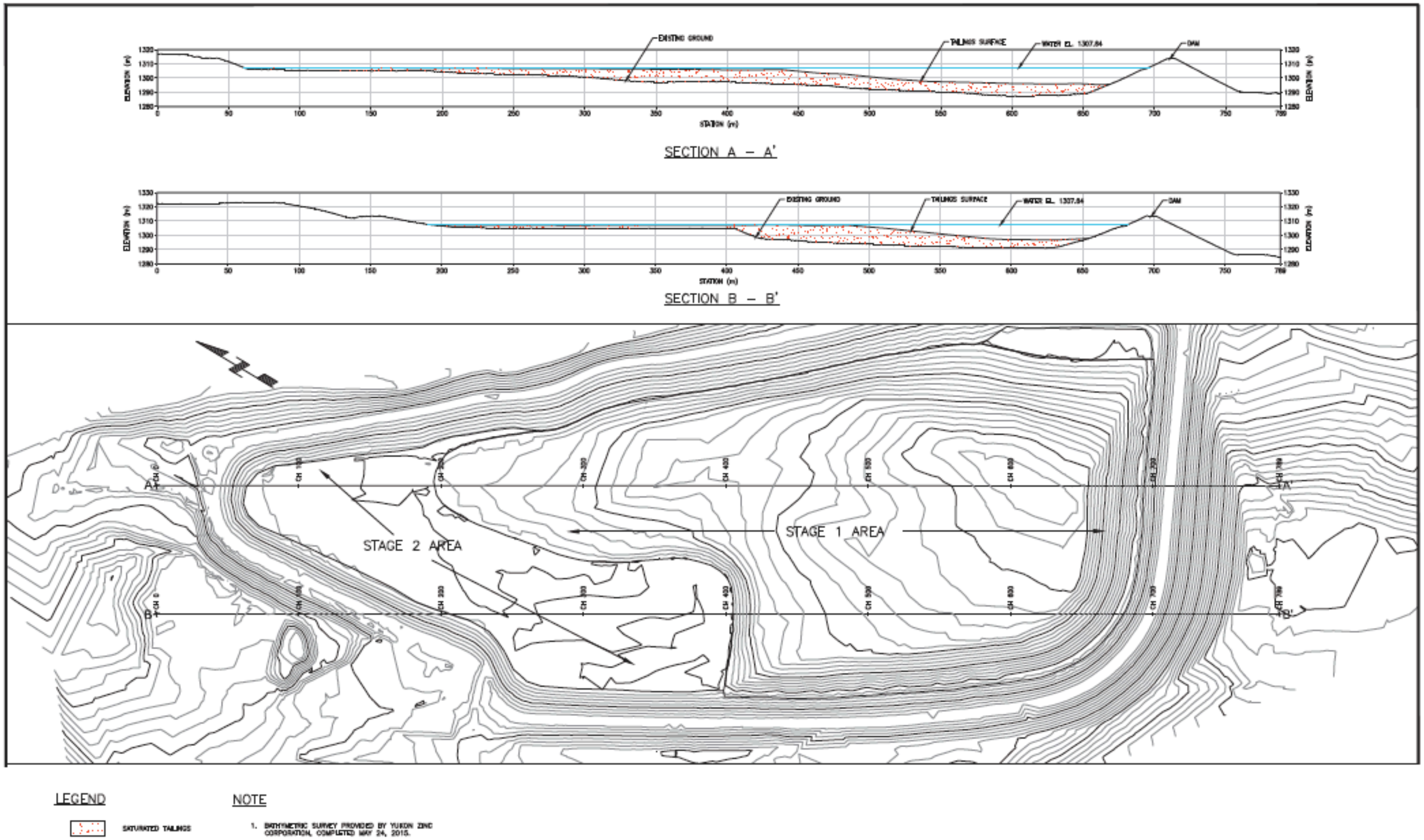


Figure 4-19: Bathymetric Survey of Tailings Storage Facility completed May 2015

4.9 Exploration Camp

There are some plywood tents, offices, and a cookhouse remaining at the original exploration camp. These will be sorted for deleterious materials, which will be removed and buried or disposed of as appropriate; remaining wooden elements would then be bulldozed into a pile and burned in a winter month. This work is currently planned to be completed during the winter of 2015/2016. Sediment and erosion control measures will be taken to minimize sediment flow into the lake during the following spring thaw due to the ground disturbance. The stored core at the camp will be kept in place during the operational phases of the mine and at closure will then either re-located to secure storage elsewhere, or bulldozed and buried as appropriate. The site of the exploration camp will then be re-contoured and re-seeded as appropriate.

4.10 Ongoing Monitoring

4.10.1 Dam Safety and Monitoring

The tailings dam is designed with a minimum factor of safety of 1.15 for the Maximum Credible Earthquake. Consequently, the main concerns with dam safety on closure are associated with erosion of the dam or blockage of the spillway. Accordingly, a long-term care and maintenance plan will be prepared to confirm that erosion is not occurring and that the spillway is clear. Measures to mitigate these potential concerns include the following:

- The downstream slope of the dam will be re-vegetated during the operations phase to minimize erosion.
- Rockfill will be placed adjacent to the upstream crest of the dam at the spillway, up to 10 m in width. The rockfill will keep the "free water" away from the dam crest, further reducing the potential for water release even with a significant erosion event.
- The ultimate dam spillway, located at the end of the impoundment away from the dam, will consist of an excavated channel lined with large riprap with discharge capacity for the routed peak flow resulting from the 1 in 10,000-year rainfall plus snowmelt event.

The physical and seepage conditions in the dam and area directly downstream of the dam will be monitored during closure as follows:

- Quarterly: visual monitoring by mine personnel, along with the water sampling program, until safe long term trends are indicated;
- Intermediate: annual review of monitoring data and dam performance by the designated independent TSF engineer;
- Comprehensive: Dam safety review by dam engineer prior to decommissioning and otherwise routinely every five years (even after decommissioning); and
- Special Reviews: site visit and review of monitoring data are required after the occurrence of any potentially damaging events (e.g., floods, earthquakes) or unusual observations (e.g., cracks, sinkhole formation).

Details pertaining to these monitoring requirements as well as the monitoring of inclinometers, piezometers, survey monuments, climate conditions, pond level and groundwater wells are included in the Wolverine Mine Tailings Facility Operation, Maintenance and Surveillance Manual V2011-03.

4.10.2 Environmental Monitoring

Water quality monitoring of the surface stations and excess water discharge during the ice-free months represents the most significant closure monitoring requirement of the Wolverine Mine.

During the first three years of closure, 19 surface water quality sites (including the TSF location T1) will be monitored quarterly and groundwater quality monitoring at 24 wells will occur annually. While daily monitoring of the discharge quality at the retention pond (R1) and at the compliance point in Go Creek (W80) during any discharge period from May to October (approximately 184 days) was proposed in RCP V2013-05, the retention pond is not closure phase infrastructure, as it was proposed to be constructed to ensure discharge from the active water treatment plant met discharge criteria. The retention pond, as described in License QZ04-065 has not been constructed. Additionally, the intent of daily monitoring at station W80 as described in License QZ04-065 was to monitor down stream water quality when discharging from the active water treatment plant. Therefore, under the conditions described in this RCP, discharge to the environment will be only from the TSF spillway, and daily monitoring at R1 or W80 are not required. As such, proposed surface water and groundwater quality monitoring sampling frequency under RCP V2015-06 is summarized in Table 4-4.

Also incorporated into Table 4-4, is site-specific knowledge of sampling of the surface and groundwater well sites over the past two years, which indicate that it is not possible to sample all sites year-round due to frozen/no flow conditions or safety issues that limit access (frequency = seasonal in Table 4-4). Therefore, as summarized in Table 4-4, the total analytical load for water quality monitoring is approximately 258 samples over the initial three-year closure period.

Once TSF water is demonstrated to be consistently within permitted discharge limits, annual monitoring in the summer of the 18 surface water, T1 and 24 groundwater well locations is proposed for the next seven years (Closure Years 4-10).

Table 4-4: Surface Water and Groundwater Quality Sampling Frequency During Closure

Station Number	Quarterly Samples Year 1	Year 2	Projected	Well Station	Annual Samples
T1	4	4	4	MW05-1A	1
W82	4	4	4	MW05-1B	1
W9	3	3	3	MW05-2A	1
L1	4	4	4	MW05-2B	1
W31	3	3	3	MW05-3A	1
W80	3	3	3	MW05-3B	1
W22	4	4	4	MW05-4A	1
W71	2	2	2	MW05-4B	1
W72	2	2	2	MW05-5A	1
W73	2	2	2	MW05-5B	1
				MW05-6A	1
				MW05-6B	1
				MW05-7B	1
				MW05-8S	1
				MW05-8M	1
				MW05-8D	1
				MW05-9S	1
				MW05-9M	1
				MW05-10S	1
				MW05-10M	1
				MW05-10D	1
				MW05-11S	1
				MW05-12S	1
				MW05-13	1
Totals	27	27	27		24
		3 Year Total =	**81**		**72**

4.11 Reclamation and Closure Cost Estimate

The estimation of reclamation and closure costs from the Reclamation and Closure Plan Version 2013-05 (RCP V2013-05) jointly prepared by David Flather (Lorax) and Robin McCall (YZC) was used as the starting point for the estimate of closure costs for this CMP. It was adjusted to reflect the actual situation on site, including:

- The mechanical water treatment plant was not installed as planned; and
- The mine waste stored on waste pad #1 and #2 was not returned to the mine as backfill.

Most of this section is extracted from Version 2013-05, with changes to reflect the financial impact of these modifications.

Although the unit costs used in the estimate in RCP V2013-05, are two years old, they are still considered to be valid for application to this RCP, because of reductions in Northern wages and current reduced charge out rates for construction equipment etc. in the current mining downturn. As a consequence, no inflation has been added to these rates. In fact, due to the retraction of the mining and energy industries, an argument could be advanced that construction deflation has occurred, particularly to wages in the North, given the high rates of unemployment in the energy and mining sectors. These rates should therefore be considered valid and conservative for use in 2015.

The costs for two different versions are presented – the Current Case and the LOM Case. The only difference between cases is that for the current case, there is no waste rock cap placed on the TSF. As the TSF did not receive its designed allotment of tailings and as such, it was not filled to its maximum capacity with tailings and the resulting water depth is sufficient to prevent wave action from stirring up placed tailings. Thus, the inert coarse rock cover is not required.

4.11.1 Basis of Costing

4.11.1.1 Closure Manpower

A number of personnel will be required onsite to implement the various decommissioning, closure and reclamation tasks. The majority of these activities will be undertaken on a seasonal basis (May–October) and directed by an onsite supervisor. A caretaking staff similar to the current C&M staff can complete the bulk of this work during the summer season.

The work force requirements for the decommissioning or initial closure period (Year 1 to Year 3) and the late closure phases (Year 4 to Year 10) are provided in Table 4-5.

Table 4-5: Site Decommissioning, Closure, and Reclamation Work Force Requirements

Personnel	Decommissioning Period Year 1 to Year 3	Late Closure Period Years 4 to 10
Project Manager (Corp Part Time)	1	1
Site Supervisor	1	1
Environmental Monitor (as necessary)	1	
Equipment Operators	2	1
Mechanics/Welders/Electricians	2	
General Laborers	2	1
Camp Support Staff	2	
Total Seasonal on Site	**10**	**4**
Total Off-Season (Caretaker)	**4**	

4.11.1.2 Unit Rates for Equipment and Supplies

Decommissioning and closure costs for implementing the Wolverine Mine closure plan as described herein have been prepared for the existing condition (July 2015) and Life of Mine (LOM) at end of 2020.

The cost summaries provided below include costs associated with project shutdown, the decommissioning of facilities and support infrastructure, reclamation activities, and compliance and reclamation monitoring. The estimated cost is based on the following assumptions, rationale and information:

- No salvage value is included in the estimate.
- No discounting has been included in the estimate.
- Reclamation and decommissioning costs are based on having the work completed by a third party contractor.
- Unit rates for equipment for dry conditions were obtained from Government of Yukon Third Party Equipment Rental Rates (2011/2012) and focused on contractors and rates published out of Whitehorse, Ross River and Watson Lake. A summary of the unit rates employed in the cost evaluations are provided in

Table 4-6.

- Costs associated with closure monitoring and in particular surface water quality and groundwater quality analytical are based on current costs incurred by YZC. The number of samples for analysis over the total closure period is significantly reduced from monitoring requirements set forth in Water Use Licence QZ04-065.
- Contingencies, ranging from 10% to 15%, have been included in the cost estimate for each closure component based on the level of uncertainty in the assessment and the degree of risk associated with each component. The overall contingency averages 12% in this estimate.
- Decommissioning, reclamation and closure (including post-closure) phases are assumed to be complete 10 years after the cessation of mining.
- The closure phase water balance for the tailings facility will depend on when the mine is finally closed. However for the purposes of this exercise, the worst case scenario has been assumed, when there is a net positive water balance and the water will require treatment before being discharged to Go Creek for an estimated 3-year period. No funds for active treatment have been allocated beyond this 3-year closure phase.
- Closure water treatment costs have based on the development of a passive treatment system. They include costs for research and to construct a small discharge pond for bulk release of treated water.
- Non-acid generating fill and rock and glacial till will be available within the project area for closure activities.

4.11.1.3 Overlap with the TCP Costs

The following costs are included in both the TCP and RCP:

1. Installation of the hydraulic pressure bulkheads in the mine. This was necessary, as the TCP is not viable for an extended duration of time without sealing the mine.
2. Passive water treatment costs at the TSF.
3. Installation of the Wolverine Creek Biopass.
4. Annual tailings dam inspections.

The following TCP costs have not been placed in the RCP:

1. Moving all temporarily stored ore and waste that is not on lined facilities; (which will be done this summer).
2. Conversion of the power generation system to smaller gensets. (To be completed as part of the C&M program this year).

Site Manpower, while included in both estimates, is not identical between plans.

Table 4-6: Unit Rates for Closure Cost Estimates

Equipment	Rate	
	Hourly	Monthly
Cat D8N Dozer (1991)	$245	
Volvo A30D Rock Truck (2006)	$197	
Compactor - Cat CS563 84" (2006)	$140	
Cat 320CL Excavator (2004)	$125	
Cat 320 Excavator + Hammer (2004)	$170	
Cat 14G grader (2000)	$160	
Cat 950H Loader (2009)	$150	
Drill Rig	$190	
Crane 30 ton	$160	
Light-duty vehicle		$2,500
Labourer	$50	
Tradesman	$80	
Site Supervisor	$95	
Design Engineer	$130	
Project Engineer	$140	
Project Manager		$9,700
Site Caretaker		$6,100
Environmental Monitor		$6,000

Contractor Unit Rates; Misc Costs	Units	Cost
Excavation of Soil in Stockpile	m^3	$5
Supply and place geotextile	m^2	$12
Load, haul and place topsoil	m^3	$5
Load, haul and place tailings cover (CIM)	m^3	$7
Load, haul and place rock cover, organics, granular till and clay	m^3	$8
Drill, Blast and Haul Rip Rap	m^3	$22
Place Rip Rap	m^3	$14
Camp Costs	day/person	$75
Surface water quality analyses	sample set	$420
Groundwater quality analyses	sample set	$290
Water Treatment Cost	m^3	$0.40
Revegetation Seed Mix	kg	$13.00
Fertilizer	kg	$1.00
Seed and Fertilizer Application	ha	$1,500
Concrete	m^3	$85
Culvert Removal (<1200mm)	each	$1,500
Culvert Removal (>1200mm or multiple/location)	each	$5,000
Flights (Whitehores-Wolv + commercial connections)	weekly	$3,000
Erosion barrier	per linear km	$3,000

The total estimated cost for reclamation and closure is shown in Table 4-7. The table shows a comparison to V2013-05 costs for better understanding of where costs were adjusted to reflect current conditions at site.

Details for each cost build up, including specific comparisons between RCP cost estimates, are included in Appendix A for each the following mine components:

- Mine workings
- Tailings facility
- Infrastructure
- Access road
- Reclamation and revegetation; and
- Site Management and Monitoring.

The total closure cost estimated for this RCP is approximately $7.4 M, which includes $0.8 M of contingency (12.2% average). This cost represents the current case.

Should mining operations be resumed, the TSF would be filled to its maximum capacity and require a coarse inert material capping. This would add an additional $1.1 M of direct costs, increasing the total LOM closure costs to $8.5 M (including $907 K of contingency).

Table 4-7: Total V2015-06 Reclamation Costs, with Comparison to V2013-05

Work Item Description	V2013-05 Costs	+/-	V2015-06 Costs	
			Current	LOM
Mine Workings				
1345 Portal & Vent Raise Closures	75,664	-29,979	45,685	45,685
Install Hydraulic Plugs in Access Ramp	185,800	57,900	243,700	243,700
Install Hydraulic Plug in Ventillation Raise	123,100	8,500	131,600	131,600
15% Contingency	57,685	5,463	63,148	63,148
	442,248	**41,884**	**484,133**	**484,133**
Tailings Facility				
Reclaim TSF Dam Face		33,600	33,600	33,600
Reclaim Seepage Recovery Dam	15,120		15,120	15,120
Decommission Diversion Ditches	24,370		24,370	24,370
Remove Tailings Pipeline	64,650		64,650	64,650
Remove Reclaim Pipeline	64,650		64,650	64,650
Cover Tailings with Coarse/Inert Material (CIM)	1,138,000	-1,015,000	123,000	1,138,000
Water Treatment of Excess Tailings Water	223,090	86,910	310,000	310,000
10% Contingency	152,988	-89,449	63,539	165,039
	1,682,868	**-983,939**	**698,929**	**1,815,429**
Infrastructure				
Industrial Complex + Office Buildings	571,801		571,801	571,801
Temporary Waste Rock Storage Areas	853,870	384,523	1,238,393	1,238,393
Power Supply - Gensets	54,700		54,700	54,700
Reclaim Site Diversions	31,500		31,500	31,500
Water Supply Wells	10,346		10,346	10,346
Camp and Facilities	39,580	2,760	42,340	42,340
Work Item Description	**V2013-05 Costs**	**+/-**	**V2015-06 Costs**	
			Current	**LOM**
Explosive Magazines	5,150		5,150	5,150

Miscellaneous Buildings and Structures	110,910		110,910	110,910
Industrial Reagents Fuels and Waste	40,000	170,000	210,000	210,000
Spill Cleanup	32,100	25,000	57,100	57,100
Demolition Overhead	110,000		110,000	110,000
10% Contingency	185,996	58,228	244,224	244,224
	2,045,953	**640,511**	**2,686,464**	**2,686,464**
Decommission and Reclaim Access Road				
Lower road grade and slope stabilization	71,080		71,080	71,080
Remove culverts	138,500		138,500	138,500
Bunker Creek rehabilitation	77,000		77,000	77,000
Scarify Road Surface	62,400		62,400	62,400
Recountour staging, spoil and borrow areas	47,350		47,350	47,350
Revegetation, maintenance	84,450		84,450	84,450
Barrier installations	7,000		7,000	7,000
Engineering and surveying	48,778		48,778	48,778
10% Contingency	53,656		53,656	53,656
	590,214		**590,214**	**590,214**
Remaining Land Reclamation				
Stockpile Footprints	12,600		12,600	12,600
Mine Site Roads	92,010		92,010	92,010
10% Contingency	10,461		10,461	10,461
	115,071		**115,071**	**115,071**
Site Management and Monitoring				
Organization, Security and Overhead	1,724,325	-271,200	1,453,125	1,453,125
Document Control	55,200		55,200	55,200
Compliance Monitoring and Reporting	1,463,120	-824,120	639,000	639,000
Closure Maintenance	100,000		100,000	100,000
Wolverine Creek Biopass Contingency	224,130		224,130	224,130
15% Contingency	535,016	-164,298	370,718	370,718
	4,101,791	**-1,259,618**	**2,842,173**	**2,842,173**
TOTAL CLOSURE COSTS:				
Base Costs	7,982,344	-1,371,106	6,611,238	7,626,238
Contingency ($)	995,801	-190,056	805,746	907,246
Contingency (%)	12.5%	13.9%	12.2%	11.9%
TOTAL	**8,978,145**	**-1,561,161**	**7,416,984**	**8,533,484**

5 References

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Government of Yukon. 2013. Reclamation and Closure Planning for Quartz Mining Projects: Plan requirements and closure costing guidance. August 2013. Yukon Water Board & Yukon Energy, Mines and Resources.

Appendix B: Detailed Closure Cost Estimates

Table 5-1: Closure Costs Details, Underground Mine Workings

Mine Workings							
Action	**Notes**	**Units**	**Quantity**	**Unit Cost**	**V2013-05 Cost**	**+/-**	**V2015-06 Cost**
1345 Portal & Vent Raise Closures							
Plug portal and ventillation raisewith tires	Cat 320CL Hoe	hrs	30	125	3,750		3,750
Place waste rock cap over tires	Cat 320CL Hoe	hrs	20	125	2,500		2,500
Place waste rock cap over tires	A30D Rock truck	hrs	40	197	7,880		7,880
Supply broken rock/ discharge channel riprap	Cat 320CL Hoe	hrs	20	125	2,500		2,500
Supply broken rock/ discharge channel riprap	A30D Rock truck	hrs	40	197	7,880		7,880
Construct rock drain at base of plug	Cat 320CL Hoe	hrs	10	125	1,250		1,250
Supply fill to seal discharge channel	Cat 320CL Hoe	hrs	10	125	1,250		1,250
Supply fill to seal discharge channel	A30D Rock truck	hrs	20	197	3,940		3,940
Construct 300m lined open channel to biopass	Cat 320CL Hoe	hrs	20	125	2,500		2,500
Construct 300m lined open channel to biopass	Compactor	hrs	10	140	1,400		1,400
Stabilize and vegetate area around channel	Seed and Fertilize	ha	0.09	1,500	135		135
Labour for channel construction	Labourer	hrs	30	50	1,500		1,500
Labour to assist with placing tires & cap	Labourer	hrs	80	50	4,000		4,000
Design of rock drain and channel (Engineering)	Design Engineer	hrs	40	130	5,200		5,200
Interim Portal Discharge Treatment	Water Treatment (1 L/s x 2 years)	m^3	63,072	40%	25,229	-25,229	
Supervision to design & install tires and cap	Site Supervisor	hrs	50	95	4,750	-4,750	
	Subtotal 1345 Portal & Vent Raise Closures				**$ 75,664**	**$ (29,979)**	**$ 45,685**
Install Hydraulic Plugs in Access Ramp							
Drill and grout	grouting 10 m into wall; 20 m length x 2 plugs	hours	300	190	57,000		57,000
Install concrete plugs	20 m length x 5 m x 5 m x 2 plugs	m^3	1000	85	85,000	-85,000	
Labour for plug installation	Labourer	hours	300	50	15,000	-15,000	
Install Hydraulic Pressure Bulkhead						186,700	186,700
Engineering	Design of plugs	hours	60	130	7,800	-7,800	incl
Supervision	Project engineer	hours	150	140	21,000	-21,000	incl
	Subtotal Install Hydraulic Plugs in Access Ramp				**$ 185,800**	**$ 57,900**	**$ 243,700**
Install Hydraulic Plug in Ventillation Raise							
Install concrete plug	75 m length x 4 m x 4 m x 1 plug	m^3	1200	85	102,000	-102,000	
Install Hydraulic Pressure Bulkhead							131,600
Labour for plug installation	Labourer	hours	150	50	7,500	-7,500	incl
Engineering	Design of plug	hours	40	130	5,200	-5,200	incl
Supervision	Project engineer	hours	60	140	8,400	-8,400	incl
	Subtotal Install Hydraulic Plug in Ventillation Raise				**$ 123,100**	**$ 8,500**	**$ 131,600**
	Subtotal				**384,564**	**36,421**	**420,985**
	contingency			15%	**57,685**	**5,463**	**63,148**
	Total				**$ 442,248**	**$ 41,884**	**$ 484,133**

Table 5-2: Closure Cost Details, Tailings Management

Action	Notes	Units	Quantity	Unit Cost	V2013-05 Cost	+/-	V2015-06 Cost
Tailings Management Area							
Reclaim Seepage Recovery Dam							
Seepage Dam Regrade	Cat D8N Dozer - regrade and contour	hours	16	245	3,920		3,920
Load Haul and Place topsoil	Area of 8000 m^2 with 0.25 m depth	m^3	2000	5	10,000		10,000
Revegetate	Seed and Fertilize	ha	0.8	1,500	1,200		1,200
	Subtotal Reclaim Seepage Recovery Dam				**15,120**		**15,120**
Decommission Diversion Ditches							
Decommission Diversion Ditches A&B	Cat D8N Dozer - regrade and contour	hours	60	245	14,700		14,700
Decommission Diversion Ditch B	Cat 320CL Excavator for steep slopes	hours	20	125	2,500		2,500
Revegetate and Stabilize	Seed and Fertilize area 1.56 km x 5 m	ha	0.78	1500	1,170		1,170
Culvert remove (800 mm)	Uncovering and remove	Ea.	4	1500	6,000		6,000
	Subtotal Decommission Diversion Ditches				**24,370**		**24,370**
Remove Tailings Pipeline							
Remove Pipeline	Cat 320CL Excavator	hrs	150	125	18,750		18,750
	A30D Rock Truck	hrs	150	197	29,550		29,550
	Labour	hrs	300	50	15,000		15,000
Revegetation	Seed, fertilize - 3km length x 3 m corridor	ha	0.9	1500	1,350		1,350
	Subtotal Remove Tailings Pipeline				**64,650**		**64,650**
Remove Reclaim Pipeline							
Remove Pipeline	Cat 320CL Excavator	hrs	150	125	18,750		18,750
	A30D Rock Truck	hrs	150	197	29,550		29,550
	Labour	hrs	300	50	15,000		15,000
Revegetation	Seed, fertilize - 3km length x 3 m corridor	ha	0.9	1500	1,350		1,350
	Subtotal Remove Reclaim Pipeline				**64,650**		**64,650**
Cover Tailings with Coarse/Inert Material (CIM)							
Load Haul and Place Tailings Cover	Place and level CIM on ice in winter	m^3	145,000	7	1,015,000	-1,015,000	
Load Haul and Place Rockfill	Erosion control on dam face	m^3	15,000	8	120,000		120,000
Revegetate CIM stockpile area	Seed and Fertilize	ha	2	1,500	3,000		3,000
	Subtotal Cover Tailings with Coarse/Inert Material (CIM)				**1,138,000**	**-1,015,000**	**123,000**
Water Treatment of Excess Tailings Water							
Biotreatment of excess tailings water	Treatment for 3 years; ~170,000 m^3/yr	m^3	510,000	40%	204,000	-204,000	
Decommissioning and Dismantling of WTP	Labour	hours	230	50	11,500	-11,500	
Dismantle WTP infrastructure	Cat 320CL Excavator	hours	30	125	3,750	-3,750	
	Crane	hours	24	160	3,840	-3,840	
Reasearch for Passive Treatment Option						50,000	50,000
Passvie Treatment (over five years)	$10K/a allowance for five years					50,000	50,000
Construct release pond	allowance					200,000	200,000
biopass in spillway	allowance - multi-media and actaivated carbon					10,000	10,000
	Subtotal Water Treatment of Excess Tailings Water				**223,090**	**86,910**	**310,000**
			Subtotal		**1,529,880**	**-928,090**	**601,790**
			contingency	10%	**152,988**	**-92,809**	**60,179**
			Total		**$ 1,682,868**	**$ (1,020,899)**	**$ 661,969**

Table 5-3: Closure Cost Details, Infrastructure Decommissioning

Infrastructure Decommissioning							
Action	**Notes**	**Units**	**Quantity**	**Unit Cost**	**V2013-05 Cost**	**+/-**	**V2015-06 Cost**
	Industrial Complex + Office Buildings						
Remove salvageable equipment	General Labour	hours	1,152	50	57,600		57,600
Remove salvageable equipment	Trades Labour	hours	1,128	80	90,240		90,240
Dismantle Building - Manpower	General Labour	hours	1,152	50	57,600		57,600
Dismantle Building - Manpower	Trades Labour	hours	576	80	46,080		46,080
Dismantle Building - Equipment and Loading	Cat 320CL Excavator	hours	160	125	20,000		20,000
Dismantle Building - Equipment and Loading	Crane	hours	80	160	12,800		12,800
Concrete Demolition	Cat 320CL Excavator with Hammer	hours	80	170	13,600		13,600
Misc. Supplies & Tools	Misc.	L.S.	L.S.		10,000		10,000
Scrap haul to landfill	A30D Rock Truck	hours	208	197	40,976		40,976
Reslope and contour and bury	Cat D8N Dozer	hours	80	245	19,600		19,600
Load, Haul and place topsoil	Area of 145244 m^2 x 0.25 m depth	m^3	36,311	5	181,555		181,555
Revegetate	Seed and Fertilize	ha	15	1,500	21,750		21,750
	Subtotal Industrial Complex + Office Buildings				**571,801**		**571,801**
	Power Supply - Gensets						
Remove salvageable equipment	General Labour	hours	180	50	9,000		9,000
Remove salvageable equipment	Trades Labour	hours	108	80	8,640		8,640
Salvage and remove powerline and poles		L.S.	L.S.		25,000		25,000
Dismantle Building - Manpower	General Labour	hours	96	50	4,800		4,800
Dismantle Building - Manpower	Trades Labour	hours	48	80	3,840		3,840
Dismantle Building - Equipment	Cat 320CL Excavator	hours	12	125	1,500		1,500
Dismantle Building - Equipment	Crane	hours	12	160	1,920		1,920
	Subtotal Power Supply - Gensets				**54,700**		**54,700**
	Reclaim Site Diversions						
Decommission 1500 m of diversion ditches	Cat 320 CL Excavator	hours	150	125	18,750		18,750
Remove culverts (<1200 mm)		L.S.	8	1,500	12,000		12,000
Revegetate	1.5 km x 3 m	ha	0.5	1,500	750		750
	Subtotal Reclaim Site Diversions				**31,500**		**31,500**
	Water Supply Wells						
Remove salvageable eqt - pipe pumps and tank	General Labour	hours	24	50	1,200		1,200
Remove salvageable eqt - pipe pumps and tank	Trades Labour	hours	24	80	1,920		1,920
Remove pipeline and haul to Waste Pile #2	A30D Rock Truck	hours	8	197	1,576		1,576
Remove pipeline and haul to Waste Pile #2	Cat 320CL Excavator	hours	8	125	1,000		1,000
Decommission water supply wells	fill with concrete	Ea.	2	2,000	4,000		4,000
Misc. Supplies & Tools	Misc.	L.S.	L.S.		500		500
Revegetate	Seed and Fertilize	ha	0.1	1,500	150		150
	Subtotal Water Supply Wells				**10,346**		**10,346**
	Camp and Facilities						
Remove salvageable material	General Labour	hours	108	50	5,400		5,400
Remove salvageable material	Trades Labour	hours	48	80	3,840		3,840
Dismantle Building - Manpower	General Labour	hours	48	50	2,400		2,400
Dismantle Building - Manpower	Trades Labour	hours	48	80	3,840		3,840
Dismantle Building - Equipment and Loading	Cat 320CL Excavator	hours	16	125	2,000		2,000
Demolish and burn exploration camp	Cat D8N Dozer	hours	8	245		1,960	1,960
Demolish and burn exploration camp	Labour	hours	8	50		400	400
Demolish and burn exploration camp	install silt fences	hours	8	50		400	400
Remove sewage treatment plant	Labour	hours	24	50	1,200		1,200
Misc. Supplies & Tools		L.S.			1,000		1,000
Scrap haul to landfill	A30D Rock Truck	hours	20	197	3,940		3,940
Reslope and contour	Cat D8N Dozer	hours	48	245	11,760		11,760
Revegetate	Seed and Fertilize	ha	2.8	1,500	4,200		4,200
	Subtotal Camp and Facilities				**39,580**	**2,760**	**42,340**
	Explosive Magazines						
remove from site		L.S.			5,000		5,000
Revegetate	Seed and Fertilize	ha	0.1	1,500	150		150
	Subtotal Explosive Magazines				**5,150**		**5,150**
	Miscellaneous Buildings and Structures						
Dismantle Building - Manpower	General Labour	hours	216	50	10,800		10,800
Dismantle Building - Manpower	Trades Labour	hours	216	80	17,280		17,280
Remove salvageable equipment	Cat 950H loader	hours	150	150	22,500		22,500
Remove salvageable equipment	General Labour	hours	216	50	10,800		10,800
Remove salvageable equipment	Trades Labour	hours	216	80	17,280		17,280
Dismantle Building - Equipment and Loading	Cat 320CL Excavator	hours	40	125	5,000		5,000
Dismantle Building - Equipment and Loading	Crane	hours	8	160	1,280		1,280
Concrete Demolition	Cat 320CL Excavator with Hammer	hours	40	170	6,800		6,800
Reslope, contour & bury	Cat D8N Dozer	hours	60	245	14,700		14,700
Misc. Supplies & Tools	Misc.	L.S.			2,500		2,500
Scrap haul to landfill	A30D Articulated haul truck	hours	10	197	1,970		1,970
	Subtotal Miscellaneous Buildings and Structures				**110,910**		**110,910**
	Industrial Reagents Fuels and Waste						
Industrial Reagents	remove from site	L.S.			15,000	-15,000	
Industrail Reagents - truck to Swan Hills, AB	50 tonnes total @ $100/t					5,000	5,000
Industrail reagents - incineration cost	$1 to $5 /kg quoted, $3 per kg average assumed					150,000	150,000
Remove Glycol from site	6 trips at $5000 ea						30,000
Fuels	remove from site	L.S.			5,000		5,000
Wastes	remove from site	L.S.			20,000		20,000
	Subtotal Industrial Reagents Fuels and Waste				**40,000**	**170,000**	**210,000**
	Spill Cleanup						
Concentrate haul out area		L.S.			15,000		15,000
Other building site contamination clean up		L.S.			15,000		15,000
Remove Special Wastes	allowance - 2 trips @ $12,500 ea						25,000
Reclaim Landfill area	Seed and Fertilize	ha	1	1,500	1,500		1,500
Reclaim landfarm area	Seed and Fertilize	ha	0.4	1,500	600		600
	Subtotal Spill Cleanup				**32,100**	**25,000**	**57,100**
	Demolition Overhead						
Supervision	Site Supervisor	hours	1,000	95	95,000		95,000
Office/Admin Costs	Contracts oversight	Year	3	5,000	15,000		15,000
	Subtotal Demolition Overhead				**110,000**		**110,000**
	Subtotal				**1,006,087**	**197,760**	**1,203,847**
	contingency			10%	**100,609**	**19,776**	**120,385**
	Total				**$ 1,106,696**	**$ 217,536**	**$ 1,324,232**

Table 5-4: Closure Cost Details, Decommission and Reclaim Access Road

Decommission and Reclaim Access Road								
Action	**Notes**	**Units**	**Quantity**	**Unit Cost**	**V2013-05 Cost**	**+/-**	**V2015-06 Cost**
Lower road grade	Cat 14G Grader	Hrs	100	160	16,000		16,000
Lower road grade	Cat 320CL Excavator	Hrs	140	125	17,500		17,500
Lower road grade	A30D Rock Truck	Hrs	140	197	27,580		27,580
Stabilize cut/fill slopes	Cat 320CL Excavator	Hrs	80	125	10,000		10,000
Culvert remove (<1200mm)	remove to offsite for re-use, reslope banks and amoring wetted section	Each	69	1,500	103,500		103,500
Culvert remove >1200mm or multiple at 1 locatior	remove to offsite for re-use, reslope banks and amoring wetted section	Each	3	5,000	15,000		15,000
Culvert Crossing restoration work	Install environmental protection measures	L.S.	1	20,000	20,000		20,000
Bunker Creek Bridge remove	Remove bridge complete with bin-wall, reslope of banks	L.S.	1	75,000	75,000		75,000
Bunker Creek habitat restoration	Restoration in riparian zone and re-seeding	L.S.	1	2,000	2,000		2,000
Scarify road surface	To encourage re-vegetation (24 km x 13 m) - Cat D8N Dozer	Ha	31.2	2,000	62,400		62,400
Corridor re-vegetate	Using ATV mounted applicator for seed and fertilizer	Ha	31.2	1,500	46,800		46,800
Maintenance S&F-after 1 year	Assume coverage of 50% with seed & fertilizer alone	Ha	17.5	1,500	26,250		26,250
Permanent barrier at highway	Install trench and barricades	L.S.	1	3,500	3,500		3,500
Permanent barrier at Km 14	Install barricade to prevent interior access	L.S.	1	3,500	3,500		3,500
		Subtotal Direct Costs			**429,030**		**429,030**
Engineering	For major components, particularly Remove bridge		5%		21,452		21,452
Surveying	For final as-builts of new contours and stream crossings		5%		21,452		21,452
			Subtotal		**471,933**		**471,933**
			contingency	10%	**47,193**		**47,193**
		Total			**$ 519,126**	**$ -**	**$ 519,126**

Table 5-5: Remaining Land Reclamation

Remaining Land Reclamation							
Action	**Notes**	**Units**	**Quantity**	**Unit Cost**	**V2013-05 Cost**	**+/-**	**V2015-06 Cost**
	Stockpile Footprints						
Stabilize Slopes	Unit Cost Basis	km	3	3,000	9,000		9,000
Revegetate	Seed and Fertilize	ha	2.4	1,500	3,600		3,600
		Subtotal Stockpile Footprints			**12,600**		**12,600**
	Mine Site Roads						
Lower road grade	Cat 14G Grader	hours	60	185	11,100		11,100
	Cat 320CL Exavator	hours	80	125	10,000		10,000
	A30D Rock Truck	hours	80	197	15,760		15,760
Stabilize slopes	Cat 320CL Exavator	hours	40	125	5,000		5,000
Culvert remove (<1000m)	uncover, remove and stabilize	Ea.	15	1,500	22,500		22,500
Scarify	Cat D8N Dozer	hours	70	245	17,150		17,150
Revegetate	Seed and Fertilize	ha	7	1,500	10,500		10,500
		Subtotal Mine Site Roads			**92,010**		**92,010**
		Subtotal Remaining Land Reclamation			**104,610**		**104,610**
			contingency	10%	**10,461**		**10,461**
	Total				**$ 115,071**	**$ -**	**$ 115,071**

Table 5-6: Closure Cost Details, Management and Monitoring

Site Management and Monitoring							
Action	**Notes**	**Units**	**Quantity**	**Unit Cost**	**V2013-05 Cost**	**+/-**	**V2015-06 Cost**
Organization, Security and Overhead							
Pre closure planning and organization	Project Manager (Corporate)	months	6	9,700	58,200		58,200
Site Manager	Project Manager	months	36	9,700	349,200		349,200
Camp Costs[1]	per diem	days[1]	3,175	75	431,325	-193,200	238,125
Site caretaker	Security, camp operation, general maintenance	months	36	6,100	219,600		219,600
pre closure environmental assessment	contract	L.S.			75,000		75,000
post closure env cleanup confirmation	contract	L.S.			75,000		75,000
vehicles for security and manager	light-duty vehicle	months	72	2,500	180,000		180,000
site maintenance costs	general maintenance	year	3	10,000	30,000		30,000
Flights - charter and commercial	bi-weekly	flights	26	3,000	156,000	-78,000	78,000
miscellaneous office/supply/costs	miscellaneous	year	10	15,000	150,000		150,000
Subtotal Organization, Security and Overhead					**1,724,325**	**-271,200**	**1,453,125**
Document Control							
Document reviews and storage	miscellaneous	monthly	120	200	24,000		24,000
final as built drawings	manhours	hours	240	130	31,200		31,200
Subtotal Document Control					**55,200**		**55,200**

Closure Maintenance							
Action	**Notes**	**Units**	**Quantity**	**Unit Cost**	**V2013-05 Cost**	**+/-**	**V2015-06 Cost**
Compliance Monitoring and Reporting							
Environmental Monitor	Sampling and monitoring	months	36	6,000	288,000	-72,000	216,000
Water Quality Analytical (Closure Y1 to Y3)	Surface water quality analytical (20 sites, incl. T1 & R1)	samples	81	420	744,660	-710,640	34,020
Water Quality Analytical (Closure Y1 to Y3)	Groundwater quality analytical (24 sites)	samples	72	290	20,880		20,880
Water Quality Analytical (Post-Closure to Y10)	Surface water quality analytical (19 sites, incl. T1)	samples	189	420	55,860	23,520	79,380
Water Quality Analytical (Post-Closure to Y10)	Groundwater quality analytical (24 sites)	samples	168	290	48,720		48,720
Hydrological Monitoring		L.S.			15,000	-15,000	
EEM Monitoring requirements		annual	3	30,000	90,000		90,000
External Consulting Services		L.S.			50,000	-50,000	
Geotechnical Inspections Closure Phase		annual	3	15,000	45,000		45,000
Geotechnical Inspections Post-Closure Phase		annual	7	15,000	105,000		105,000
Subtotal Compliance Monitoring and Reporting					**1,463,120**	**-824,120**	**639,000**
Tailings Closure Spillway	twice per year inspection/maintenance	annual	10	10,000	100,000		100,000
Subtotal Closure Maintenance					**100,000**		**100,000**
Wolverine Creek Biopass Contingency							
Construction of Biopass Channel	Cat 320CL Excavator	hrs	60	170	10,200		10,200
Construction of diversion channel	Cat 320CL Excavator	hrs	80	170	13,600		13,600
Placement of liner in channel	Labour and materials	m	600	200	120,000		120,000
Source, haul and place organics	400 m x 2.5 m x 2.6 m	m^3	2,600	8	20,800		20,800
Organics and fill placement	Labour	hrs	432	50	21,600		21,600
Engineering, CM and Survey Control	15% of capital cost				27,930		27,930
Maintenance	twice per year for 5 years	bi-annual	10	1,000	10,000		10,000
Subtotal Wolverine Creek Biopass Contingency					**224,130**		**224,130**
Subtotal Site Management and Monitoring					**3,566,775**	**-1,095,320**	**2,471,455**
		contingency		15%	**535,016**	**-164,298**	**370,718**
Total					**$4,101,791**	**$(1,259,618)**	**$2,842,173**

Table 5-7: Closure Cost Details, Reclaim Tailings Facility

Action	Notes	Units	Quantity	Unit Cost	V2013-05 Cost	+/-	V2015-06 Cost
Reclaim TSF Dam Face							
Load Haul and Place topsoil	Area of 24000 m^2 with 0.25 m depth	m^3	6,000	5	30,000		30,000
Revegetate	Seed and Fertilize	ha	2	1,500	3,600		3,600
		Subtotal Direct Costs			**33,600**		**33,600**
			contingency	10%	**3,360**		**3,360**
			Total		**$ 36,960**	**$ -**	**$ 36,960**

Table 5-8: Closure Cost Details, Temporary Waste Piles

Action	Notes	Units	Quantity	Unit Cost	V2013-05 Cost	+/-	V2015-06 Cost
Temporary Waste Rock Storage Areas							
Load and haul rock and granular till layer	For disposal in tailings facility	m^3	110,500	7	773,500	-773,500	
Reclaim Pile #1 in place	Move Excess from Dump #1 Resloping to Tailings Pond					728,209	728,209
	Cap Both with Granular Till					692,209	692,209
	Install Biopass for Waste Pile #1					16,334	16,334
Remove liners and encapsulate in mine	2 liners	L.S.	2	8,000	16,000	-16,000	
Regrade and contour	Cat D8N Dozer	hours	30	245	7,350	-7,350	incl
Load Haul and place topsoil	33585 m^2 x 0.25 m	m^3	8,396	5	41,980		41,980
Engineering and Survey Control		L.S			10,000		10,000
Revegetate	Seed and Fertilize	ha	3.36	1,500	5,040		5,040
		Subtotal Direct Costs			**853,870**	**639,903**	**1,493,773**
			contingency	10%	**85,387**	**63,990**	**149,377**
			Total		**$ 939,257**	**$ 703,893**	**$ 1,643,150**

Table 5-9: Closure Cost Details, Decommission and Reclaim Access Road

Action	Notes	Units	Quantity	Unit Cost	V2013-05 Cost	+/-	V2015-06 Cost
Decommission and Reclaim Access Road							
Regrade Lower Road	Cat 14G Grader	Hrs	100	160	16,000		16,000
Regrade Lower Road	Cat 320CL Excavator	Hrs	140	125	17,500		17,500
Regrade Lower Road	A30D Rock Truck	Hrs	140	197	27,580		27,580
Stabilize side slopes	Cat 320CL Excavator	Hrs	80	125	10,000		10,000
Remove Culverts (<1200mm)	Removefsite for re-use, reslope banks, armour wetted section	Each	69	1,500	103,500		103,500
Remove Culverts >2400	Removefsite for re-use, reslope banks, armour wetted section	Each	3	5,000	15,000		15,000
Restore Culvert Crossings	Install environmental protection measures	L.S.	1	20,000	20,000		20,000
Remove Bunker Creek Bridge	Remove bridge complete with bin-wall, reslope of banks	L.S.	1	75,000	75,000		75,000
Restore Bunker Creek habitat	Restoration in riparian zone and re-seeding	L.S.	1	2,000	2,000		2,000
Scarify road surface	To encourage re-vegetation (24 km x 13 m) - Cat D8N Dozer	Ha	31.2	2,000	62,400		62,400
Recontour staging and roadside stockpile areas	Cat 320CL Excavator, Cat 14G Grader	L.S.		20,000	25,000		25,000
Stabilize slopes - borrow sources	Stabilize the slopes of the excavations - Cat D8N Dozer	Hrs	30	245	7,350		7,350
Revegetate Borrow Sources	Using ATV mounted applicator for seed and fertilizer	Ha	10	1,500	15,000		15,000
Revegitate road surface & disturbed areas	Using ATV mounted applicator for seed and fertilizer	Ha	37.5	1,500	56,250		56,250
Maintenance after 1 year	Assume coverage of 50% with seed & fertilizer	Ha	18.8	1,500	28,200		28,200
Place Permanent barrier at highway	Trench and Barricade using natural materials in the area to dissuade casual access	L.S.	1	3,500	3,500		3,500
Place Permanent barrier at Km 14	Barricade to provide ultimate barrier to more interior access	L.S.	1	3,500	3,500		3,500
		Subtotal Direct Costs			**487,780**		**487,780**
Indirects - Engineering 5%	For major components, particularly Remove bridge				24,389		24,389
Indicrects - Surveying 5%	For final as-builts drawings				24,389		24,389
			subtotal		**536,558**		**536,558**
			contingency	10%	**53,656**		**53,656**
			Total		**$ 590,214**	**$ -**	**$ 590,214**