Sä Dena Hes Mine

Post-Reclamation Adaptive Management Plan

June 30, 2016

Prepared for:

SÄ DENA HES OPERATING CORPORATION C/O TECK RESOURCES LIMITED

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1 Introduction

1.1 Overview

The Sä Dena Hes (SDH) mine was a lead/zinc mine located 45 km north of Watson Lake in southeastern Yukon within the Traditional Territory of the Kaska First Nation, specifically Liard First Nation (LFN). The SDH mine was constructed in 1991 and operated between August 1991 and December 1992 by Curragh Resources Inc. under Water Licence IN90-002 pursuant to the *Northern Inland Waters Act*. Approximately 700,000 tonnes of ore were mined and processed onsite during the 16-month operation of the mine. The mine has not been in operation since that time.

After 14 years in Temporary Closure, on January 26, 2012, Teck Resources Limited (Teck), on behalf of the Sä Dena Hes Operating Corporation (SDHOC), informed YG of its intention to enter the SDH mine into permanent closure and begin to implement the approved Detailed Decommissioning and Reclamation Plan (DDRP) on January 29, 2013. The decommissioning, closure and reclamation activities to permanently close the SDH mine was conducted from 2013 to 2015 in accordance with the licensed and approved DDRP.

During the 25-year post-reclamation phase, Teck proposes:

- to continue to discharge neutral mine drainage;
- to decommission the Main Access Road and Site Access Road; and,
- to undertake post-reclamation monitoring and adaptive management, inspections and maintenance of constructed/engineered structures.

This Adaptive Management Plan (AMP) is a tool used to address uncertainty or conditions beyond those anticipated in post-reclamation. AMPs outline a range of possible but unexpected outcomes and the responses that will be undertaken to curb possible negative impacts associated with these unexpected situations.

There are several very prescriptive and detailed management plans required for both operational control and regulatory approval for the post-reclamation period. Teck has developed a number of operational management plans which describe the management and response actions for expected conditions at the site. These plans currently include:

- Detailed Decommissioning and Reclamation Plan (Teck, 2015); and,
- Environmental Monitoring, Surveillance, Reporting Plan (Teck, 2016).

This AMP provides a framework for responses to conditions beyond those expected and identified in these decision-based management plans. Consequently, this AMP addresses a limited range of components. It is expected that the AMP will be reviewed and revised as the closure measures are evaluated over time.

1.2 Adaptive Management Planning

Adaptive management is an approach to environmental management that is appropriate when a mitigation measure may not function as intended or when broad-scale environmental change is possible. Adaptive management plans are precautionary in nature, and provide a level of security in long term environmental planning. Adaptive management plans also allow for the inclusion of improved science into mitigation measures as they are continually revised.

Adaptive management has been evolving since its emergence in the 1970s. Adaptive approaches include an ability to incorporate knowledge into the management plan as the knowledge is gleaned and circumstances change. Eberhard et al. (Eberhard, et al., 2009) described the categories of knowledge that may trigger changes to water quality management plans; system understanding, measuring progress and anticipating changes. These categories allow for the inclusion of knowledge and adaptation of management to changed conditions. Embedding adaptation into environmental plans involves thinking about how the results of monitoring will change management actions. Adaptive management plans are a way to accept uncertainties and build a structured framework to respond to changing conditions.

Adaptive management constructs a flexible path with actions to take when specific triggers occur. AMPs are a formalization of a plan for performance monitoring and project re-evaluation in the future. The general structure of adaptive management can be described by the following steps:

1. Identify risk triggers associated with vulnerabilities or uncertainties;
2. Quantify impacts and uncertainties;
3. Evaluate strategies and define implementation path that allows for multiple options at specific triggers;
4. Monitor the performance and critical variables in the system; and,
5. Implement or re-evaluate strategies when triggers are reached.

Although there are no widely used AMP terms, the steps listed above are representative of typical AMP processes. Within AMPs, triggers provide decision points in a stepwise decision-making framework that identifies how and when management action should be taken. A key characteristic of adaptive management is monitoring, which is used to document and track the status of the system of interest and to adjust management policies in an iterative process. Adaptive management is a rigorous method for addressing uncertainties in ecosystem management.

1.3 Adaptive Management Plan Objectives

An AMP is a management tool or framework to make quick and effective decisions to guide responses to unforeseen events. This document identifies areas of uncertainty within the operational phase of Permanent Closure at Sä Dena Hes Mine and provides an AMP framework for each. For each component the AMP describes monitoring commitments, thresholds, triggers and responses to underperforming elements or emerging risks within the component. The steps laid out in the AMP framework are precautionary, and therefore they provide the confidence that action will be taken before adverse environmental impacts are observed.

Response planning, and results for anticipated events are contained within site management plans while AMPs guide responses to unforeseen or contingency events. This AMP provides a framework to guide responses to unanticipated monitoring results and to potential but low probability events where uncertainty exists.

It is difficult to predict the specific environmental condition that may arise which requires a response from management and, therefore, the AMP does not provide specific detailed descriptions of responses to a situation. The AMP provides a range of possible responses to use as a guide to respond to specific environmental conditions encountered. Management should use the information provided in the AMP and undertake the appropriate response.

1.4 Adaptive Management Plan Approach

In addition to the conclusions drawn from monitoring, the approach presented in this AMP follows the Environmental Code of Practice for Metal Mines, Section 4.1.17 on Adaptive Management:

"Mine owners/operators should use adaptive management methods to revise and refine the environmental management strategy. Adaptive management should consider a wide range of factors, including:

- the results of environmental audits or other evaluation activities;
- the results of environmental monitoring;
- the results of monitoring of the performance or condition of environmental infrastructure, such as containment structures, water management systems or treatment facilities;
- technological developments; and,
- changing environmental conditions." (Environment Canada, 2009)

In addition to the guidance provided by the Environmental Code of Practice for Metal Mines, the AMP meet the Yukon Government's Protocol for the Contaminated Sites Regulation under the Environment Act Protocol 13: Adaptive Management.

1.4.1 AMP Components

Receiving environment surface water quality, groundwater quantity and quality, physical stability and soil covers are the AMP components that have been identified as having the potential for unexpected conditions during the post-reclamation period for which the Operational Management Plans may not provide adequate mitigation against potential effects to the environment or human health and safety. The specific AMP framework for the components are described in subsequent sections.

1.4.2 AMP Framework

The AMP is laid out using a common element approach to consistently implement the AMP protocol as illustrated in Figure 1-1. The common elements are:

1. Description of the component:
    - *Description* - description and understanding of the component leads to risk narrative and specific performance thresholds.
    - *Risk Narrative* describe the possible environmental impacts and environmental conditions that implementation of the AMP will prevent.
2. Monitoring the component:

- *Specific Indicators* are the environmental or physical parameters to be monitored and assessed. Specific indicators are measurable or observable, and are indicative of changes from the designed or expected condition.
- *Monitoring Requirements* describes the monitoring regime for the component including frequency, type of data required and interpretation of results.
- *Specific Performance Thresholds* define the conditions, in terms of specific indicators, when action is triggered. Performance thresholds are staged to accommodate levels of concern and a diversity of actions. To the extent possible, specific performance thresholds will include early warning thresholds.

3. Responding to unexpected conditions of the component:

   Specific Responses are staged according to specific performance thresholds and describe the actions to be implemented if those thresholds are crossed. They are provided in the following categories:

   a) Notification
   b) Review
   c) Evaluation
   d) Action

4. Annual Reporting and Review:

   Annual Reporting reflects annual changes made to the AMP as the site conditions change. The AMP should be modified whenever unexpected circumstances are encountered and the protocol is implemented or when additional proven science or technology becomes available. The annual review will include a review of the relevant monitored data and AMP elements. Updates, amendments, performance thresholds crossed, and trigger(s) activated will be provided to the appropriate governmental organizations as required and will be part of the annual report.

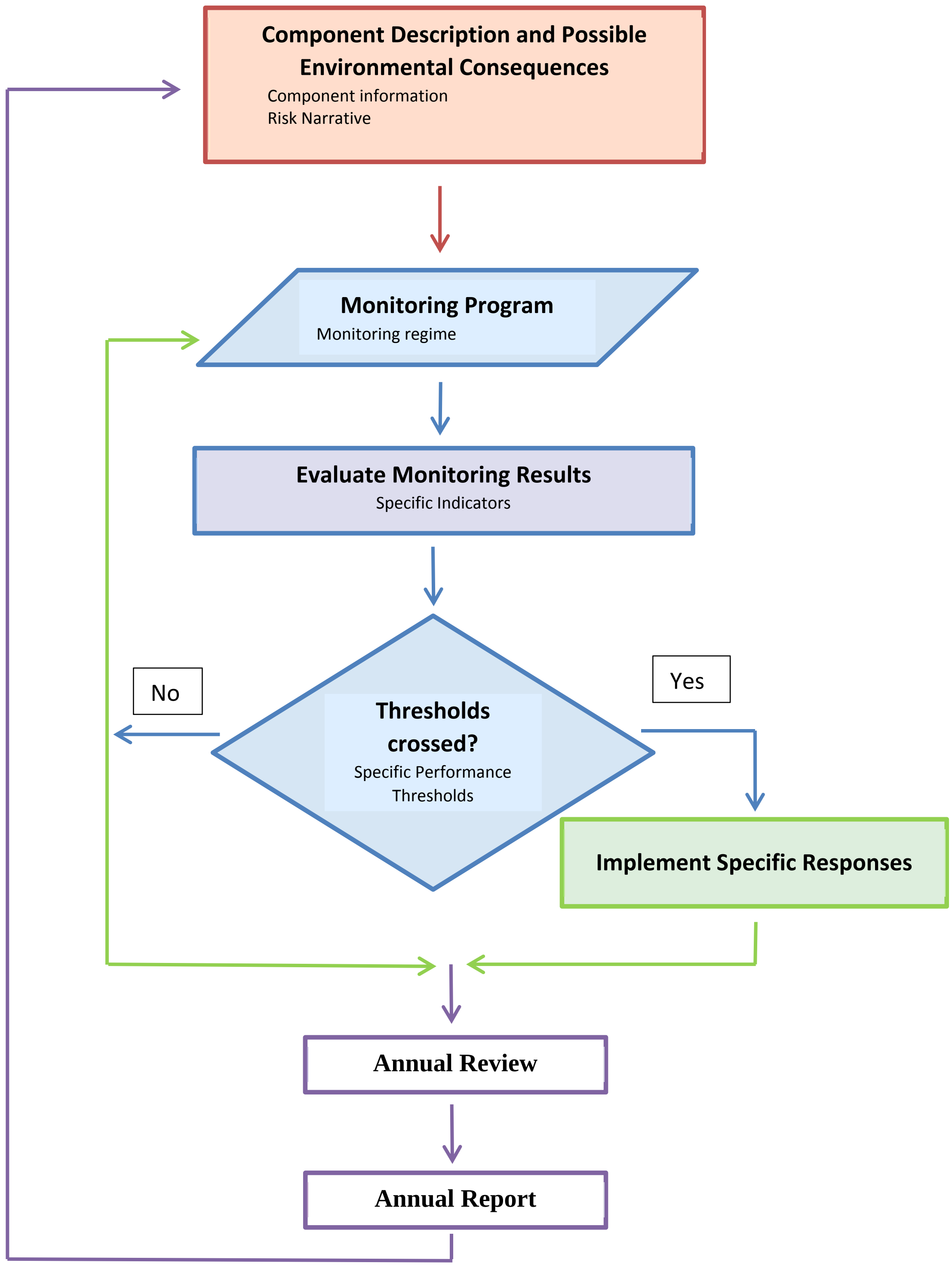


Figure 1-1: Sequential Components of the AMP (Adapted from AECOM 2010).

2 Adaptive Management Plans for Mine Components

2.1 Receiving Environment Surface Water Quality

2.1.1 Description

The monitoring points where the AMP triggers are applied are MH-11 and MH-12 (Figure 2-1). These monitoring points are selected to be protective of the receiving environment (Camp Creek, North Creek and ultimately False Canyon Creek). The monitoring for MH-11 and MH-12 is outlined in detailed in the Environmental Monitoring, Surveillance and Reporting Plan (Teck, 2016). The frequency been proposed to be bi-monthly in 2016-2017, semi-annual in 2018-2020, annual from 2021-2025 and every other year from 2026-2040.

There are three site discharges which include the 1380 Portal, the Burnick Portal and seepage from the tailings impoundment. Discharge from both the 1380 Portal and Burnick Portal flow through the downgradient waste rock dumps, after which the flow infiltrates into the ground and is naturally attenuated. Groundwater from these sources ultimately discharges to False Canyon Creek. Monitoring of the discharges is further described in Section 2.2. There will be no onsite water collection or treatment during the post-reclamation time period. Only neutral mine water will be naturally discharged during this time.

2.1.2 Risk Narrative

An increase in the receiving environment surface water quality concentrations trending towards permit limits as a result from the reclaimed mine area.

2.1.3 Specific Indicators, Performance Thresholds and Responses

Applicable water quality guidelines for the site are generally the most recent of the BC or CCME guidelines (Azimuth, 2016), as shown in Table 2-1. These were used to identify constituents of Potential Concern (COPCs), which are those constituents in mine discharges that may be of potential concern to aquatic life. The COPCs identified for MH-11 and MH-12 are constituents exceeding water quality guidelines at the 1380 Portal and seepage at MH-02, respectively. Then, starting with the generic water quality guidelines for some parameters and then developing site-specific values for others, permit limits were developed for the site (Azimuth, 2016). These permit limits were designed to be protective of the receiving environment surface water quality in False Canyon Creek (at station MH-13) and North Creek (at MH-12). It is anticipated that, if future conditions are similar to current conditions, exceedances of the permit limits would be rare and anomalous, meriting adaptive management.

The applicable water quality guidelines were adopted as the permit limits for most constituents. In the case of chromium, copper, iron, lead, and zinc, alternative methods were used to develop permit limits for MH-11 and MH-12 (see Table 2-2 and Azimuth [2016]). Indicators, performance thresholds and responses specific to water quality and the monitoring program are provided below in Table 2-3.

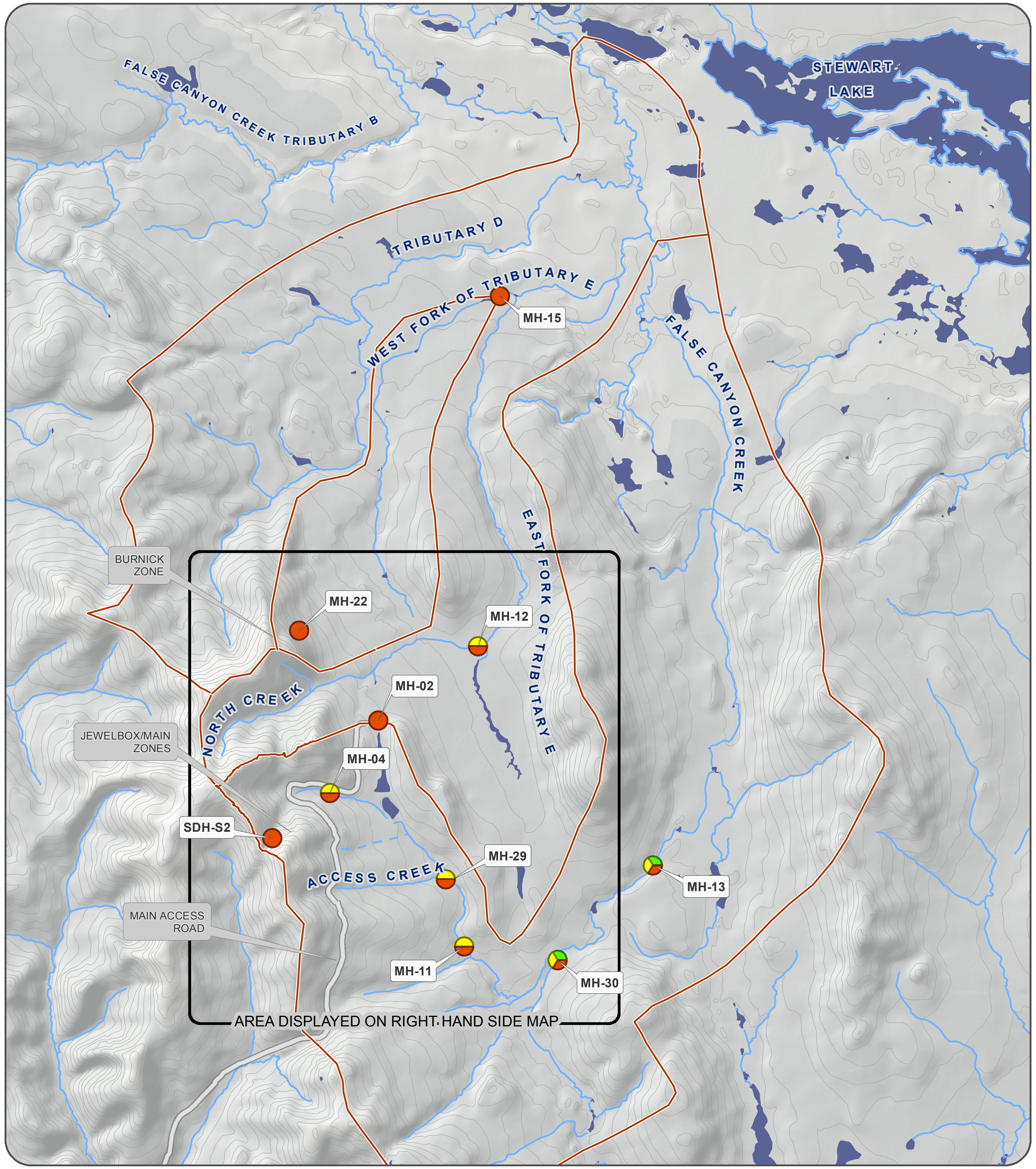
2.1.4 Investigate Nature and Extent of the Threshold Exceedance

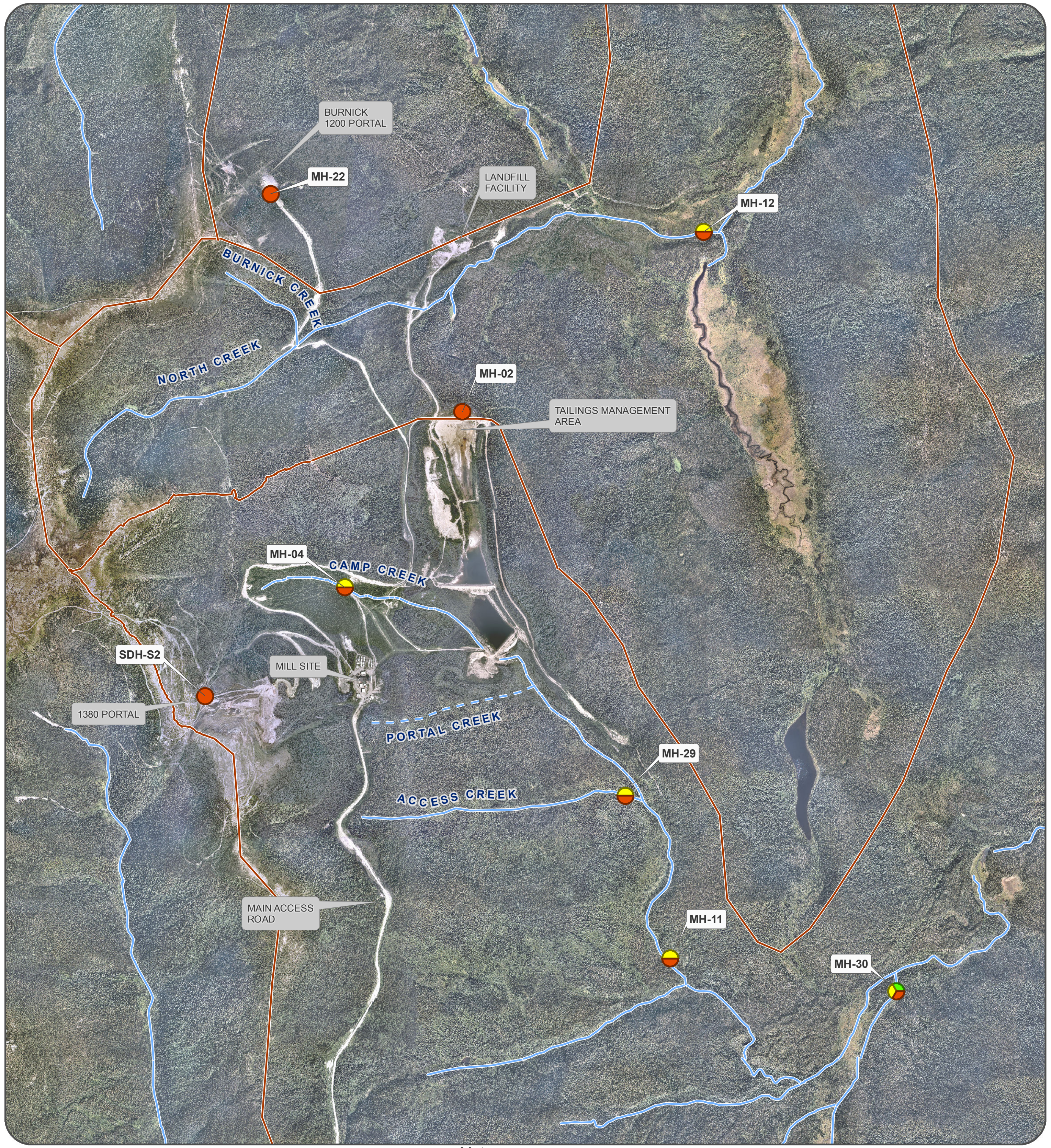
Any threshold exceedance will be assessed and a monitoring plan created to investigate the nature and extent of the exceedance. The plan may include more frequent sampling of existing stations and/or the addition of new monitoring stations, and would take into consideration various factors, including but not limited to:

- Magnitude of threshold exceedance;

- Duration of an increasing trend for a threshold;
- Location of station that has exceeded a threshold (source load, groundwater, surface water, or compliance point); and,
- Results of biological monitoring.

Depending on the findings of the investigation, the water quality model may be revised to re-evaluate potential changes to downstream water quality. The Water Board would be notified in writing of any changes in monitoring and the outcome of the investigation.





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

Datum: NAD 83; Map Projection: UTM Zone 9N

Post-Reclamation Monitoring Stations

- Fisheries Monitoring
- Benthos/Sediment Monitoring
- Surface Water Quality Monitoring

— Catchments Boundaries

Teck

ACCESS

SĀ DENA HES MINE
POST- RECLAMATION PHASE WATER LICENSE APPLICATION

FIGURE 2-1
POST-RECLAMATION SURFACE WATER MONITORING STATIONS

JULY 2015

I:\Sa_Dena_Hess\GIS\Maps\02-Permitting\04-Closure WUL 2015\Fig-5-1_Post_Reclamation_MonitoringProgram_20150708.mxd (*Last edited by: mducharme;7/8/2015/14:09 PM*)

Table 2-1: Water Quality Guidelines used to select contaminants of potential concern.

Parameter	WQ Guideline	Guideline Source	Guideline Date
Aluminum (dissolved)	$e^{[1.6-3.327(\text{median pH})+0.402(\text{median pH})^2]}$ if pH < 6.5 0.05 mg/L if pH ≥ 6.5	BC	2001
Antimony	9 µg/L	BC Working	ANZECC (2000b)
Arsenic	5 µg/L	BC Working	2002
Boron	1.5 mg/L	CCME	2009
Barium	1 mg/L	BC Working	Haywood & Drinnin (1983)
Beryllium	0.13 µg/L	BC Working	ANZECC (2000a)
Cadmium (dissolved)	$e^{[0.736 \times \ln(\text{hardness})-4.943]}$ µg/L if hardness ≥ 3.4 mg/L and ≤ 285 mg/L 0.475 µg/L if hardness > 285 mg/L	BC	2015
Cobalt	4 µg/L	BC	2004
Chromium (IV)	1 µg/L	CCME	1997
Copper	2 µg/L if hardness ≤ 50 mg/L 0.04*(mean hardness) if hardness > 50 mg/L In addition, no more than 20% of values in a 30-day period should exceed 1.5 times the long term average WQG.	BC	1987
Iron	1 mg/L (total) 0.35 mg/L (dissolved)	BC	2008
Manganese	0.0044*hardness + 0.605 mg/L if hardness ≥ 37 mg/L and ≤ 450 mg/L	BC	2001
Molybdenum	0.073 mg/L	CCME	1999
Nickel	25 µg/L if hardness (as $CaCO_3$) ≤ 60 mg/L or unknown $e^{\{0.76[\ln(\text{hardness})] + 1.06\}}$ if hardness > 60 mg/L and ≤ 180 mg/L 150 µg/L if hardness > 180 mg/L	BC Working	CCREM (1987)
Nitrate (as N)	3.0 mg/L	BC	2009
Nitrite (as N)	0.02 mg/L when chloride (Cl^-) ≤ 2 mg/L	BC	2009
Total Ammonia	Temperature and pH dependent Screening completed using pH 8 and 15°C, for a guideline value of 1.09 mg/L	BC	2009
Total Cyanide	5 µg/L (as free CN)	CCME	1987
Weak-acid dissociable Cyanide	5 µg/L Note: no WAD data were available. Strong-acid dissociable data were screened against the WAD guideline	BC	1986
Lead	$3.31 + e^{[1.273 \ln(\text{hardness}) - 4.704]}$ µg/L if hardness > 8 mg/L	BC	1987
Selenium	Guideline 2 µg/L Alert concentration 1 µg/L	BC	2014

Silver	**0.25 µg/L**	**CCME**	**2015**
Sulphate	**Long Term Average:** **128 mg/L if hardness ≤ 30 mg/L** **218 mg/L if hardness > 30 mg/L and ≤ 75 mg/L** **309 mg/L if hardness > 75 mg/L and ≤ 180 mg/L** **429 mg/L if hardness > 180 mg/L and ≤ 250 mg/L** **Site Specific if hardness > 250 mg/L**	**BC**	**2013**
Thallium	**0.8 µg/L**	**CCME**	**1999**
Uranium	**15 µg/L**	**CCME**	**2011**
Zinc	**7.5 µg/L if hardness ≤ 90 mg/L** **7.5 + 0.75 * (hardness – 90) µg/L if hardness > 90 mg/L**	**BC**	**1999**

Table 2-2: Proposed Permit Limits for parameters not based on generic guidelines

<table>
<tr><th>Parameter</th><th>Proposed Permit Limit</th></tr>
<tr><td>Chromium (total CrVI)</td><td>Set permit limit for Cr(VI) equal to the water quality guideline for Cr(VI), and apply using data for Cr(VI) rather than total chromium; this requires collection of speciated chromium data.</td></tr>
<tr><td>Copper (total)</td><td>May: 4 µg/L if hardness < 50 mg/L; 0.08 * (mean hardness) if hardness between 50 and 187 mg/L). In addition, no more than 20% of values in a 30-day period during the month of May should exceed 1.5 times the permit limit.

Other months: equal to the water quality guideline.</td></tr>
<tr><td>Iron (total)</td><td>May: 3.9 mg/L

Other months: 1 mg/L (water quality guideline)</td></tr>
<tr><td>Lead (total and dissolved)</td><td>Apply to dissolved fraction when TSS is 4 mg/L or higher:
$guideline$= 3.31+ $e1.273*loge(hardness)-4.704$
MH-12 Limit (µg/L) = $guideline$
MH-11 Limit (µg/L) = 1.928$*guideline$

The effective limit at MH-11 at various levels of hardness is as follows:
<table>
<tr><td>Hardness (mg/L)</td><td>Permit Limit (µg/L)</td><td>Hardness (mg/L)</td><td>Permit Limit (µg/L)</td></tr>
<tr><td>100</td><td>12.5</td><td>200</td><td>21.2</td></tr>
<tr><td>150</td><td>16.7</td><td>250</td><td>26.1</td></tr>
</table></td></tr>
<tr><td>Zinc (total and dissolved)</td><td>Apply to dissolved fraction when TSS is 4 mg/L or higher:
MH-12 Limit:
For hardness < 90 mg/L: 7.5 µg/L
For hardness > 90 mg/L:
Limit (µg/L) = $guideline$
$where\ guideline$= 7.5+(0.75$*$($hardness$−90))

MH-11 Limit:
For hardness < 90 mg/L: 18.75 µg/L
For hardness > 90 mg/L:
Limit (µg/L) = 2.500$*guideline$

The effective limit at various levels of hardness is as follows:
<table>
<tr><td>Hardness (mg/L)</td><td>Permit Limit (µg/L)</td><td>Hardness (mg/L)</td><td>Permit Limit (µg/L)</td></tr>
<tr><td>100</td><td>37.5</td><td>200</td><td>225</td></tr>
<tr><td>150</td><td>131</td><td>250</td><td>319</td></tr>
</table></td></tr>
</table>

Table 2-3: Specific Indicators, Performance Thresholds and Responses for Surface Water Quality Monitoring at MH-11 and MH-12.

<table>
<tr><th>Specific Performance Thresholds</th><th>Specific Responses</th></tr>
<tr><td>Threshold 1
T-Pb & D-Pb, D-Cd, and T-Zn & D-Zn
Trend analysis of the sample results of grab samples collected from MH-11 or MH-12 indicate that the concentration is increasing towards the applicable guidelines or permit limits</td><td>Notification
Teck Representative/Environmental Monitor.
Liard First Nation representative.
Include in annual reporting.
Review
Follow QA/QC investigative protocol:
Review laboratory QA/QC report
Validate original result, or re-run sample if a laboratory error is indicated.
Evaluation
Investigate potential causes for any observed trend to determine if cause is mine site related, lab variability, etc.
Action
Re-sample if initial result is validated. Compare re-sample results with initial result.
Investigate nature and extent of the threshold exceedance.</td></tr>
<tr><td>Threshold 2
T-Pb & D-Pb, D-Cd, and T-Zn & D-Zn
Any exceedance of applicable guidelines or permit limits in grab samples collected from MH-11 or MH-12.</td><td>Notification
Teck Representative/Environmental Monitor.
Liard First Nation representative.
Include in annual reporting.
Review
Follow QA/QC investigative protocol:
Review laboratory QA/QC report
Validate original result, or re-run sample if a laboratory error is indicated.
Evaluation
Conduct trend analysis on metal concentrations.
Investigate potential causes for any observed trend to determine if cause is mine site related, lab variability, etc.
Action
Re-sample if initial result is validated. Compare re-sample results with initial result and dissolved metal concentrations.
Investigate nature and extent of the threshold exceedance.</td></tr>
<tr><td>Threshold 3
T-Pb & D-Pb, D-Cd, and T-Zn & D-Zn and TSS
Two consecutive sample collected from MH-11 or MH-12 exceeds 30 mg/L (Maximum authorized concentration in a grab sample as outlined in MMER)</td><td>Notification
Teck Representative/Environmental Monitor.
Liard First Nation representative.
Report on results of investigation within 3 months of resampling and comparative findings at key downstream receiving environment locations.
Review
Follow QA/QC investigative protocol:
Review laboratory QA/QC report
Validate original result, or re-run sample if a laboratory error is indicated
Evaluation
Conduct trend analysis on metal concentrations.
Investigate potential causes for any observed trend to determine if cause is mine site related, lab variability, etc.
Action
Re-sample if initial result is validated.
Compare re-sample results with initial result and dissolved metal concentrations
Investigate nature and extent of the threshold exceedance.</td></tr>
</table>

2.2 Mine Source Water Quality

The AMP for this mine component is adapted from SRK Consulting's draft Adaptive Management Plan, Sä Dena Hes Mine that was prepared in October, 2014. The entire document is available as Appendix A.

2.2.1 Description

Water quality monitoring has been conducted as a condition of the current Water Use Licence (WUL) since 1991. The ongoing monitoring has been used to identify existing loading sources that discharge water with elevates concentrations of zinc, cadmium and lead. These sources are:

- North Tailings Dam Seepage (MH-02);
- Burnick Portal (MH-22); and,
- 1380 Portal (SDH-S2 as MH-25 has been decommissioned).

Water from these sources infiltrates to groundwater near the source and then migrates downgradient to areas of groundwater discharge. Monthly and quarterly water quality monitoring results currently meet the effluent quality limits in the Water Use Licence at the receiving water bodies.

Water quality will be monitored after reclamation to observe any potential changes indicative of loading from the North Dam, Burnick Portal and 1380 Portal.

2.2.2 Risk Narrative

The objective of the AMP is to detect changes from existing conditions and ensure that water quality does not exceed post-reclamation WUL limits. If water quality changes from current conditions, the AMP describes the process for developing a plan to understand why the change has occurred and how it may be addressed. Loading from each of the three mine site loading sources could increase mining related constituent concentrations.

Exceedance of the thresholds should occur sequentially from statistically significant increasing trends at monitoring locations most proximal to the loading sources (Level 1) that may eventually lead to an exceedance of limits at the two surface water compliance point monitoring stations (Level 2). Indicators, performance thresholds and responses specific to water quality and the monitoring program are provided below in

Table 2-4.

2.2.3 Investigate Nature and Extent of the Threshold Exceedance

Any threshold exceedance will be assessed and a monitoring plan created to investigate the nature and extent of the exceedance. The plan may include more frequent sampling of existing stations and/or the addition of new monitoring stations, and would take into consideration various factors, including but not limited to:

- Magnitude of threshold exceedance;
- Duration of an increasing trend for a Level 1 threshold;
- Number of stations within a source load flow path that have exceeded a threshold;
- Location of station that has exceeded a threshold (source load, groundwater, surface water, or compliance point);
- Which level of threshold has been exceeded (Level 1 or Level 2); and,
- Results of biological monitoring.

Depending on the findings of the investigation, the water quality model may be revised to re-evaluate potential changes to downstream water quality. The Water Board would be notified in writing of any changes in monitoring and the outcome of the investigation.

Table 2-4: Specific Indicators, Performance Thresholds and Responses for Mine Source Water Quality

Specific Indicators	Specific Performance Thresholds	Specific Responses
Concentrations, in mg/L at stations MH-02, MH-22 and SDH-S2 of: • Dissolved cadmium • Total and dissolved lead • Sulphate • Total and dissolved zinc.	**Specific Threshold 1 (for D-Cd, T-Pb & D-Pb, SO_4^{2-} and T-Zn & D-Zn)** • Statistically significant increasing trend of zinc, cadmium, lead and/or sulphate concentrations at surface water	**Notification** • Teck Representative/Environmental Monitor. • Liard First Nation Representative. • Include in annual reporting. **Review** • Follow QA/QC investigative protocol: o Review laboratory QA/QC report o Validate original result, or re-run sample if a laboratory error is indicated • Statistical significance of the trend will be tested using a Mann-Kendall test used to evaluate water quality data for surface water. The large existing dataset from 1991 to 2014 supports using trend analysis to identify statistically significant changes in water quality. **Evaluation** • An upward trend for a single AMP indicator or compliance station will trigger a lower level of response than multiple stations showing upward trends. Similarly, an upward trend that continues for multiple years will trigger a greater response than if the trend were observed in a single year. • Compare with receiving environment water quality results. **Action** • Re-sample if initial result is validated. o Compare re-sample results with initial result and dissolved metal concentrations • Investigate nature and extent of the threshold exceedance.

2.3 Groundwater Quality and Quantity

2.3.1 Description

The long term groundwater monitoring plan is described in detail in the Environmental Monitoring, Surveillance and Report Plan (Teck, 2016) which includes monitoring groundwater flow and quality within the reclaimed mine footprint (Figure 2-2):

- Monitor groundwater quality downgradient of the 1380 Portal discharge and waste dump prior to it reaching Camp Creek: monitor wells MW13-01, and MW13-13;
- Monitor groundwater flow direction and quality at the Burnick Portal discharge and waste dump: monitor MW13-06;
- Monitor groundwater flow and quality originating from Jewelbox or the mill site prior to reaching Camp Creek: monitor MW13-05 and MW13-10;
- Monitor groundwater flow direction and quality from Burnick towards North Creek and the landfill area: monitor MW14-04;
- Monitor groundwater flow direction and quality in the tailings pond area: monitor MW13-07; and,
- Monitor groundwater quality in the landfill area: monitor MW14-01, MW14-02 and MW14-03.

The monitoring schedule includes:

1. Quarterly monitoring of water levels and water quality at the landfill for two years, then semi-annually for the next three years and then reduce to annually for five years.
2. Semi-annual monitoring of the mine waste discharge monitoring wells MW13-01, MW13-06, and MW13-13 for five years, then annually for five years.
3. Annual monitoring of general groundwater monitoring wells for four years, then biannually for six years.

2.3.2 Risk Narrative

An increasing trend in groundwater quality and quantity within the reclaimed mine having the potential to cause adverse effects to the receiving environment.

2.3.3 Specific Indicators, Performance Thresholds and Responses

The thresholds for groundwater quality are based on the Yukon contaminated sites regulations for the protection of aquatic life. The groundwater quality threshold parameters are sulphate, hydrocarbons, and dissolved cadmium, lead and zinc. Indicators, performance thresholds and responses specific to groundwater quality and quantity, and the monitoring program are provided below in Table 2-5 and Table 2-6.

2.3.4 Investigate Nature and Extent of the Threshold Exceedance

Any threshold exceedance will be assessed and a monitoring plan created to investigate the nature and extent of the exceedance. The plan may include more frequent sampling of existing stations and/or the addition of new monitoring stations, and would take into consideration various factors, including but not limited to:

- Magnitude of threshold exceedance;
- Location of station that has exceeded a threshold (source load, groundwater, surface water, or compliance point);

- Which level of threshold has been exceeded; and,
- Results of biological monitoring.

Depending on the findings of the investigation, the water quality model may be revised to re-evaluate potential changes to downstream water quality. The Water Board would be notified in writing of any changes in monitoring and the outcome of the investigation.

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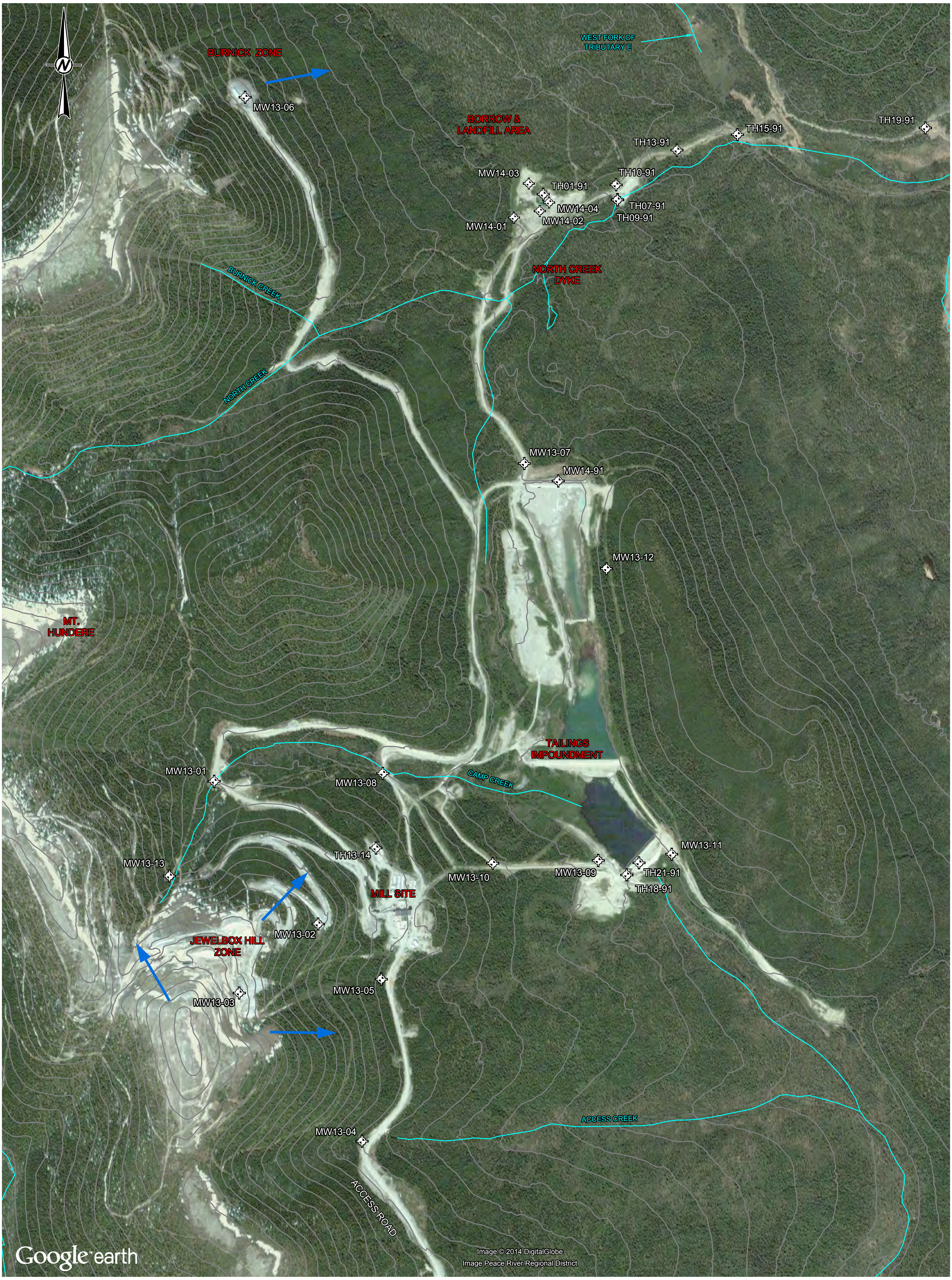

LEGEND

- SDH MW WELL LOCATION
- INFERRED GROUNDWATER FLOW DIRECTION FROM JEWELBOX AND BURNICK
- CONTOURS (20m INTERVAL)

REFERENCE

All units are in metres unless otherwise noted.
Base imagery obtained from Google Earth Pro under licence.
Google Earth Imagery date June 12th, 2006.
Google Earth Image is to be used for surrounding detail reference only.
Datum: NAD 83 Projection: UTM Zone 9

0 300 600 900
SCALE METRES

PROJECT

TECK METALS
SA DENA HES HYDROGEOLOGICAL ASSESSMENT
SA DENA HES MINE, YUKON TERRITORY

TITLE

MONITORING WELL & TESTHOLE LOCATIONS

PROJECT No.	12-1021-0006-7000	FILE No.	1210210006-7000-01
DESIGN	TR	2013-12-03	SCALE AS SHOWN
CADD	LYT	2013-12-03	FIGURE
CHECK	TR	2014-03-24	Figure 2-2
REVIEW	HG	2014-03-24	

Golder Associates

Table 2-5: Specific Indicators, Performance Thresholds and Responses for Groundwater Quality

Specific Indicators	Specific Performance Thresholds	Specific Responses
D-Cd, D-Pb, SO_4^{2-} & D-Zn at Monitoring wells: MW13-01, MW13-05, MW13-06 MW13-07, MW13-10, MW13-13, MW14-01, MW14-02, MW14-03, and MW14-04. Hydrocarbons at Monitoring wells: MW13-05, MW13-06 MW13-10, MW14-01, MW14-02, and MW14-03.	**Specific Threshold 1** • Trend analysis of the sample results of grab samples collected from monitoring wells indicate that the concentration is increasing towards the applicable guidelines	**Notification** • Teck Representative/Environmental Monitor. • Liard First Nation Representative. • Include in annual reporting. **Review** • Follow QA/QC investigative protocol: o Review laboratory QA/QC report o Validate original result, or re-run sample if a laboratory error is indicated **Evaluation** • Compare with groundwater well results. **Action** • Investigate nature and extent of the threshold exceedance. • Re-sample if initial result is validated. o Compare re-sample results with initial result and dissolved metal concentrations
	Specific Threshold 2 • Any exceedance of applicable guidelines in grab samples collected from the monitoring wells	**Notification** • Teck Representative/Environmental Monitor and Inspector. • Liard First Nation Representative. • Report on results of investigation within 3 months of resampling and comparative findings at key downgradient monitoring wells. **Review** • Follow QA/QC investigative protocol: o Review laboratory QA/QC report o Validate original result, or re-run sample if a laboratory error is indicated **Evaluation** • Conduct trend analysis on threshold exceedance parameter. • Investigate potential causes for any observed trend to confirm cause is mine site related. **Action** • Re-sample if initial result is validated. • Investigate nature and extent of the threshold exceedance.

Table 2-6: Specific Indicators, Specific Performance Thresholds and Specific Responses Groundwater Elevation

Specific Indicators	Specific Performance Thresholds	Specific Responses
Groundwater elevation below landfill. (MW14-01, MW14-02 and MW14-03)	**Specific Threshold 1** Water table measurements are within 3.0 m of the base of the landfill for 1 sampling event	**Notification** • Teck Representative/Environmental Monitor. • Liard First Nation Representative. • Include in annual reporting. **Review** • Follow QA/QC investigative protocol: o Validate original result **Evaluation** • Compare with local groundwater elevations in other wells. **Action** • Investigate nature and extent of the threshold exceedance. • Re-sample within 30 days if initial result is validated. o Compare re-sample results with initial result
	Specific Threshold 2 Water table measurements are within 3.0 m of the base of the landfill for 2 consecutive sampling events	**Notification** • Teck Representative/Environmental Monitor and Inspector. • Liard First Nation Representative. • Report on results of investigation within 3 months of resampling. **Review** • Follow QA/QC investigative protocol: o Validate original result **Evaluation** • Conduct trend analysis of groundwater elevation. • Investigate potential causes for any observed trend to confirm cause is mine site related. **Action** • Re-sample if initial result is validated. o Install datalogger within well
	Specific Threshold 3 Water table measurements are within 3.0 m of the base of the landfill for 3 consecutive sampling events	**Notification** • Teck Representative/Environmental Monitor, Inspector and Liard First Nation representative. • Report on results and comparative findings at key downstream receiving environment locations. **Review** • Follow QA/QC investigative protocol: o Validate original result **Evaluation** • Continue trend analysis on water elevations using data logger data. • Confirm causes for any observed trend. **Action** • Review remedial options with regulators and LFN and develop implementation plan and schedule.

2.4 Physical Stability

2.4.1 Description

The physical stability of the engineered geotechnical facilities will be monitored during post-reclamation according to the Geotechnical Monitoring Program (SRK, 2014). The document describes the mine components, the type of inspections, reviews and plans that would be completed over the years following reclamation of the mine.

The purpose of the monitoring program is to identify conditions that could potentially adversely impact the long-term performance of structures during the post reclamation period. The engineered facilities included in the post-reclamation geotechnical inspection are listed in Table 2-7.

Table 2-7*:* Engineered Geotechnical Facilities

Facility
North Dam
Sediment Retaining Structure and Spillway
Drainage Channels
1408, 1250, and 1380 Jewelbox and Main Zone Portals
1200 and 1300 Burnick Portals
Ventilation Raises
Jewel Box and Main Zone Open Pits
Jewelbox, Main Zone and Burnick Waste Dumps
North Creek Crossings

2.4.2 Risk Narrative

A mass failure of one of the engineered geotechnical facilities has the potential to endanger the health and safety of site visitors, or lead to an increase in contaminant loadings from the mine and subsequent adverse effects to environmental quality in the affected receiving environment.

2.4.3 Specific Indicators, Performance Thresholds and Responses

Indicators, performance thresholds and responses specific to engineered geotechnical facilities are provided in Table 2-8. The monitoring results that are evaluated and utilized for this component of the AMP are a requirement of the Geotechnical Monitoring Program (SRK, 2014).

Table 2-8: Specific Indicators, Performance Thresholds and Responses for Engineered Geotechnical Facilities

Specific Indicators	Specific Performance Thresholds	Specific Responses

• Piezometer levels and settlement readings at North Dam
• Visual observations of physical damage to engineered geotechnical facilities
• Visual observations of evidence that could suggest mass movement
• Occurrence of seismic events
• Occurrence of flood events
	Specific Threshold
	• Observation of unusual occurrence including:
	  • tension cracks, bulging slopes, settlement, or sloughing;
	  • abnormal seepage from any area of the slopes;
	  • increased turbidity from seepage;
	  • buildup of debris or vegetation in flow channels;
	  • blockage of the Portal Seal or Ventilation Raise drainage pipes;
	  • piezometric levels in North Dam; and,
	  • A 50-year flood event or a seismic event that exceeds the Modified Mercalli Intensity scale of IV (Moderate) as felt in Watson Lake.
		Notification
		• Teck Representative/Environmental Monitor, LFN representative and Inspector.
		• Include in annual report.
		Review
		• Review previous inspection reports, existing instrumentation including piezometer, temperature, inclinometer, and survey data.
		Evaluation
		• Geotechnical Engineer to compare recent monitoring results against older results for additional evidence of instability.
		Action
		• Inspect the area for any other signs of instability.
		• Follow any recommendations of the Geotechnical Engineer. At a minimum, the Engineer will consider the need for:
		  o An increase in the frequency of routine inspections and monitoring.
		  o Additional inspection, instrumentation, monitoring, or analyses
		  o Remedial actions to correct the issue identified.
		• If the results of the analysis indicate there is a stability concern, the mine inspector and LFN will be notified immediately.

2.5 Covers Performance

2.5.1 Description

Exposed tailings were capped with a minimum 0.5 m soil cover to prevent wind erosion, minimize the impact of dust, break contaminant exposure pathways to humans and ecological receptors, and to provide a growth medium for vegetation. Portions of the Jewelbox/Main Zone waste dump and Mill site were also covered with a minimum 0.2 m soil cover to reduce incidental ingestion by birds, mammals and humans of elevated soils. The cover is not designed as a low infiltration barrier. Other areas around the site were capped with a soil cover to provide a growth medium for vegetation.

2.5.2 Risk Narrative

Poor cover performance re-exposes the covered surface to the environment. Erosion, sloughing, geotechnical or hydraulic instability decreases vegetation success in the capped areas and may increase contaminant exposure. These conditions may contribute to negative impacts on the receiving environment.

2.5.3 Specific Indicators, Performance Thresholds and Responses

Indicators, performance thresholds and responses specific to tailings cover performance are provided in Table 2-9. The monitoring results that are evaluated and utilized for this component of the AMP are a requirement of the Geotechnical Monitoring Program (SRK, 2014).

Table 2-9: Specific Indicators, Performance Thresholds and Responses for Covers

<table>
<tr><th>Specific Indicators</th><th>Specific Performance Thresholds</th><th>Specific Responses</th></tr>
<tr><td>Cover integrity and geotechnical stability, including erosion/slumping evidence
Ponded water on cover surface
Vegetation success</td><td>Specific Threshold
Observation of unusual occurrence including:
erosion, settlement, or sloughing;
geotechnical and hydraulic instability;
ponding on surface; and,
vegetation success.</td><td>Notification
Teck Representative/Environmental Monitor.
Liard First Nation Representative.
Site Engineer.
Include in annual report.
Review
Review previous inspection reports.
Evaluation
Site engineer to compare recent monitoring results against older results for additional evidence of cover performance.
Action
Inspect the area for any other signs of instability.
Follow any recommendations of the Site Engineer. At a minimum, the Engineer will consider the need for:
An increase in the frequency of routine inspections and monitoring.
Additional inspection, instrumentation, monitoring, or analyses.
Remedial actions to correct the issue identified with the cover.
Consider notifying risk assessors in cases where soil cover is significantly compromised (and therefore may invalidate assumptions of risk assessments). Determining the "significance" of a compromised cover should consider information such as the size of area that is affected, the depth of perturbation, the number of areas that are affected, chemical concentrations, etc.</td></tr>
</table>

3 Reporting

The reporting associated with AMP will part of the annual Quartz Mining License and Water Use Licence report and will include:

- Summary of monitoring data collected as part of the AMP;
- Trend analysis in water quality in Camp Creek (MH-11) and North Fork Creek (MH-12);
- Trend analysis in mine source water quality;
- Trend analysis for groundwater quantity and quality;
- Physical stability geotechnical inspection results;
- Cover inspection results;
- Summary of any thresholds exceeded and any activities undertaken in relation the AMP;
- Proposed updates and revisions to the AMP; and,
- Any other revisions necessary to comply with the conditions of the post-reclamation Water Licence.

4 References

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Teck Resources Limited (2016). S*ä* Dena Hes Mine Environmental Monitoring, Reporting, and Surveillance Plan*.*

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APPENDIX A

ADAPTIVE MANAGEMENT PLAN, SÄ DENA HES MINE – DRAFT (SRK, 2014)

Adaptive Management Plan, Sä Dena Hes Mine - DRAFT

Prepared for

Teck Resources Ltd.

Prepared by

SRK Consulting (Canada) Inc.
1CT008.043
October 2014

Adaptive Management Plan, Sä Dena Hes Mine - DRAFT

October 2014

Prepared for

Dormant Properties
Teck Resources Ltd.
601 Knighton Road
Kimberley, BC V1O 1C7

Tel: +1 250 427 8423
Web: www.teck.com

Prepared by

SRK Consulting (Canada) Inc.
2200–1066 West Hastings Street
Vancouver, BC V6E 3X2
Canada

Tel: +1 604 681 4196
Web: www.srk.com

Project No: 1CT008.043

File Name: Adaptive_Management_Plan_1CT008_043_DRAFT_LC_LB_TRS_20141023

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List of Abbreviations

AMP	Adaptive Management Plan
CCME	Canadian Council of Ministers of the Environment
WQMP	Water Quality Monitoring Plan
M-K	Mann-Kendall
SDH	Sä Dena Hes Mine
SWQO	Site Water Quality Objective
TDS	Total Dissolved Solids
USEPA	United States Environmental Protection Agency
WUL	Water Use Licence

1 Introduction

The Sä Dena Hes lead/zinc mine (SDH) operated from 1991 to 1992 and is currently owned by Teck Resources Limited and Korea Zinc. The mine was in care and maintenance from 1992 to 2013. Permanent closure of the mine is currently underway in 2014 and 2015. Closure activities completed in the summer of 2014 include demolishing of the mill and other site buildings, backfilling of portals, removing the South Dam and Reclaim Dams, reconstructing a portion of the Camp Creek channel and selectively covering portions of the site. Work in 2015 includes decommissioning site roads, final resloping and capping, and revegetation. Following reclamation, the site will be monitored to ensure objectives have been met.

1.1 Regulatory Context

Operation and closure of the site is authorized by a Quartz Mining Licence issued by the Yukon Department of Energy, Mines and Resources. The Quartz Mining Licence expires December 31, 2015. A Detailed Decommissioning Reclamation Plan (Teck 2013) describes closure objectives and activities.

Water use and discharge is regulated by the Yukon Territory Water Board under the Water Use Licence (WUL) QZ99-045, which expires on December 31, 2015. Water quality and flow have been monitored according to the licence since 1991. The licence requires monthly data reports and an annual report. The most recent annual report was submitted to the Yukon Water Board in April 2014 (SRK 2014a).

A WUL will continue to govern water discharge after closure. The application for a new licence or renewal of the existing WUL will include this adaptive management plan (AMP) and a water quality monitoring plan (WQMP). The WQMP for surface water and groundwater is presented in Attachment 1. Biological monitoring of the site will also occur and is described in the YESAB Project Proposal for Post-Reclamation Activities, in Section 7 (Access, 2014)

The AMP and WQMP are companion documents. The WQMP describes the monitoring locations, frequency, and parameters for the post-reclamation WUL application. Monitoring locations for the WQMP and referenced in the AMP are shown on Figure 1. The WQMP provides the data necessary for evaluating if water quality conditions are changing. The AMP describes how these data are evaluated, thresholds that trigger additional action, potential management actions and reporting requirements for the AMP. The connection between the WQMP and the AMP is presented in Figure 2.

1.2 Problem Statement

Water quality monitoring has been conducted as a condition of the current water licence since 1991. The ongoing monitoring dataset has been used to identify existing loading sources that discharge water with elevated concentrations of zinc, cadmium, and lead. These sources are:

- North Tailings Dam Seepage (MH-02)

- Burnick Portal (MH-22)
- 1380 Portal (MH-25)

Figure 3 is a conceptual loading diagram for each of these sources, including flow paths, attenuation mechanisms and AMP water quality monitoring stations. Water from these sources infiltrates to groundwater near the source and then migrates downgradient as groundwater to areas of groundwater discharge (i.e., surface water features). Discharge from both the 1380 Portal and the Burnick Portal drainage flow through the downgradient waste rock dumps, after which the flow infiltrates into the ground. Monthly and quarterly water quality monitoring results currently meet the effluent quality limits in the WUL at the receiving water bodies (Camp Creek, False Canyon Creek, and Tributary E).

SRK conducted previous investigations (SRK 2014b) that demonstrated that the loads (mass per time or kg/day) of dissolved zinc, cadmium, and lead from the Burnick and 1380 portals are not observed at the downstream monitoring locations, indicating that these loads are attenuated along the migration pathway or have not yet arrived at the monitoring location. Additional information about the attenuation mechanisms and water quality predictions is provided in the Water Quality Loading Assessment report (SRK 2014b).

Drainage from all three loading sources travels as groundwater ultimately discharging to False Canyon Creek. Consequently, the rate at which surface water concentrations change is a function of reactive transport along the groundwater flowpath. Any potential concentration increase in the receiving waters would be gradual and would depend on many factors, including mixing with other groundwater, dispersion, attenuation, the subsequent consumption of attenuation capacity, and the travel time between the source and discharge locations. The lag time between the initial increase in concentration and the maximum predicted concentration could be tens to hundreds of years (SRK 2014b).

1.3 Purpose

Surface water quality will be monitored after reclamation to observe any potential changes indicative of indicative of loading from the North Dam, Burnick Portal and 1380 Portal. The objective of the AMP is to detect changes from existing conditions and ensure that water quality does not exceed post-reclamation WUL limits.

1.4 Approach

Site water quality has remained relatively constant over the last twenty years and is expected to remain the same as in the past. The AMP is a tool to identify changes in water quality from current and historical conditions. It provides a framework describing the process to identify, evaluate, and manage/mitigate potential changes to water quality. If water quality changes from current conditions, the AMP describes the process for developing a plan to understand why the change has occurred and how it may be addressed.

Monitoring data is collected and evaluated relative to prescribed thresholds to assess if additional action is warranted. Changes in water quality that exceed thresholds trigger action as described in Section 2.

The general method and objectives are the same for the three potential loading sources (North Dam seepage, Burnick Portal discharge and 1380 Portal discharge), and is described as follows:

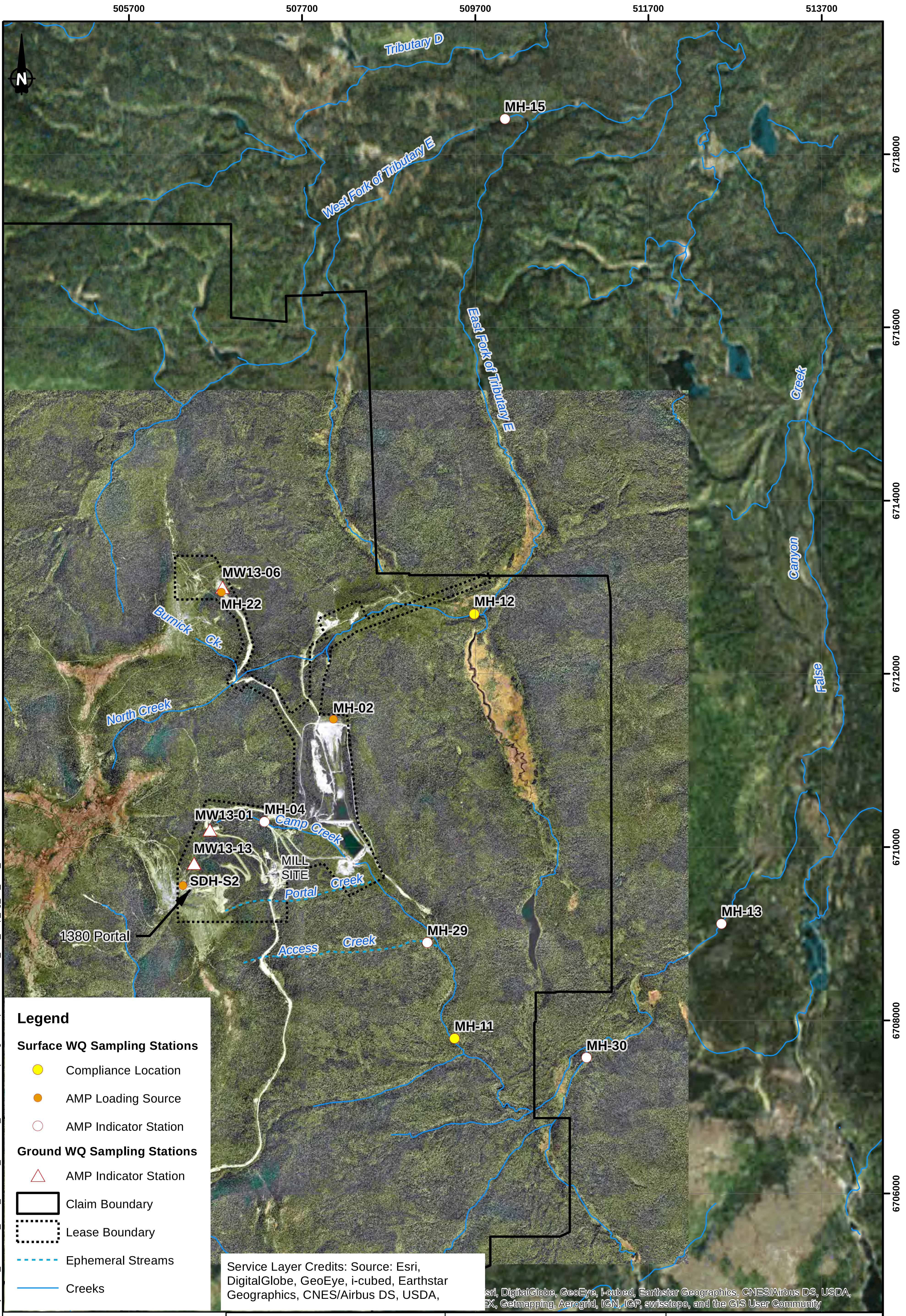
1. Description of AMP Loading Sources and Objectives of the AMP monitoring (developed from the conceptual model for each source),
2. Identification of specific indicators to be monitored,
3. Establishing thresholds for triggering action,
4. Evaluation of monitoring results, and
5. Description of a framework for escalating response if thresholds are exceeded.

1.5 Implementation Process

This AMP will be in effect for the duration of the post-reclamation water licence. It is a living document and can be revised as additional data and information become available over time. The AMP was prepared in support of the application to renew the water licence. It is anticipated that the AMP will be revised to incorporate other relevant permit requirements as the regulatory process proceeds to the water use licensing phase.

1.6 Annual Reporting

Reporting of the results of the WQMP monitoring and interpretation and recommendations from the AMP will be included in the annual report, submitted to the Water Board each March.



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Water Quality Monitoring Plan

Post-Reclamation Water Quality AMP Monitoring Stations

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Sä Dena Hes Mine

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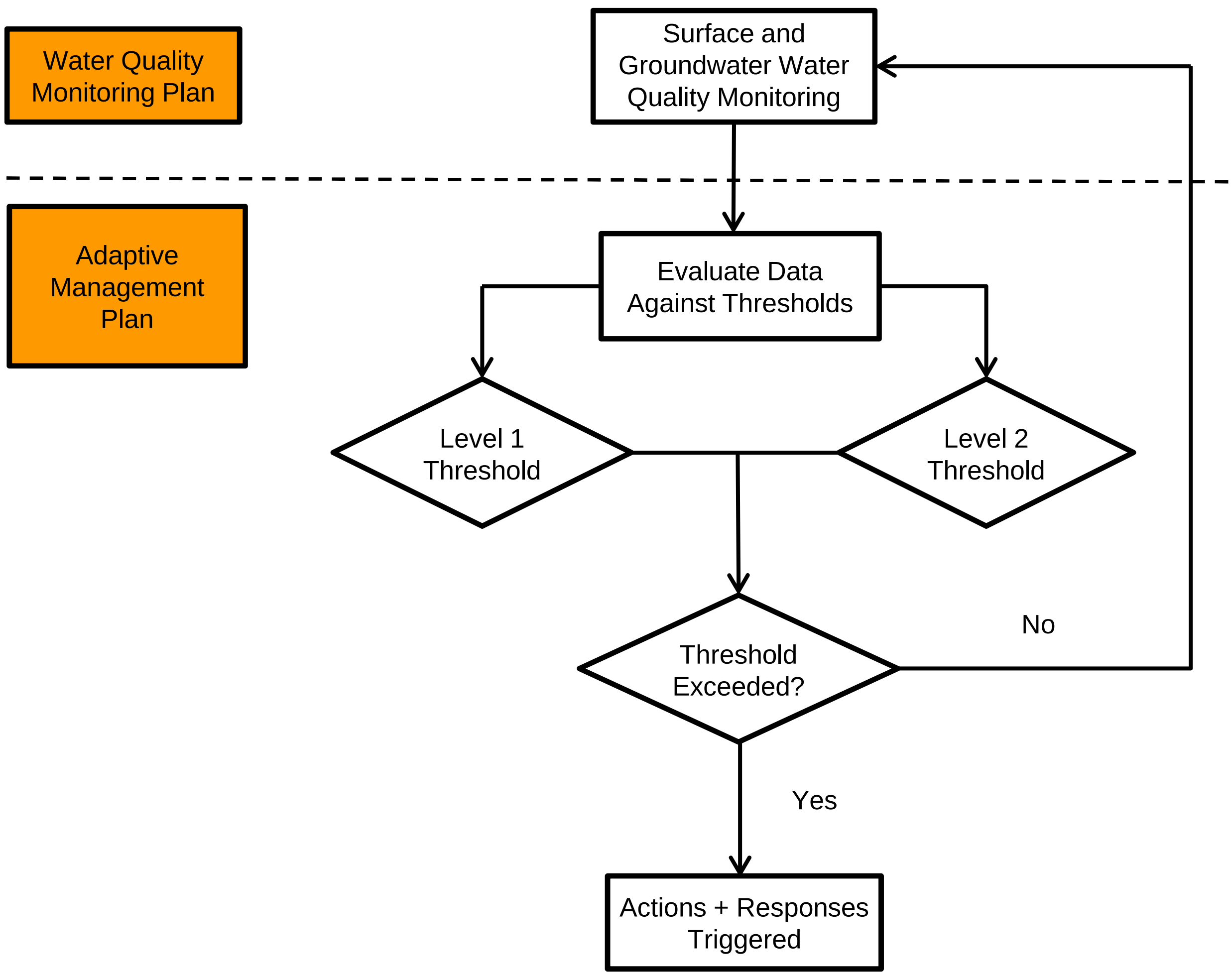

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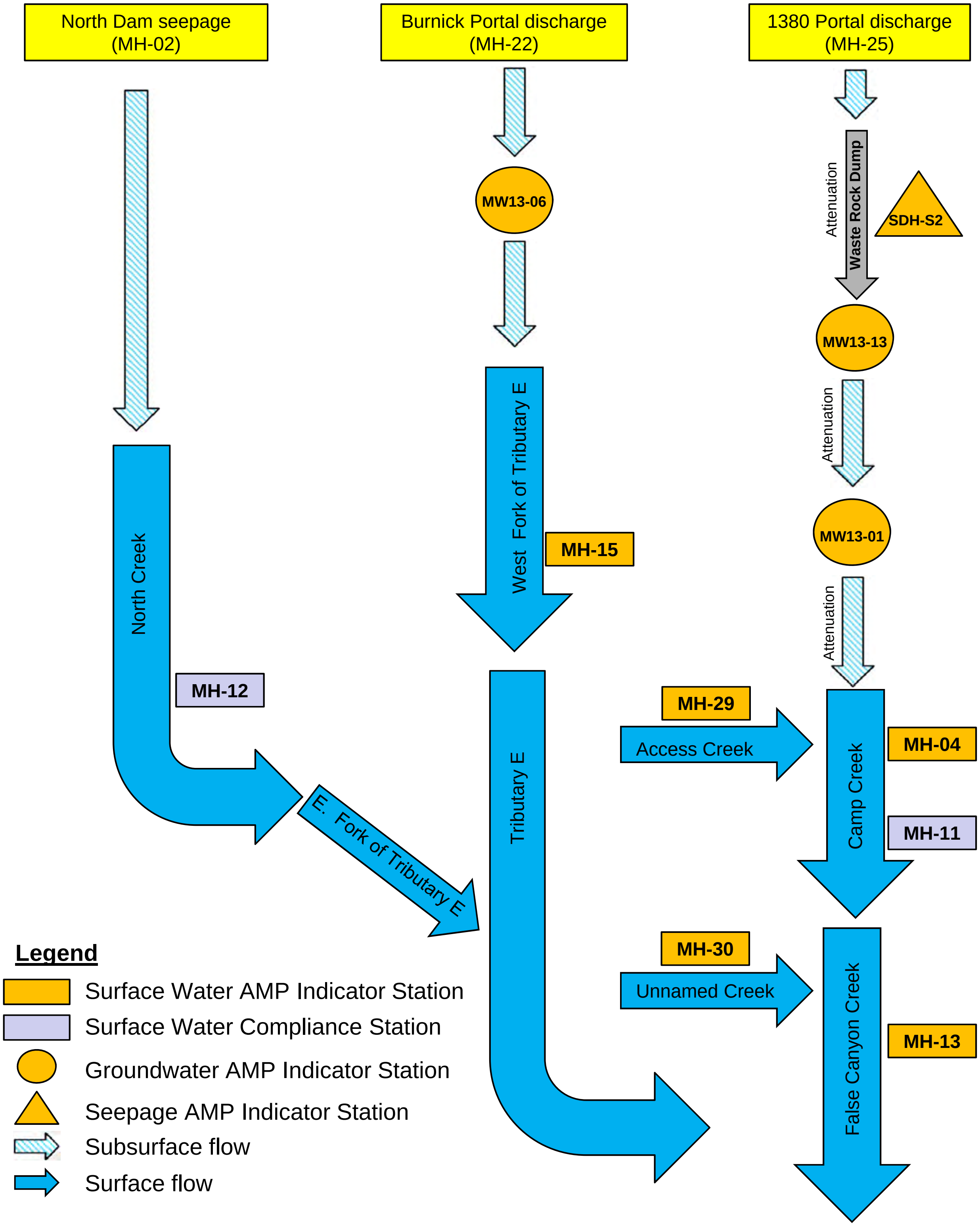

srk consulting | Teck | Adaptive Management Plan

Conceptual Loading Diagram

Job No: 1CT008.043

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Sä Dena Hes

Date: Sept 26, 2014 | Approved: LNB | Figure: 3

2 Adaptive Management Plan

As discussed in Section 1.2, the AMP applies to three loading sources from the mine site, specifically:

- North Dam Seepage (MH-02)
- Burnick Portal (MH-22)
- 1380 Portal (MH-25)

2.1 Description of AMP Loading Sources and Flow Paths

Loading from each of the three mine site loading sources (North Dam Seepage, Burnick Portal and 1380 Portal) could increase mining related constituent concentrations. Currently geochemical attenuation, groundwater transport and mixing with other surface water and groundwater limit these potential changes. This section describes each loading source, the geochemical conceptual model and the drainage/seepage flow path.

2.1.1 North Dam Seepage

During operations, most tailings were discharged to the North Tailings Pond. Currently, there is no ponded water in the pond, but the tailings are saturated at depth. There is seepage from the toe of the North Dam, which is routinely monitored at MH-02 as required by the WUL. The seepage at MH-02 is tailings porewater that has been diluted by groundwater from the valley sides and runoff from the North Dam face (SRK 2000). The seepage quality at MH-02 is routinely in compliance for all WUL parameters.

Seepage from the North Tailings Dam flows throughout the entire year. Flow at MH-02 is highest during freshet and lowest during the winter. The seepage flows aboveground for a short distance from the North Dam before infiltrating the ground. It then flows as groundwater before discharging to North Creek and the headwaters of the East Fork of Tributary E. From the East Fork of Tributary E, the water flows to Tributary E and then to False Canyon Creek (Figure 1 and Figure 3).

Metal attenuation along this pathway has not been evaluated. The flowpath is relatively short compared to the groundwater pathways downgradient of the Burnick Portal and 1380 Portal. For the purposes of the post-reclamation water quality predictions, it was conservatively assumed that the entire constituent load from the seepage discharges to North Creek above MH-12 and that there was no attenuation of metals by the soil (SRK 2014b).

Specific Issues

The objective of the AMP for the North Dam seepage is to detect any deterioration in water quality in the tailings dam seepage and manage and mitigate these changes before any effects are observed in the downstream receiving surface waters. AMP monitoring locations include tailings seepage monitoring at MH-02 located at the toe of the dam and surface water monitoring station MH-12 in North Creek.

Monitoring MH-02 would detect any changes in water quality proximal to the loading source. Downstream of these stations, tailings seepage flows as groundwater. Any potential change in surface water quality in the receiving waters would therefore be a function of groundwater reactive transport. Any water quality changes are expected to be slow and would be detected by monitoring over multiple years for a statistically significant increasing trend.

2.1.2 Burnick Portal Discharge

The Burnick Portal is located 3 km from the SDH mill and was constructed to access the Burnick Zone ore body. There are two portals (1200 and 1300) at the Burnick Zone. The lower portal previously discharged continuously and has been routinely monitored during temporary closure at MH-22 as part of WUL QZ99-045. Now discharge from MH-22 is ephemeral (June to November). The discharge water quality exceeds the WUL limits for zinc during low flow months.

MH-22 discharge flows through a buried culvert, cascades over the crest of the Burnick waste rock dump, and then infiltrates under the waste rock dump. It then flows downgradient to the east-northeast as groundwater) to the headwaters of the West Fork of Tributary E, which is more than 1.5 km downgradient of the portal (Figure 1). The headwaters of the West Fork of Tributary E are marshy and channeled surface flow is intermittent. Surface water flows to the east-northeast from the West Fork of Tributary E to Tributary E and then to False Canyon Creek. There is currently no evidence that the zinc load from the Burnick Portal is observed in Tributary E or False Canyon Creek (SRK 2005). From this observation, SRK concluded zinc is attenuated through extensive contact with the soils between the Burnick Portal and the West Fork of Tributary E.

Column experiments using discharge from the Burnick Portal and downstream soils were used to evaluate the attenuation mechanism (SRK 2005). The testwork concluded that downgradient soils have the potential to significantly attenuate zinc concentrations at the levels observed in the discharge for much longer than 200 years. Column tests showed the attenuation capacity was not exhausted and no secondary minerals were formed. The studies confirmed that zinc is passively removed by contact with downgradient soils.

Because the zinc attenuation mechanism has more than 200 years of capacity, the attenuation capacity of the soils was considered to last for the duration of the licenced post-reclamation period.

Specific Issues

The objective of the AMP for the Burnick Portal discharge is to detect any deterioration in water quality in the drainage flowing from the Burnick Portal and downgradient surface water. AMP monitoring locations include the Burnick portal drainage (MH-22), groundwater monitoring well MW13-06 downgradient of the Burnick portal and surface water monitoring stations and MH-15 in the West Fork of Tributary E (Figure 1).

Monitoring at MH-22 and MW13-06 would detect any changes in water quality in the portal drainage or groundwater near the portal. Downstream of these stations, the drainage flows as groundwater. Any potential change in surface water quality in the receiving waters would be a function of reactive transport along the groundwater flowpath. Any changes are expected occur slowly and would be detected by monitoring over time to establish statistically significant increasing trend.

2.1.3 1380 Portal Discharge

The Main Zone Pit is a box cut located in the headwaters of Camp Creek. The 1380 Portal is located at the south end of the cut. In June 1999, drainage from the portal was observed. The drainage is routinely monitored at MH-25 as part of WUL QZ99-045. MH-25 was sampled for the first time in 1999 to support the closure plan and was found to contain 41 mg/L dissolved zinc.

Drainage from MH-25 is ephemeral (June to October) and consistently exceeds the WUL limits for zinc and cadmium and less frequently for lead. The zinc is leached from oxidizing exposed rock and talus around the portal area, which contain sphalerite. The source water is likely shallow groundwater with minor contributions from Jewelbox Pit (SRK 2000).

In 2000, MH-25 was monitored continuously for two months to assess variations in flow and chemistry. SRK (2000) reported that the drainage from the Main Zone pit portal contained elevated zinc, cadmium, and lead concentrations. Flow was estimated at 1 L/s. Flow decreased following freshet, but constituent concentrations were relatively constant. The constituent load associated with this flow was not detected in Camp Creek or False Canyon Creek at any time during the summer, suggesting attenuation along the flow path.

The 1380 Portal drainage flows through the marble Main Zone waste rock dump immediately downstream of the portal. Flow within the waste rock dump is audible but difficult to locate and/or access, resulting in infrequent monitoring. The dissolution of the marble attenuates zinc, cadmium, and lead by precipitation of metal carbonates. This attenuation mechanism of drainage from MH-25 is considered to last in perpetuity. Station SDH-S2 located within the waste rock below the 1380 Portal characterizes concentrations after attenuation by the waste rock. MH-25 and SDH-S2 have similar sulphate levels, but the zinc concentration is approximately four times lower at SDH-S2 than at MH-25, the level of cadmium is approximately five times lower, and the level of lead is approximately 1.5 times lower. Geochemical modelling indicates that that precipitation of zinc, cadmium, and lead carbonates is the probable attenuation mechanism resulting from the interaction of MH-25 drainage with marble waste rock (Day and Bowles 2005).

After passing through the waste rock dump, the 1380 Portal drainage is further attenuated downstream as groundwater flows through the soils along the flow path to Camp Creek. Studies indicate that there may eventually be a loss of attenuation capacity in the soils. The groundwater flow discharges to surface as a spring near the headwaters of Camp Creek. The length of the flow path from the 1380 Portal to the spring near the headwaters of Camp Creek is approximately 900 m. The spring is relatively large and is located where the southern fork of Camp Creek originates which mixes about 100 m downstream with water from a second groundwater spring on the southwestern flank of Mt. Hundere. Camp Creek flows to the south and is a tributary to False Canyon Creek (Figure 1 and Figure 3).

Specific Issues

The objective of the AMP for the 1380 Portal drainage is to detect any deterioration in the portal drainage water quality within the waste rock dump and monitor for the potential loss of attenuation capacity of the soils upstream of Camp Creek. AMP monitoring locations include:

- Seepage monitoring at station SDH-S2 within the Main Zone waste rock dump,
- Groundwater monitoring at MW13-01 and MW13-13 located downgradient of SDH-S2 and upstream of Camp Creek, and
- Surface water monitoring at MH-04 in lower Camp Creek and MH-11 and MH-13 in upper False Canyon Creek

All the locations are shown in Figure 1 and Figure 3.

Any potential change in surface water quality in the receiving waters would be a function of reactive transport along the groundwater flowpath. Any changes are expected to be slow and would be detected by monitoring over time to establish statistically significant increasing trend.

2.2 Indicator Parameters

The surface water and groundwater monitoring programs for the North dam seepage, Burnick portal and 1380 portal are outlined in the WQMP and include monitoring of relevant downstream stations (Figure 1). Figure 3 shows a loading schematic of the sources and each water monitoring station to the loading sources. The AMP indicator parameters for the WQMP stations are zinc, lead, cadmium, and sulphate.

2.3 Thresholds

Exceedance of a threshold triggers action. There are two threshold levels.

A Level One threshold is a statistically significant increasing trend of zinc, cadmium, lead and/or sulphate concentrations at surface water or groundwater WQMP monitoring locations. Detecting an increasing concentration trend earlier will allow for sufficient time to reduce the likelihood of exceeding a Level 2 threshold.

A Level Two thresholds are the WUL limits at surface water monitoring stations MH-11 and MH-12. These are water quality compliance points for the site. These licence limits will be defined in the post-reclamation WUL. The locations of the surface water compliance points are shown on Figure 1 and their relationship to the loading sources is shown in Figure 2. MH-11 and MH-12 define the boundary where site-influenced water enters the receiving environment, and are proposed to be specified as such in the WUL.

Exceedance of the thresholds should occur sequentially from statistically significant increasing trends at monitoring locations most proximal to the loading sources (Level 1) that may eventually lead to an exceedance of limits at the two surface water compliance point monitoring stations (Level 2).

2.4 Evaluation of Monitoring Results

This section provides the details of how the data are evaluated in the context of Level 1 and Level 2 triggers.

2.4.1 Level 1

The Level 1 trigger is a statistically significant increasing trend in concentrations of zinc, cadmium, lead and/or sulphate at surface water or groundwater monitoring locations. Trends observed at multiple monitoring locations downgradient of a loading source provide more evidence than an increasing trend at a single location. Statistical significance of the trend will be tested using a Mann-Kendall test or other predetermined criteria to assess an increasing trend in the data will be used to evaluate water quality data for surface water and groundwater monitoring locations. The large existing dataset from 1991 to 2014 supports using trend analysis to identify statistically significant changes in water quality.

The Mann-Kendall test is a statistical test that used to evaluate a dataset to test for statistically significant trends in time series data. The test does not require data to have a normal distribution. This statistical test is commonly used in monitoring data analysis programs (Helsel and Hirsch 2002). There are a variety software packages, including the publically available ProUCL software from the United States Environmental Protection Agency (USEPA 2013) that can perform the test.

A statistically significant increasing trend in concentrations may trigger further action. The results of the statistical test from multiple stations will be used to assess the appropriate level of response. An upward trend for a single AMP indicator or compliance station will trigger a lower level of response than multiple stations showing upward trends. Similarly an upward trend that continues for multiple years will trigger a greater response than if the trend were observed in a single year. The details of the response will be defined during permitting.

2.4.2 Level 2

The Level 2 threshold is the exceedance of WUL limits for surface water stations MH-11 and MH-12. Water quality at MH-11 and MH-12 will be compared to the standards for lead, zinc and cadmium as indicated in the WUL.

2.5 Response and Actions

Action is triggered when thresholds are exceeded. When a Level 1 or Level 2 threshold is exceeded, a step-wise plan of responses and actions will be followed. The sections below describe the types of action that may be taken and are presented as a framework in order of escalating action, as presented in Figure 4.

Each level of action includes documentation of the steps undertaken and resulting recommendations and responses that would result in escalation to the next level of action, as appropriate. Each section notes the type of report and distribution.

2.5.1 Verification of Data

When a threshold (Level 1 or Level 2) is exceeded, the result needs to be verified. The first step includes confirmation of the result with the lab. If the result is confirmed, the subsequent step is to verify the initial result by resampling the site within 60 days. If resampling confirms the initial result and Level 1 or Level 2 thresholds are exceeded, then the nature and extent of the exceedance needs to be investigated (Section 2.5.2).

In the case of an exceedance of a Level 1 or Level 2 threshold, management will be notified in writing, including a summary of the outcome of the verification program and if escalation of action is warranted.

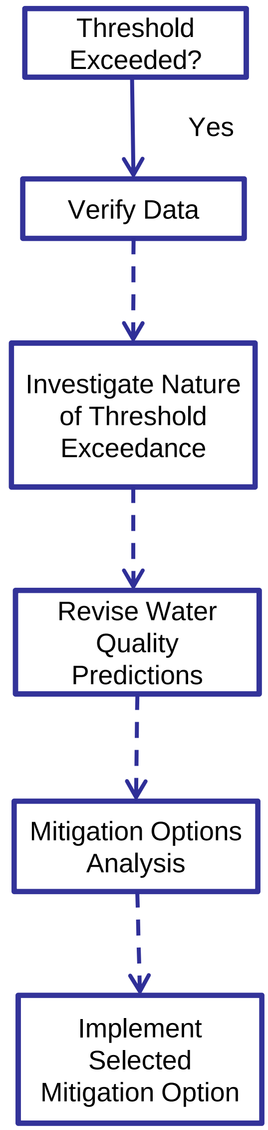
2.5.2 Investigate Nature and Extent of the Threshold Exceedance

Any threshold exceedance will be assessed and a monitoring plan created to investigate the nature and extent of the exceedance. The plan may include more frequent sampling of existing stations and/or the addition of new monitoring stations, and would take into consideration various factors, including but not limited to:

- Magnitude of threshold exceedance,
- Duration of an increasing trend for a Level 1 threshold,
- Number of stations within a source load flow path that have exceeded a threshold,
- Location of station that has exceeded a threshold (source load, groundwater, surface water, or compliance point),
- Which level of threshold has been exceeded (Level 1 or Level 2), and
- Results of biological monitoring

Depending on the findings of the investigation, the water quality model may be revised to re-evaluate potential changes to downstream water quality.

The Water Board would be notified in writing of any changes in monitoring and the outcome of the investigation.



Note: Dashed arrow denotes action escalates progressively based on recommendations from preceding response.

srk consulting	Teck	**Adaptive Management Plan**		
		Framework of Escalating Responses and Actions		
Job No: 1CT008.043 Filename: AdaptiveManagementPlanFigures_1CT008.043_Rev01_LMC_LNB.pptx	Sä Dena Hes	Date: October 2014	Approved: LNB	Figure: 4

2.5.3 Revise Water Quality Predictions

As additional data become available from the increased monitoring, the data could be used to validate the water quality prediction model (SRK 2014b). Model validation may indicate the conceptual model for constituent loading be re-evalated and potentially revised. The loss of attenuation capacity or more rapid groundwater transport may warrant model revision. A revised model could then be used to reassess the situation and/or develop further action plans. This could include assessing if increasing constituent concentrations could impact aquatic life. Additional biological monitoring could also be undertaken. The results from additional monitoring could be used to verify if increasing concentrations are affecting aquatic life.

A report outlining the revised water quality predictions would be submitted to the Water Board.

2.5.4 Mitigation Options Assessment

If the revised water quality predictions indicate that water quality will exceed WUL water quality limits or suggest that there could be effects to the aquatic receiving environment a plan outlining mitigation will be developed. Potential mitigation measures would include source control, migration control and treatment options. These options will be based on data collected as part of the escalating response to increasing constituent concentration and are dependent on the magnitude, timing and potential impact of increasing concentrations.

A report outlining the mitigation options analysis with mitigation recommendations would be submitted to the Water Board.

2.5.5 Implement Mitigation

If mitigation is warranted, the preferred option recommended from the options analysis would be implemented. Any proposed mitigative actions, including any associated monitoring, would be documented and reported to the Water Board before works are undertaken.

3 Conclusion

The AMP describes how to use data collected by the WQMP to identify and evaluate increasing concentrations in sources and receiving water during post reclamation at the Sä Dena Hes mine. The AMP also provides a framework to develop plans for understanding the processes responsible for increasing concentrations, their potential impact and their mitigation if needed. Results of the AMP will be reported in the WUL annual report.

The AMP is living document and is expected to be revised as needed in response to any significant changes in water quality resulting from loading sources at the site. Additional detail will be added to the AMP as it becomes available. This may include new or revised conditions (e.g. WUL water quality limits) within the WUL. Implementing the AMP will ensure post reclamation water quality in receiving water downgradient of the Sä Dena Hes mine site is protected.

This report, Adaptive Management Plan, Sä Dena Hes Mine - DRAFT, was prepared by

“DRAFT”

Lee Christoffersen, EIT, GIT
Consultant (Environmental Engineering)

“DRAFT”

Lisa Barazzuol, PGeo
Senior Consultant (Geochemistry)

and reviewed by

“DRAFT”

Tom Sharp, PhD, PEng
Principal Consultant

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

4 References

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Attachment 1:
Sä Dena Hes Mine Post-Reclamation Water Quality
Environmental Monitoring Plan

SRK Consulting (Canada) Inc.
2200–1066 West Hastings Street
Vancouver, BC V6E 3X2

T: +1.604.681.4196
F: +1.604.687.5532

vancouver@srk.com
www.srk.com

Memo

To:	Michelle Unger, Teck	**Client:**	Teck Resources Ltd.
From:	Saskia Nowicki Lisa Barazzuol Tom Sharp	**Project No:**	1CT008.043
		Date:	Revised October 16, 2014
Subject:	Sä Dena Hes Mine Post-Reclamation Water Quality Monitoring Plan - DRAFT		

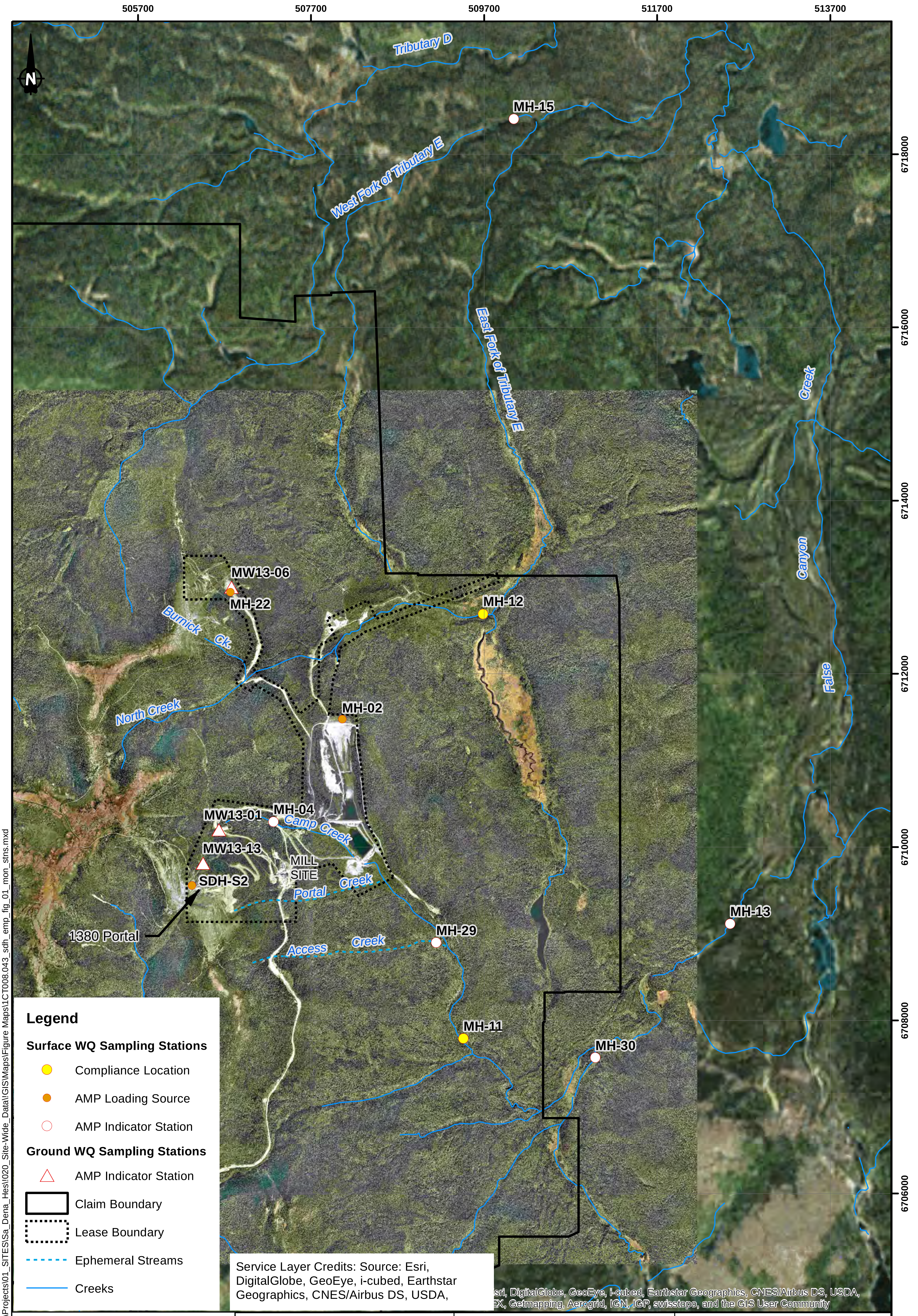
1 Introduction

This memorandum presents the post-reclamation water quality monitoring plan (WQMP) for the Sä Dena Hes (SDH) Mine property and immediate receiving environment. The WQMP collects surface water and groundwater quality data to be evaluated by Sä Dena Hes' water quality Adaptive Management Plan (AMP).

Surface water and groundwater quality monitoring is discussed in Section 2 – including sampling locations and frequency, field measurements, and laboratory analyses. Section 3 discusses the integration of the water quality monitoring program within the context of the AMP.

2 Water Quality Sampling

Figure 1 presents the post-closure surface water and groundwater monitoring locations that are within the scope of the AMP. The surface water and groundwater sampling programs are discussed separately because there are variations in the monitoring requirements.



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Job No: 1CT008.043

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Teck

Sä Dena Hes Mine

Water Quality Monitoring Plan

Post-Reclamation Water Quality AMP Monitoring Stations

Date:	Approved:	Figure:
September 2014	LNB	1

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2.1 Surface Water Sampling

2.1.1 Stations

Table 1 lists the location and purpose of the surface water monitoring stations.

There are three categories of surface water monitoring stations, which are described as follows:

1. Compliance Points: These locations define the boundary of where site-influenced water enters the receiving environment, and would be specified as such in the WUL. Water quality at these stations will be compared to the standards indicated in the WUL. Two stations, MH-11, and MH-12 are the proposed compliance point stations.

2. AMP Loading Source: These stations are surface water monitoring locations most proximal to the identified mine site loadings sources (SRK 2014). These three stations monitor the seepage from the North Dam (MH-02) and drainage from the Burnick Portal (MH-22) and 1380 Portal (SDH-S2).

3. AMP Indicator: These stations are downstream of the mine site loading sources and are not permitted compliance points. The objective of monitoring at stations MH-04, MH-13 and MH-15 is to provide data for evaluation by the AMP to evaluate if water quality has or is changing. Water quality data collected at MH-29 and other biological monitoring locations support the biological monitoring program of the AMP, however the data will be evaluated as described in the AMP water quality data assessment process.

Table 1: Surface Water Quality Sampling Stations

Station Category	Station ID	Coordinates		Station Description
		Northing	Easting	
Compliance Point	MH-11	509460	6707788	Upper False Canyon Creek
	MH-12	509688	6712755	East Fork of Tributary E
AMP Loading Source	MH-02	508060	6711477	North Dam seepage
	MH-22	506767	6712946	Burnick 1200 Portal discharge
	SDH-S2	506325	6709558	Drainage from the 1380 Portal, present as a seep in the downslope waste rock dump
AMP Indicator	MH-04	507267	6710292	Camp Creek
	MH-13	512541	6709113	False Canyon Creek main channel
	MH-15	510041	6718408	West Fork of Tributary E
	MH-29*	509146	6708895	Access Creek Upstream of Camp Creek
	MH-30*	510985	6707568	Unnamed Tributary Upstream of False Canyon Creek

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Notes:
*Denotes biological AMP station but the associated water quality data will be interpreted as part of the AMP.

2.1.2 Surface Water Sampling Frequency

For the first five years of post-reclamation, from 2016 to 2020, surface water sampling will be conducted semi-annually to capture freshet flow (June to July) and baseflow (September or October). In 2014, the South and Reclaim dams were removed and Camp Creek channel reconstructed. Sampling during the freshet in the first five years is proposed to monitor for erosion of the channel or runoff from these reclaimed areas, which is most likely to occur during freshet.

After this initial five year period, surface water quality data will be evaluated to determine if annual sampling would be appropriate in the following years. It is anticipated that monitoring will demonstrate that water quality will be stable and annual monitoring would be appropriate. The potential effects of groundwater discharge on surface water quality are most observable during baseflow when groundwater contributes a larger portion to the flow than surface water runoff. The loading source migration pathways that can potentially impact surface water are via groundwater, so surface water would be monitored annually during baseflow after the first five years.

After 10 years of post-reclamation water quality monitoring, the data would be further assessed to determine if further reductions in the sampling frequency, e.g. every second year, are warranted.

2.1.3 Field Measurements

The following field measurements will be taken at each surface water station:

- Temperature,
- pH,
- Specific conductivity,
- Oxidation-Reduction Potential (ORP),
- Turbidity, and
- Flow rate.

2.1.4 QA/QC Program

Each sampling event will include the following QA/QC samples:

- 10% sample duplicates;
- 1 field blank; and
- 1 travel blank.

The QA/QC program for the surface water sampling can be combined with the groundwater program if conducted at the same time.

2.1.5 Laboratory Analytical Requirements

For each surface water station and QA/QC sample, multiple sample bottles will be collected and shipped to a laboratory to be analysed for general parameters, anions and nutrients, total elements and dissolved elements. Details of the analyses are provided in Table 2.

Table 2: List of Laboratory Analyses for Surface Water Stations

Category	Parameter	Method of Analysis
General Parameters	pH	Electrode
	Conductivity	
	Acidity	Potentiometric Titration
	Alkalinity	Titration
	Total Organic Carbon	Combustion
	Dissolved Organic Carbon	Combustion
	Total Dissolved Solids	Gravimetric
	Total Suspended Solids	Gravimetric
	Turbidity	Nephlometer
Anions and Nutrients	Chloride	Ion Chromatography
	Fluoride	
	Nitrite	
	Nitrate	
	Sulphate	
	Bromide	
Trace Elements	Total Concentrations	Inductively Coupled Plasma Mass Spectrometry (ICP-MS)
	Dissolved Concentrations	

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2.2 Groundwater Sampling Program

There are two post-reclamation groundwater monitoring programs for SDH. The scope of the EMP program is to monitor the groundwater downstream of the mine-influenced loading sources presented in Table 1. These data will be evaluated by the AMP. Golder (2014) also outlines a groundwater monitoring program, however the scope of monitoring is in the context of a closed contaminated site.

2.2.1 Stations

Table 3 lists the location and purpose of the groundwater monitoring stations. All groundwater stations are AMP indicator stations in that they monitor downgradient flow from the AMP loading sources identified in Table 1 and the purpose is to evaluate the data collected as described in the AMP.

Table 3: Groundwater Quality Sampling Stations

Station Category	Station ID	Station Description
AMP Indicator	MW13-06	Adjacent to Burnick Portal
	MW13-01 MW13-13	Downstream of 1380 Portal

2.2.2 Sampling Frequency

Groundwater sampling will be conducted during baseflow groundwater periods (August to September). The limited sulphate data suggest that there is dilution during freshet when there is increased groundwater flow and that concentrations are slightly higher during baseflow. Furthermore, the loading source migration pathways that can potentially impact surface water are via groundwater. The potential effects of groundwater discharge on surface water quality are most observable during baseflow when groundwater contributes a larger portion to the flow than surface water runoff.

The long-term sampling scheduling is parallel to the surface water quality monitoring program, specifically annual sampling for the first ten years of post-reclamation, after which the data would be further assessed to determine if further reductions in the sampling frequency, e.g. every second year, are warranted.

2.2.3 Field Measurements

The following field measurements will be taken at each groundwater station after purging three times the well volume:

- Temperature,
- pH,
- Specific conductivity,

- Oxygen-reduction potential,
- Turbidity, and
- Water level.

2.2.4 QA/QC Program

Each sampling event will include the following QA/QC samples:

- 10% sample duplicates;
- 1 field blank; and
- 1 travel blank.

The QA/QC program for the groundwater sampling can be combined with the surface water program if conducted at the same time.

2.2.5 Laboratory Analytical Requirements

For each groundwater station and after purging three times the well volume, multiple sample bottles will be collected and shipped to a laboratory to be analysed for general parameters, anions and nutrients, and dissolved elements. The analytical suite for the QA/QC program will be the same. Details of the analyses are provided in Table 4. The list of required analyses outlined in Table 4 differs slightly from the historical groundwater monitoring conducted by Golder.

Table 4: List of Laboratory Analyses for AMP Groundwater Stations

Category	Parameter	Method of Analysis
General Parameters	pH	Electrode
	Conductivity	
	Acidity	Potentiometric Titration
	Alkalinity	Colourimetry
	Total Dissolved Solids	Gravimetric
	Turbidity	Nephlometer
Anions and Nutrients	Chloride	Ion Chromatography
	Fluoride	
	Nitrite	
	Nitrate	
	Sulphate	
	Bromide	
Trace Elements	Dissolved Concentrations	ICP-MS

3 Integration with the Adaptive Management Plan

Surface water and groundwater quality data collected as part of the EMP will be analyzed using the methods outlined in the AMP. The sampling locations and frequencies discussed herein are subject to change based on specifications presented in Sä Dena Hes' AMP. The AMP specifies various thresholds for water quality that if exceeded, would result in the re-evaluation of the EMP in the context of the management issue identified.

4 References

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SRK Consulting (Canada) Inc.

"DRAFT"

Saskia Nowicki, BSc
Staff Consultant

"DRAFT"

Lisa Barazzuol, P.Geo.
Senior Consultant (Geochemistry)

Reviewed by:

"DRAFT"

Tom Sharp, P.Eng.
Principal Consultant (Water Management)