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GOVERNMENT OF YUKON ENERGY, MINES AND RESOURCES - ASSESSMENT AND ABANDONED MINES

Clinton Creek Engineering Review and Assessment

Part 2

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PROJECT 307071-01014 - CLINTON CREEK ENGINEERING REVIEW AND ASSESSMENT

REV	DESCRIPTION	ORIG	REVIEW	WORLEYPARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for Client Review	J. Gentles	A. Timmis	A. Timmis	30-Jan-15		
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ABBREVIATIONS

Abbreviation	Description
AAM	Assessment and Abandoned Mines
AANDC	Aboriginal Affairs and Northern Development Canada
DS1	Drop Structure No. 1
EC	Environment Canada
m	metres
m^3	cubic metres

DEFINITIONS

Definition	Description
Almost Certain	Event happens often - once every five years.
Extreme Flow	An unusually large flow generated by freshet or precipitation flows with a return period greater than 1.
Freshet	The flow generated as a result of snow and ice melt.
Gabion	A metal cage filled with rock installed to provide erosion protection in a channel.
Likely	Event could easily happen - once every 15 years.
Possible	Could happen and has happened elsewhere - once every 40 years.
Risk Rating	A rating assigned based on likelihood / consequence classifications and the AANDC risk table.
Trigger	A qualitative value assigned to a specific attribute of a site component that, when exceeded, should prompt a pre-defined response to address the stability of the component.
Unlikely	Has not happened yet, but could - once every 200 years.
Very Unlikely	Conceivable, but only in extreme circumstances - once every 1,000 years.

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1. INTRODUCTION

Government of Yukon: Energy Mines and Resources Assessment and Abandoned Mines (AAM) has engaged WorleyParsons Canada Services Ltd. (WorleyParsons) to complete an engineering review and assessment of the site-wide components of the Clinton Creek site (the assessment). The assessment is a component of the ongoing Clinton Creek Long-Term Monitoring Program (LTMP). The content and structure of this report are based on the Scope of Services presented in Section 3 of AAM's Engineering Agreement No. C00025977. This report does not include an assessment of Drop Structure No. 4 (DS4) or a cascading failure of the Clinton Creek Channel, which was presented in the Clinton Creek Engineering Review and Assessment - Part 1 report.

1.1 Resources

The following information, data, and observations were used to develop this assessment:

- 2014 survey completed by Underhill Geomatics Ltd. (Underhill);
- Observations made during a site visit conducted by WorleyParsons on August 25, 2014 (discussed in Section 2);
- Risk assessment format developed by Aboriginal Affairs and Northern Development Canada (AANDC); and
- Findings, triggers (i.e., a qualitative value assigned to a specific attribute of a site component that, when exceeded, should prompt a pre-defined response to address the stability of the component), and recommendations included in previous Long-Term Performance Monitoring reports.

1.2 Site Components

The site includes the following infrastructure and natural / anthropogenic features (the components) that comprise the assessment:

- Gabion drop structures;
- Clinton Creek channel;
- Hudgeon Lake outlet;
- Clinton Creek access road;
- Clinton Creek crossings;
- Clinton Creek waste rock piles;
- Wolverine Creek channel;
- Wolverine Creek tailings piles;
- Porcupine Pit; and
- Snowshoe Pit.

1.3 Site Background

The Clinton Creek site (the Site) is the location of a former asbestos mine which was in operation between 1968 and 1978. The Site is located 80 km northwest of Dawson City, Yukon (YT), near the confluence of Fortymile River and the Yukon River (Figure A). During operation, waste rock was dumped along the south valley wall of Clinton Creek while tailings from the milling operation were deposited along the west valley wall of Wolverine Creek (Figure B). Subsequent movement of the waste rock and tailings have since blocked Clinton Creek and Wolverine Creek, respectively.

1.3.1 Clinton Creek and Hudgeon Lake

The blockage of Clinton Creek resulted in impoundment of approximately 10 million m^3 of runoff from the surrounding natural portion of the watershed and the formation of Hudgeon Lake. Water quality testing indicates that the water impounded in Hudgeon Lake is largely anoxic. In the summer of 2013, piers were constructed at the outlet of Hudgeon Lake to anchor log booms that will retain debris in the lake, which could otherwise collect at one of the drop structures and potentially impede flow.

Discharge from Hudgeon Lake is conveyed southeast by Clinton Creek to Fortymile River. Four rock gabion drop structures were constructed across the upper portion of Clinton Creek between 2002 and 2004 to stabilize the waste rock pile to the south and promote aeration of discharge from Hudgeon Lake; however, DS4 was destabilized in 2010 (as a result of blockage at Hudgeon Lake coinciding with a period of intense precipitation) and the channel immediately downstream continues to degrade due to downcutting.

1.3.2 Site Access Road

The Site is accessible from Dawson City via a gravel access road connected to the Top of the World Highway near the village of Forty Mile. The site access road crosses Clinton Creek at the following two points:

- Crossing No. 1 - located 560 m downstream of DS4; and
- Crossing No. 2 - at the Hudgeon Lake Outlet.

Downstream of Crossing No. 1 the access road runs on the north side of Clinton Creek. Between Crossing Nos. 1 and 2, the access road is located adjacent to and across the waste rock dump. Beyond Crossing No. 2 the access road continues on along the edge of Hudgeon Lake before switching back to climb the slope on the north side of Clinton Creek. The access road ends at the former mill site above the tailings pile.

1.3.3 Wolverine Creek

The blockage of Wolverine Creek resulted in the formation of two ponds (collectively named the Wolverine Creek ponds) separated by the tailings pile lobes: the lower pond is located between the north and south lobes and the upper pond is located upstream of the north lobe (Figure B). Discharge from the ponds is conveyed off the tailings pile via a rock lined channel back to Wolverine Creek, where it flows to the confluence with Clinton Creek located near the Site entrance.

1.3.4 Waste Rock Dumps and Pits

In addition to the Clinton Creek waste rock dump, waste rock was also dumped in the Porcupine waste rock dump located to the south of Porcupine Pit (Figure B).

There are two open pits at the Site:

- Porcupine Pit - located between the Clinton Creek and Porcupine Pit waste rock dumps; and
- Snowshoe pit - located southeast of the Clinton Creek waste rock dump.

1.3.5 Mill and Tailings Pile

The former mill site is located at the top of the slope above Clinton Creek and Wolverine Creek.
The tailings pile extends from the mill site to the east, down the slope, and crosses the Wolverine Creek valley. The bottom portion of the tailings pile formed the north and south lobes, divided by the lower Wolverine Pond.

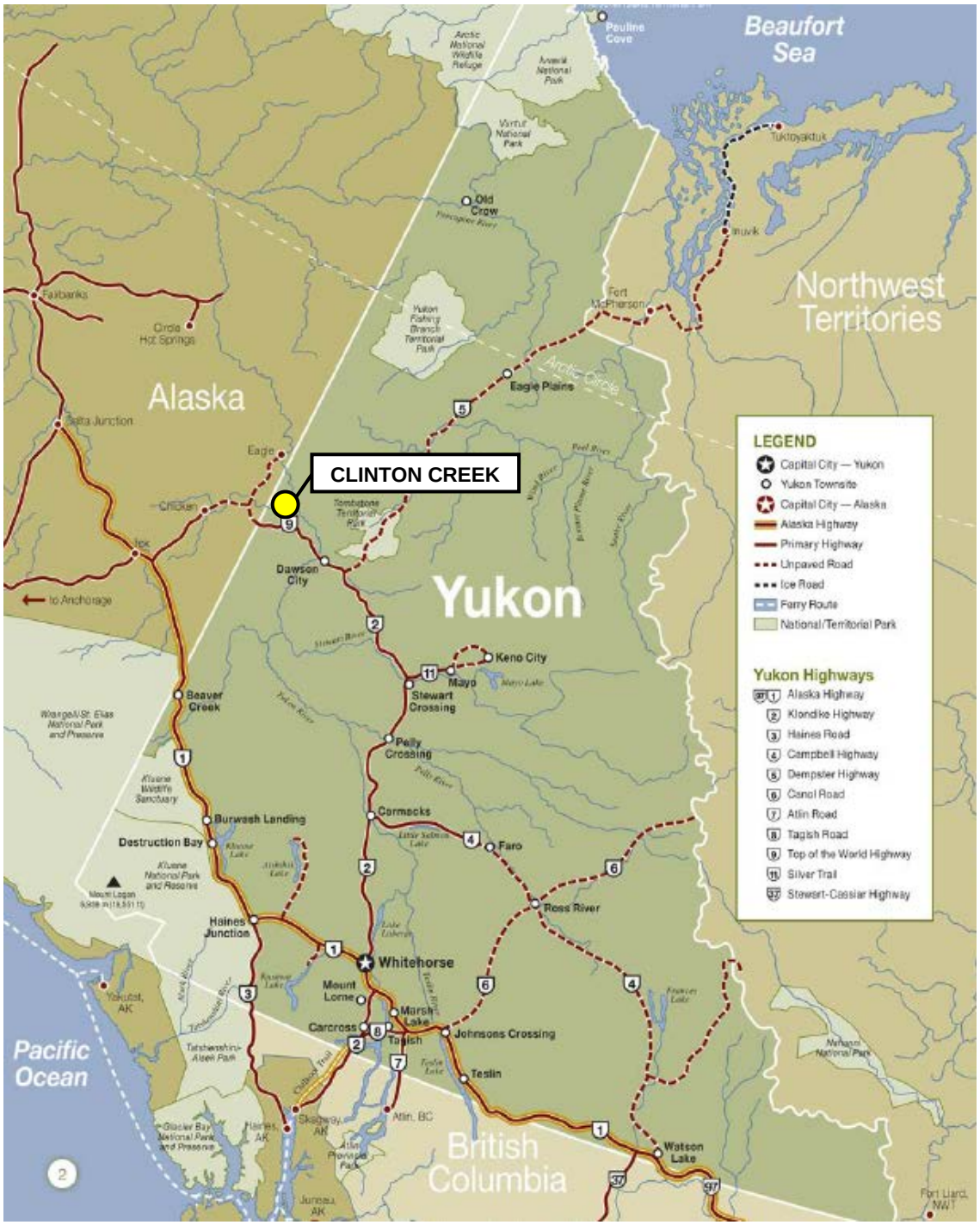

Figure A Clinton Creek Location Map

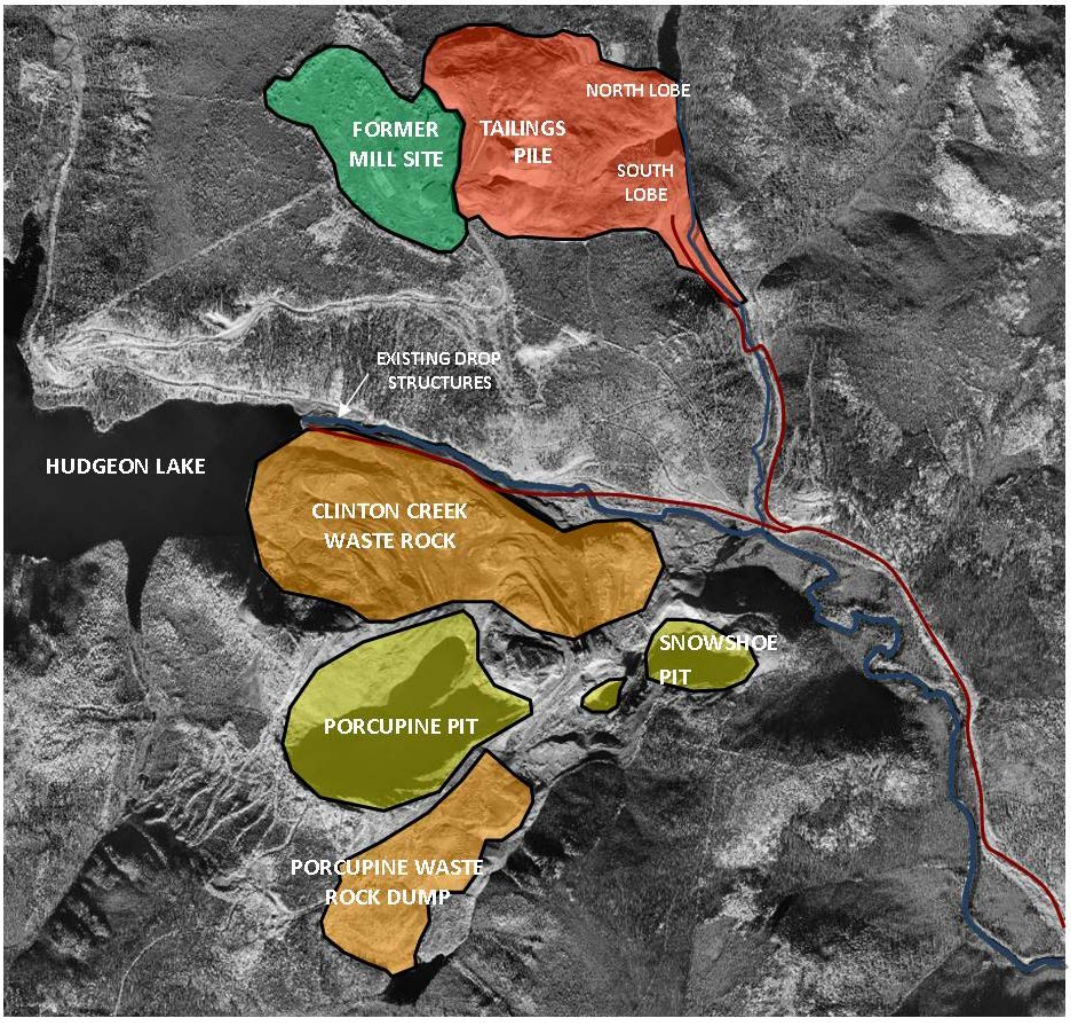

Figure B Clinton Creek Site Map

1.4 Report Components

This report includes the following:

- Summary of observations made during WorleyParsons' site visit related to components of the Clinton Creek channel (Section 2);
- The methodology used to complete the risk assessments (Section 3);

- Presentation and discussion of a risk assessment completed for each Clinton Creek site component (Section 4) and Wolverine Creek site component (Section 5) - excluding DS4 and the potential cascading failure of DS1 to DS4 and Hudgeon Lake - included the following:
  - Potential failure mechanisms;
  - Likelihood classifications;
  - Consequence scenarios;
  - Existing and recommended preventative measures;
  - Risk event statement;
  - Overall risk rating;
- Review of existing triggers to determine if they have been exceeded and recommendations to assess their validity;
- Risk assessment summary; and
- Conclusions and recommendations.

1.5 Objectives

The assessment of the Clinton Creek site components listed in Section 1.2 is part of the larger LTMP. The LTMP was developed to monitor, track, and evaluate the topographical changes that occur at the site to achieve the following objectives provided in the Scope of Work:

- Capture the year-to-year changes of the site components;
- Assess risk of failure of stabilization works (e.g., the gabion drop structures); and
- Evaluate the movement of the waste rock and tailings pile slopes for indications of increased mobility of the material that could pose a hazard to the environment, human safety, or site access that would require preventative intervention.

This assessment achieves the following objectives:

- Identify potential failure mechanisms for each site component;
- Identify risk events, consequence classifications, and indicative likelihoods associated with the potential failure of each site component;
- Determine if previously identified triggers have been exceeded and, if so, the appropriate response has been implemented;
- Assign a risk rating using the consequence classifications, indicative probabilities, and the AANDC risk assessment format; and
- Develop new triggers for site components for which no triggers have been previously assigned.

2. SITE VISIT OBSERVATIONS

The August 25, 2014 site visit was conducted by the following WorleyParsons staff:

- Lee Martin;
- Margaret McBride; and
- Jake Gentles.

Transportation to and from the site was achieved by helicopter (Trans North Helicopters in Dawson City). Site reconnaissance was generally conducted on foot supplemented by helicopter flyovers of inaccessible areas and areas where an elevated vantage point was advantageous. The observations made during the site visit are summarized in Table A. Site visit photographs can be found in Appendix 3.

Table A Summary of Site Visit Observations

Location	Access Method	Observations
Site Access Roads - Forty Mile Bridge to First Ford	Flyover	Road is accessible. Site access gate at Wolverine Creek confluence damaged and unlocked (note that the gate cannot be secured without repairs).
Site Access Roads - First Ford	On foot	Although the ford was not used during the site visit, it appeared to be geotechnically stable and passable by 4WD vehicles.
Site Access Roads - First Ford to Hudgeon Lake	Primarily on foot	Road is accessible with some minor rill erosion damage located periodically along route. Some of these rills may become impassible to vehicle traffic from ongoing erosion if not filled in.
Site Access Roads - Hudgeon Lake to Mill Site	Flyover	Road appears accessible.
Hudgeon Lake Outlet[1]	On foot	Outlet is in good condition; however, ford may be impassable due to high water depth. Although the boom abutments have been installed and appeared to be stable, the boom itself was not in place at the time of the visit. Though the beaver lodge located along the lakeshore (approximately 150 m west of the outlet) was not identified during the site visit, it can be seen in the background of photographs taken at the lake outlet.
Hudgeon Lake Surrounding Slopes	Flyover	No visible signs of recent slope movement or failures in the area surrounding Hudgeon Lake.
Gabion DS1	On foot	Large woody debris constricting flow at upstream side of DS1. Damage to gabion basket on north side of second drop structure tier. One basket displaced horizontally in channel. Tension cracks located along the south top of bank between DS1 and DS2.
Gabion DS2	On foot	Large woody debris located above water line. Baskets are in good condition. Tension cracks (4 m in length) located along south top of bank.

Location	Access Method	Observations
Gabion DS3	On foot	Large woody debris located primarily above water line. Baskets are in generally good condition. One basket installed downstream of drop structure along channel bottom displaced vertically.
Gabion DS4	On foot	Woody debris located in channel. In channel baskets significantly damaged beginning 3 m to 4 m above plunge pool. Baskets below this height have failed, including baskets on north and south banks. Failed basket material observed approximately 15 m downstream. Tension cracks (5 m to 6 m in length) located along south top of bank. WorleyParsons completed a site visit in 2013 (attended by Lee Martin and Alex Timmis) to review the condition of DS4 and to inform the development of a repair strategy. The condition of DS4 does not appear to be significantly different than last year, based on a comparison of photos taken during the 2013 and 2014 site visit.
Clinton Creek Channel and Site Access Road	On foot and flyover	Slope failures along north and south banks. Significant tension cracks (6 m to 7 m in length) located along south top of bank. Undercutting of bedrock along toe of north bank.
Clinton Creek Waste Rock Pile	On foot and flyover	Some rill erosion damage on south slope. Note that the rill damage was not located near the unstable section of the Clinton Creek embankment, adjacent to the closed portion of the access road.
Wolverine Creek Tailings Pile	Flyover	Tension cracks located at the following locations: • Upper slope of the south lobe; • Lower slope of the south lobe (concentrated at southeast corner); • Upper slope of the north lobe (concentrated at north face of the slope); • Mid slope of the north lobe (located at the north side of the east face of the slope).
Wolverine Creek Tailings Pile Ponds	Flyover	Although there is woody debris located at the outlets of both the north and south ponds, it does not appear that the debris is constricting discharge from the ponds. It should be noted that a beaver dam has been observed upstream of the north lobe pond by AAM staff but was not observed during the site visit. The channel connecting the north and south ponds does not appear to be obstructed by debris or tailings material.
Wolverine Creek Rock Lined Channel	On foot	Rock weirs and rock protection are in good condition. No significant erosion sites identified. Wolverine culvert is unobstructed and headwall is in good condition.
Porcupine Pit	On foot and flyover	Tension cracks located along top of north pit wall. No observed indication of recent slope failures.
Snowshoe Pit	Flyover	No observed indication of recent slope failures.

[1]Based on discussions with AAM staff, it was understood that while the boom was originally constructed during the summer of 2013, it was not installed in 2014. The boom is intended to be installed post freshet each year and removed in the fall. In 2014, AAM completed regular debris removal manually from drop structures through the open water season; where it was safe to do so.

Following the site visit, Underhill Geomatics Ltd. (Underhill) completed a topographic and monitoring survey of the features listed above as part of the 2014 Clinton Creek LTMP. The results of this survey are presented and discussed in the 2014 LTMP report (WorleyParsons 2014b).

3. RISK ASSESSMENT OVERVIEW

This report discusses risks associated with, and influenced by, the failure of site components at the Clinton Creek site (summarized in Appendix 2).

3.1 Methodology

Risk assessments for DS4 and the Clinton Creek channel cascading failure were completed using the AANDC risk assessment format (using reference documents provided by AAM). Each risk assessment includes the following:

- Estimated likelihood of occurrence of each scenario (based on professional judgement) based on Table B;

Qualitative classification of four consequence categories based on:

- Table C (note that though Special Considerations and Community / Media / Reputation categories are important components of a risk assessment, WorleyParsons' understanding of the issues related to these categories is not sufficient to assign a classification to them);
- Description of the potential consequence scenario associated with each classification, summarized as distinct risk event statements; and
- An overall qualitative risk rating, based on the AANDC risk table presented as Table D.

Table B Likelihood Terminology

Likelihood	Descriptor	Frequency Descriptor	Probability of Occurrence Over 20 Years	Probability of Occurrence in Any One Year
Almost Certain	Happens often	High frequency (more than once every five years).	98%	17.8%
Likely	Could easily happen	Event does occur, has a history, once every 15 years.	75%	6.7%
Possible	Could happen and has happened elsewhere	Occurs once every 40 years.	40%	2.5%
Unlikely	Has not happened yet but could	Occurs once every 200 years.	10%	0.5%
Very Unlikely	Conceivable, but only in extreme circumstances	Occurs once every 1,000 years.	2%	0.1%

Table C Consequence-Severity Matrix

Consequence Categories	Severity Descriptors				
	Very Low	**Minor**	**Moderate**	**Major**	**Critical**
Environmental Impact	No impact.	Minor localized or short term impacts	Significant impact on valued ecosystem component	Significant impact on valued ecosystem component and medium term impairment of ecosystem function	Serious long-term impairment on ecosystem function
Special Considerations	Some disturbance but no impact to traditional land use	Minor or perceived impact to traditional land use	Some mitigable impact to traditional land use	Significant temporary impact to traditional land use	Significant permanent impact on traditional land use
Legal Obligations	Informal advice from a regulatory agency	Technical / administrative non-compliance with permit, approval, or regulatory requirement - warning letter issued	Breach of regulations, permits, or approvals (e.g., one-day violation of discharge limits) - order or direction issued	Substantive breach of regulations, permits, or approvals (e.g., multi-day violation of discharge limits) - prosecution	Major breach of regulation - wilful violation - court order issued
Consequence Costs	<$100,000	$100,000 to $500,000	$500,000 to $2.5 million	$2.5 million to $10 million	>$10 million
Community / Media / Reputation	Local concerns, but no local complaints or adverse press coverage	Public concern restricted to local complaints or local adverse press coverage	Heightened concern by local community, criticism by non-government organizations (NGOs) or adverse local / regional media attention	Significant adverse national public, NGO, or media attention	Serious public outcry / demonstrations or adverse international NGO attention or media coverage
Human Health and Safety	Low-level short term subjective symptoms. No measurable physical effect. No medical treatment	Objective but reversible disability / impairment and/or medical treatment injuries requiring hospitalization	'Moderate' irreversible disability or impairment to one or more people	Single fatality and/or severe irreversible disability or impairment to one or more people	Multiple fatalities

Table D AANDC Risk Table

Impact	Critical	Moderately High	Moderately High	High	Very High	Very High
	Major	Moderate	Moderately High	High	High	Very High
	Moderate	Low	Moderate	Moderately High	Moderately High	High
	Minor	Low	Low	Moderate	Moderate	Moderately High
	Very Low	Low	Low	Low	Low	Low
		Very Unlikely	Unlikely	Possible	Likely	Almost Certain
		Likelihood				

3.2 Likelihood and Consequence Classifications

Likelihood and consequence classifications were assigned to each failure mode, rather than the failure mechanisms that may trigger the failure mode, and were based on the professional judgement and understanding of site conditions by WorleyParsons' staff.

3.3 Triggers and Recommendations

The triggers and recommendations provided in previous reports related to Clinton Creek infrastructure are summarized in Appendix 3 and Appendix 4, respectively.

4. CLINTON CREEK COMPONENTS

4.1 Gabion Drop Structure Nos. 1, 2, and 3

Four gabion drop structures, constructed between 2002 and 2004, are located between 70 m and 250 m downstream of the Hudgeon Lake outlet. Each drop structure is comprised of metal gabion baskets filled with rock installed in successive layers installed across the creek channel. Of these, DS1, DS2, and DS3 (the upper drop structures) were considered in this risk assessment, with DS4 previously assessed in the Clinton Creek Engineering Review and Assessment - Part 1 report (WorleyParsons 2014a).

The following failure modes were assessed for the upper drop structures:

- Partial failure - deformation of the drop structure or damage to or deterioration of the drop structure materials with partial exposure of the underlying waste rock requiring minor, localized repairs; and
- Complete failure - loss of structural integrity of the drop structure with exposure of the underlying waste rock across the majority of the channel bottom requiring full reconstruction of the drop structure.

The drop structures were installed to stabilize the creek channel which had undergone significant geomorphological changes (i.e., significant erosion and scour), following the waste rock failure that blocked the Clinton Creek valley. The installation of the drop structures was designed to lower the channel elevation over a short length of channel, such that the remainder of the channel can be relatively flat, limiting flow velocities and erosion.

The drop structures were damaged due to extreme flows driven by a large precipitation event, and a possible blockage of Hudgeon Lake, in August 2010 (R100, AECOM 2010). The following emergency repairs to the drop structures were completed in 2011 (R94, AECOM 2011):

- Filled gabion baskets - Tiers 1 to 4 (DS1 and DS3) and Tiers 1 to 5 (DS2);
- Filled floor gabion baskets - DS1;
- Installed riprap downstream of DS2 end sill; and
- Installed new end sill, downstream gabion baskets, and riprap at DS3.
- Though DS4 was the drop structure most significantly damaged in 2010 and was planned to be repaired in 2011, it could not be safely accessed and repair was postponed. In 2014, a detailed repair strategy was developed including stabilization of the south channel embankment to facilitate safe access to the drop structure.

4.1.1 Current Condition

At the time of the site visit, large woody debris, located above the water line, was observed at each drop structure but was not obstructing flow. One gabion basket at both DS1 and DS3 were visibly displaced and tension cracks were observed along the south channel bank at DS1 and DS2; however, it did not appear that these deficiencies have significantly impacted the performance of the drop structure.

The monitoring points located adjacent to the upper drop structures moved on average 3.7 cm, with a maximum movement of 6.6 cm, based on a comparison between the 2013 and 2014 survey results. Over the same timeframe, the end area at these drop structures changed by 4.9%, on average. The drop structure width between the upper monitoring points was measured as 20.6 m, less than the trigger level of 21.0 m (Section 4.1.7); however, these observed changes do not indicate that the drop structures have become destabilized or are not performing as intended. The structures should continue to be monitored to identify large and/or trending changes to the drop structures which could indicate structural issues which should be addressed.

Based on the observations made during the site visit and the results of the survey, the upper drop structures were considered stable and should be capable of conveying normal and seasonal high flows (e.g., freshet).

4.1.2 Failure Mechanisms

The partial or complete failure of the upper drop structures could be triggered by the failure mechanisms presented in the following sections.

Deterioration of the Gabion Baskets

Gabion drop structures generally have a limited service life (typically less than 25 to 35 years) due to the deterioration of the basket components (e.g., corrosion and metal fatigue of the mesh, breakdown of the basket connectors) and often require maintenance after seven to ten years of service. Although the basket mesh was coated in polyvinyl chloride (PVC) to resist corrosion (R07, UMA 2005), DS1, DS2, and DS3 have been in service for more than 10 years, and this type of deterioration could become more prevalent. If not properly addressed, these isolated partial failures could reduce the structural integrity of the drop structure resulting in a partial or complete failure.

Erosion of Base Materials

Water flowing along the interface between the gabion baskets and underlying soils can result in ongoing erosion if the soils are not protected (e.g., by a geotextile). Erosion could propagate along the baskets creating a void, particularly during periods of high flows. Although geotextile was installed to protect the underlying soils, it is possible that the fabric could have been torn during or following installation exposing the underlying soils to these flows.

As the fabric is not visible, the erosion would not be evident until it had created a void sufficient to cause the displacement of one or several gabion baskets. If not properly addressed, this erosion could reduce the structural integrity of the drop structure resulting in a partial or complete failure.

Accelerated Slope Movement

The waste rock dump located south of the Clinton Creek channel is moving north at an average rate of 2.5 cm/y through its lower slope, based on recent survey results. As the drop structures were built at the toe of the waste rock, this movement is likely putting pressure on the drop structures. If the movement rate were to increase significantly, the drop structures may not be able to resist this pressure, possibly resulting in the partial or complete failure of one or all the drop structures.

Significant Seismic Event

A significant seismic event could impart lateral stress to the gabion baskets causing buckling and loss of structural integrity resulting in the partial or complete failure of one or all of the drop structures.

Extreme Flow Event

Due to its high flow depth and velocity, the conveyance of an extreme flood flow (i.e., an unusually large flow generated by precipitation, freshet, or the release of a blockage at the Hudgeon Lake outlet) would generate large shear stresses acting against the channel cross-section (i.e., the bottom and sides of the channel). If these stresses were greater than the drop structure's resistance to shear, the gabion baskets could deform, break apart, lose material, or be undermined due to erosion, any of which could result in the partial or complete failure of the one or all of the drop structures.

WorleyParsons estimated, based on professional opinion, that the upper drop structures could fail completely due to the conveyance of the 200-year peak instantaneous flow (estimated as 45 m^3/s), or greater, and could fail partially due to the conveyance of the 25-year peak instantaneous flow or greater (estimated as 29 m^3/s) or greater.

Debris Damage

Debris or the boom at Hudgeon Lake could enter the Clinton Creek channel at the Hudgeon Lake outlet and strike the drop structures as it is conveyed downstream. The impact of the strike could damage the gabion basket mesh or connectors. This debris would be primarily comprised of woody debris including large branches and small logs.

4.1.3 Partial Failure

The partial failure of the upper drop structures could consist of one or more of the following scenarios:

- Separation of gabion baskets or loss of gabion rock such that the underlying geotextile is exposed;
- Loss of gabion baskets such that the drop structure surface area is reduced; and/or

- Deformation of the drop structure (e.g., loss of channel width, increased side slopes) such that its hydraulic performance is impacted.

Any of the failure mechanisms presented above could contribute to the partial failure of the upper drop structures.

Likelihood Classification

The likelihood of a partial failure of one of DS1, DS2, or DS3 was classified as 'Likely' based on the partial failure of DS4 and the length of service life of this type of structure (typically less than 25 to 35 years). The likelihood of a partial failure of two or more of DS1, DS2, and/or DS3 was classified as 'Possible'. As it was estimated that multiple partial failures would not result in more serious consequence than those associated with a single partial failure (i.e., the consequence classifications assigned to multiple partial failures would be the same as those assigned to a single partial failure), the more likely single partial failure was assessed as it resulted in a higher risk rating.

Consequence Scenarios

The consequence scenarios presented and discussed in the following sections were developed based on the AANDC methodology and using WorleyParsons' understanding of the site condition and professional judgement. The scenarios associated with a partial failure of one of the upper drop structures are summarized in Appendix 2 and Table E.

Table E Consequence Classifications - Partial Failure of One of the Upper Drop Structures

Category	Classification	Descriptor
Environmental Impact	Very Low	No environmental impact
Legal Obligations	Very Low	Informal advice from a regulatory agency (e.g., Environment Canada [EC])
Consequence Costs	Very Low	Less than $100,000
Human Health and Safety	Minor	Objective but reversible disability / impairment and/or injuries requiring hospitalization

Environmental Impact

The partial failure of one of the drop structures could expose a portion of the waste rock and granular materials in the channel due to erosion. These materials could be mobilized and deposited downstream; however, this would not likely result in the degradation of downstream aquatic habitat as the concentrations of sediment would likely be relatively low.

This scenario was assigned a 'Very Low' consequence classification.

Legal Obligations

As the partial failure of one of the drop structures would not likely present a risk to the environment, it is unlikely that any action would be taken by regulatory agencies.

This scenario was assigned a 'Very Low' consequence classification.

Consequence Costs

Minor repairs would likely be required to address the partial failure of one of the drop structures. This could include the replacement of gabion rocks, re-connection of adjacent baskets, closure of the mesh, or repair of base materials. It is anticipated that the associated costs may be in the range of $100,000.

This scenario, based on the partial failure of one drop structure in isolation, was assigned a 'Very Low' consequence classification. It should be noted that if all three drop structures partially failed at the same time, the associated repair costs may be in the range of $300,000 (i.e., above the upper limit for the 'Very Low' consequence classification).

Human Health and Safety

Objective but reversible disability / impairment and/or injuries requiring hospitalization could occur as a result of the partial failure of one of DS1, DS2, or DS3 if an unauthorized recreational user or worker were located within the immediate vicinity of the structure at the time of failure. The partial failure could result in minor fall injuries due to unstable / shifting footing.

This scenario was assigned a 'Minor' consequence classification.

Risk Statement

The partial failure of one of DS1, DS2, or DS3 is summarized in the following risk event statement:

"The deterioration of gabion baskets, erosion of base materials, accelerated slope movement of the waste rock dump, a significant seismic event, conveyance of an extreme flow, or damage from debris causes the partial failure of one of the upper drop structures (DS1, DS2, or DS3), which would likely have no environmental impact and could result in the provision of informal advice from a regulatory agency, repair costs less than $100,000, and/or minor injuries."

4.1.4 Complete Failure

Any of the failure mechanisms presented above could contribute to the complete failure of the upper drop structures (i.e., the failure of all or nearly the entire drop structure infrastructure in a way that is non-remediable and results in downcutting of the channel at and upstream of the drop structure).

Likelihood Classification

Although DS4 has failed, it was considered to be a partial, remediable, failure rather than a complete failure. Due to its height, channel depth, and proximity to the waste rock dump (comparative to the upper drop structures), DS4, in its pre-failure state, was considered to be more susceptible to the failure mechanisms listed above and consequently more likely to fail than the upper drop structures. This is evidenced by the greater severity of its partial failure following the 2010 high flow event; therefore, it was assumed that the upper drop structures are more stable than DS4 was in its pre-failure state.

As DS4 was assigned likelihood classifications ranging from 'Possible' to 'Almost Certain' (refer to WorleyParsons 2014a), the likelihood of a complete failure of one of DS1, DS2, or DS3 was classified as 'Possible' (i.e., could happen and has happened elsewhere).

Consequence Scenarios

The scenarios associated with a complete failure of one of the upper drop structures are summarized in Appendix 2 and Table F.

Table F Consequence Classifications - Complete Failure of One of the Upper Drop Structures

Category	Classification	Descriptor
Environmental Impact	Minor	Acute degradation of local aquatic habitat
Legal Obligations	Minor	Warning letter issued by EC for release of deleterious material causing degradation of aquatic habitat
Consequence Costs	Minor	Costs of approximately $250,000 to repair a single drop structure
Human Health and Safety - People at or near the drop structure	Major	Single fatality
Human Health and Safety - People downstream of drop structure	Minor	Objective but reversible disability / impairment and/or injuries requiring hospitalization

Environmental Impact

The failure of one of the drop structures would result in the exposure of waste rock and granular materials in the channel due to erosion. The deposition of these materials could cause an acute degradation of downstream aquatic habitat due to infilling of runs and pools impacting fish passage as well as the loss of gravels and cobbles available for spawning and shelter along the creek channel.

It is anticipated that the extent of the degradation would be localized and that the habitat would recover following the repair of the drop structure.

This scenario was assigned a 'Minor' consequence classification.

Legal Obligations

The failure of one of the drop structures could result in the degradation of downstream aquatic habitat as described above due to the deposition of waste rock and granular materials. These substances would be considered to be “deleterious substances” per the Canadian Fisheries Act (the Act). Section 36 of the Act states that *“No person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish”*. Due to the limited scale of the deposition and anticipated impact on aquatic habitat, it is likely that EC, the body responsible for enforcing the Act, may issue a warning letter rather than an order or direction.

This scenario was assigned a ‘Minor’ consequence classification.

Consequence Costs

Reconstruction would likely be required to address the complete failure of one of the drop structure. It is anticipated that the associated costs may be in the range of $250,000.

This scenario was assigned a ‘Minor’ consequence classification. Note that if all three drop structures underwent partial failure concurrently, it would be anticipated that the associated repair costs could be as high as $750,000 (i.e., above the upper limit for the ‘Minor’ consequence classification).

Human Health and Safety

A single fatality or severe, irreversible disability / impairment and/or injuries requiring hospitalization could occur as a result of the failure of one of the drop structures if an unauthorized recreational user or worker were in the vicinity (i.e., within approximately 50 m) of the structure at the time of failure. If located in the channel downstream of the structure, the person could be struck by the gabion basket materials or buried beneath waste rock material. If the person was located on the banks of the channel, the mobilized material could cause a loss of footing, resulting in them falling down the embankment.

This scenario was assigned a ‘Major’ consequence classification. The likelihood of this scenario was considered to be ‘Very Unlikely’.

Objective, but reversible, disability / impairment and/or injuries requiring hospitalization could occur as a result of the failure of one of the drop structures if an unauthorized recreational user or worker were located in the channel, downstream of the structure at the time of failure. Injuries sustained could be the result of being struck by mobilized cobbles, ingesting sediment laden water, or a loss of stable footing.

This scenario was assigned a ‘Minor’ consequence classification. The likelihood of this scenario was considered to be ‘Possible’.

Risk Statement

The complete failure of one of DS1, DS2, or DS3 is summarized in the following risk event statement:

"The deterioration of gabion baskets, erosion of base materials, accelerated slope movement of the waste rock dump, a significant seismic event, or conveyance of an extreme flow causes the complete failure of one of the upper drop structures (DS1, DS2, or DS3), which could result in the minor degradation of local aquatic habitat, issuance of a warning letter by EC, reconstruction costs of $250,000, and/or serious injuries or a fatality."

4.1.5 Overall Risk Rating

The consequence and likelihood classifications presented in the preceding sections were used to assign the qualitative risk ratings summarized in Table G. A complete list of these ratings can be found in Appendix 2.

Table G Risk Ratings for Upper Drop Structures

Consequence Category	Partial Failure	Complete Failure
Environmental	Low	Moderate
Legal Obligations	Low	Moderate
Consequence Costs	Low	Moderate
Human Health and Safety - person located downstream of drop structure at time of failure	Moderate	Moderate
Human Health and Safety - person located in the vicinity of the drop structure at time of failure	N/A	Moderate

4.1.6 Preventative Measures

The following preventative measures are in place to reduce the likelihood and/or severity of the partial or complete failure of one of the upper drop structures:

- Annual inspection and topographic survey of the upper drop structures (by consultant);
- Monthly inspection during the summer (by AAM staff);
- Debris periodically collected along the channel, drop structures, and boom structure;
- Security measures that limit access to the site (e.g., locked security gate at site entrance, warning signs) to discourage access by unauthorized recreational users; and
- Safety measures to prohibit workers and staff from accessing the drop structures or working downstream during periods of high flow without a detailed safety plan approved by AAM.

The following recommended preventative measures should be implemented to reduce the likelihood of the partial or complete failure of one of the upper drop structures:

- Ensure that the boom structure at Hudgeon Lake is in place each summer and well maintained so that it collects debris and reduces the likelihood of a dislodgement of a potential blockage at the outlet (i.e., the boom is sufficiently stable such that it can withstand increased hydrostatic pressure caused by a debris blockage, preventing dislodgement of the blockage).

The implementation of the recommended preventative measures would not reduce the overall likelihood classifications as they do not mitigate all failure mechanisms; however, they could reduce the likelihood and severity of damage to the drop structures caused by debris travelling through the channel.

4.1.7 Triggers

Existing and new triggers associated with the gabion drop structures are presented in Table H.

Table H Drop Structure Triggers

ID	Description	Value	Action	Status
DS-1 (R22)	Change to drop structure geometry: steepened side slope	<2H:1V	Develop mitigation plan for drop structures at which trigger has been exceeded	Not triggered
DS-2 (R22)	Change to drop structure geometry: minimum freeboard at design flow	<0.20 m	Develop mitigation plan for drop structures at which trigger has been exceeded	Not triggered; however, recommend that the trigger level is changed to <1.0 m freeboard during conveyance of the 50-year return period flood flow
DS-3 (R22)	Change to drop structure geometry: width at drawdown or width at end sill decreased from baseline	>0.50 m	Develop mitigation plan for drop structures at which trigger has been exceeded	Triggered at DS3; however, given that the overall risk rating assigned to DS3 is 'Moderate', it is recommended that the drop structure continues to be monitored for signs of damage or indications of instability based on survey results
DS-4 (R22)	Visual evidence of water flowing below gabion baskets or undermining baskets	N/A	Immediate appropriate repair prior to the end of the construction season	Not triggered
DS-5 (R22)	Visual evidence of damage to gabion mesh	N/A	Repair wire mesh and SPENAX rings as appropriate prior to the end of construction season	Triggered at DS1, DS3, and DS4. To be repaired in 2015
DS-6 (new)	Change to cross-sectional end area since previous monitoring period	>10% RPC	Develop mitigation plan for drop structures at which trigger has been exceeded	Baseline measurements made in 2014

4.1.8 Conclusions and Recommendations

Conclusions

The highest overall risk rating estimated for the upper drop structures was 'Moderate'. This rating was assigned to a partial failure of one of the upper drop structures (Human Health and Safety scenario) and a complete failure of one of the upper drop structures and applied to all consequence scenarios.

Based on the observations made at the Site, the results of the 2014 survey, and this assessment, the triggers provided in the 2005 LTMP report (R22 UMA 2006) remain valid. Although trigger DS3 was exceeded at DS3, the 'Moderate' risk rating assigned to the upper drop structures suggests that repairs are not required at this time. The results of future inspections and surveys for DS3 should indicate whether DS3 has stabilized or if repairs are warranted.

Recommendations

The recommendations relevant to the upper drop structures are summarized in Table I.

Table I Drop Structure Recommendations

ID	Description	Implementation	Validity
DS-A (R51)	Monitor (i.e., inspect and survey) drop structures on an annual basis	Ongoing - inspection and survey of all drop structures completed in 2013 and 2014	Valid - practice should continue
DS-B (R104)	Undertake further geotechnical investigation and evaluation to provide a more in-depth discussion on possible causes for differing movement rates between the gabion monitors and waste rock dump monitors	Not implemented	Valid - should be completed prior to site-wide remediation
DS-C (new)	Install additional monitoring points along the waste rock dump toe aligned with the drop structures. A total of eight points should be installed with each point located 20 m south of the monitoring point on the south creek embankment	Should be implemented during 2015 LTMP survey	To improve understanding of influence of waste rock movement on drop structures
DS-D (new)	Establish new monitoring points and cross-section downstream of DS4 that can be safely accessed	Should be implemented during 2015 LTMP survey	Existing monitoring cross-section at downstream end of DS4 can no longer be safely accessed
DS-E (new)	Future survey should include the clear and explicit identification of break points (e.g., toe and top of embankment) through drop structure cross-sections and the edges of each course of gabion baskets along the drop structure centerline	Should be implemented during 2015 LTMP survey	To facilitate the measurement of drop structure cross-section parameters and the review of drop structure profiles

ID	Description	Implementation	Validity
DS-F (new)	Change trigger DS-2 from <0.2 m freeboard to <0.3 m freeboard during conveyance of the 50-year peak flow and adopt revised design flows shown on Figures 1009 to 1012, Appendix 1	Included on 2014 LTMP drawings	To reflect revised peak flow depth and current hydraulic design practices
DS-G (new)	Change trigger DS3 to measure the drop structure width between the upstream and downstream monitoring points rather than at the upstream drawdown weir and between the downstream monitoring points	Should be implemented as part of 2015 LTMP	Only DS1 was installed with a drawdown weir.
DS-H(R51)	Repair the drop structures damaged by the August 2010 precipitation event	Partially complete: DS1, DS2, and DS3 were repaired; DS4 left as is	Valid - DS4 to be repaired in 2015
DS-I(R104)	Develop a stabilization plan and implement to provide long term stability to the site	Ongoing - Remediation strategy developed in 2014 by WorleyParsons	Valid - planning for site wide remediation should continue

4.2 Clinton Creek Channel

The Clinton Creek channel collects/conveys discharge from the waste rock area as well as Hudgeon Lake. Erosion and flow control infrastructure installed along the channel include a boom at the outlet of Hudgeon Lake to capture debris, four drop structures, and channel armouring between the lake outlet and DS4.

Downstream of DS4, the Clinton Creek channel continues south east to the confluence with Wolverine Creek. Following the large flow event in 2010, a 200 m portion of the creek channel immediately downstream of DS4 has eroded by as much as 4.5 m and compromised the north and south channel embankments and the closed portion of the Clinton Creek Access Road. At that time, the alignment of the lower portion of the creek, beyond station 0+700, shifted south to the toe of the waste rock.

The following failure modes were assessed for the Clinton Creek channel:

- Localized slope failure - an abrupt slope collapse along a section of the channel less than 10 m in length with material coming to rest at the bottom of the embankment;
- Minor channel blockage - embankment material or debris across a portion of the channel, restricting or obstructing flow followed by the release and mobilization of the blockage material; and
- Major channel blockage - embankment material, debris, or beaver activity across the entire channel (i.e., embankment toe to embankment toe), restricting or obstructing flow followed by the release and mobilization of the blockage material.

4.2.1 Current Condition

During the site visit, several localized slope failures were observed along the north and south banks of the channel. In addition, a significant portion of the south bank, approximately from Stations 0+250 to 0+680 (upper channel), exhibits signs of instability with tension cracks along the top of the bank and over steepened banks.

The results of the 2014 survey indicate that between 2012 and 2014, the upper channel shifted north 1.5 m and was downcut over a length of 223 m by an average of 24 cm (a 27% increase over the downcutting recorded between 2010 and 2012). The mid channel (Stations 0+680 to 0+913) shifted north 1.2 m and was downcut over a length of 225 m by an average of 67 cm (approximately a 200% increase over the downcutting recorded between 2010 and 2012).

Based on the observations made during the site visit and the results of the survey, the upper and mid portions of the Clinton Creek channel were considered unstable. It is likely that small, localized slope failures will persist and that the upper creek south bank will not stabilize without remediation.

4.2.2 Failure Mechanisms

Localized slope failures along or a minor / major blockage of the Clinton Creek channel could be triggered by the failure mechanisms presented in the following sections.

Accelerated Slope Movement

Similar to the mechanism discussed in Section 4.1.2, if the movement rate of the waste rock were to increase, it would generate increased driving force acting upon the south channel bank. If this force were greater than resisting forces of the slope (i.e., shear strength), it could result in the movement of the south channel bank materials, potentially destabilizing the bank and causing a slope failure (i.e., downslope movement of rock and soil taking the form of a fall, slide, or flow).

Down-Cutting

Down-cutting of the channel bed as a result of erosion could weaken or undermine the channel banks. This could potentially destabilize the channel banks due to the loss of shear strength or over-steepening of the channel banks.

Extreme Flow Event

The conveyance of an extreme flow event could rapidly erode the toe of the channel banks or increase pore water pressure in bank materials due to a high water level. Either outcome could potentially result in a slope failure. If the extreme flow event were driven by precipitation, infiltration of runoff into the channel bank material would increase pore water pressure, potentially triggering a slope failure.

Collection of Debris, Beaver Activity, or Large Slope Failure

The collection of debris, beaver activity, or large slope failure (i.e., greater than 10 m along the channel) could restrict or obstruct flow in the channel. This could result in increased flow velocities and elevated water levels in the channel during normal, non-extreme, flow conditions potentially destabilizing the channel embankment due to increased scouring and saturation of the channel embankment toe.

4.2.3 Localized Slope Failure

Localized slope failures could be triggered by accelerated slope movement of the waste rock, down-cutting of the channel bed, or the conveyance of an extreme flow.

Likelihood Classification

The likelihood of a localized slope failure was classified as 'Almost Certain' based on the multiple slope failures observed during the site visit.

Consequence Scenarios

The scenarios associated with localized slope failure along the Clinton Creek channel are summarized in Appendix 2 and Table J.

Table J Consequence Classifications - Localized Slope Failure along Clinton Creek Channel

Category	Classification	Descriptor
Environmental Impact	Very Low	No environmental impact
Legal Obligations	Very Low	Informal advice from a regulatory agency (e.g., EC)
Consequence Costs	Minor	Between $100,000 and $500,000
Human Health and Safety	Minor	Objective but reversible disability / impairment and/or injuries requiring hospitalization

Environmental Impact

Multiple localized slope failures could result in the encroachment of waste rock materials into the channel. This material could be mobilized and deposited downstream; however, this would not likely result in the degradation of downstream aquatic habitat as the concentrations of sediment would likely be relatively low.

This scenario was assigned a 'Very Low' consequence classification.

Legal Obligations

As multiple localized slope failures would not likely present a risk to the environment, it is unlikely that any action would be taken by regulatory agencies.

This scenario was assigned a 'Very Low' consequence classification.

Consequence Costs

Costs associated with the stabilization or repair of a localized slope failure could be as high as $500,000 depending on the size, accessibility, and severity of the failure; however, it is unlikely that a localized slope failure would need to be addressed unless it was impacting or could impact other site infrastructure (e.g., the access road).

This scenario was assigned a 'Minor' consequence classification. The likelihood of this scenario was considered to be 'Unlikely'.

Human Health and Safety

Objective but reversible disability / impairment and/or injuries requiring hospitalization could occur as a result of a localized slope failure if an unauthorized recreational user or worker were located at the top or bottom of the embankment at the time of failure. Injuries sustained could be the result of being struck by mobilized material, ingesting sediment laden water, or a loss of stable footing. The likelihood that a person would be located precisely at the slope failure was considered to be relatively low due to the extent of the slope failure (less than 10 m along the channel).

This scenario was assigned a 'Minor' consequence classification. The likelihood of this scenario was considered to be 'Unlikely'.

Risk Statement

A localized slope failure along the Clinton Creek channel is summarized in the following risk event statement:

"Accelerated slope movement of the waste rock dump, down-cutting of the channel, or the conveyance of an extreme flow causes a localized slope failure along the Clinton Creek channel which would likely have no environmental impact and could result in the provision of informal advice from a regulatory agency, repair costs as high as $500,000 and/or minor injuries."

4.2.4 Minor Channel Blockage

A minor channel blockage could be triggered by any of the failure mechanisms presented in Section 4.2.2.

Likelihood Classification

The likelihood of a minor channel blockage was classified as 'Likely' given the existence of an extended slope failure along the Clinton Creek channel and the channel movement observed following the 2010 flow event (i.e., it is likely that the re-alignment was caused by encroachment of waste rock material into the channel).

Consequence Scenarios

The scenarios associated with a minor blockage of the Clinton Creek Channel are summarized in Appendix 2 and Table K.

Table K Consequence Classifications - Minor Blockage of Clinton Creek Channel

Category	Classification	Descriptor
Environmental Impact	Minor	Acute degradation of local aquatic habitat
Legal Obligations	Minor	Warning letter issued by EC for release of deleterious material causing degradation of aquatic habitat
Consequence Costs	Minor	Between $100,000 and $500,000
Human Health and Safety	Minor	Objective but reversible disability / impairment and/or injuries requiring hospitalization

Environmental Impact

The minor blockage of the Clinton Creek channel could result in the mobilization of waste rock materials upon the release of the blockage. The deposition of these materials could cause an acute degradation of downstream aquatic habitat due to infilling of runs and pools impacting fish passage as well the loss of gravels and cobbles available for spawning and shelter along the creek channel. It is anticipated that the extent of the degradation would be localized and that the habitat would recover following the removal of the blockage and stabilization of the slope.

This scenario was assigned a 'Minor' consequence classification.

Legal Obligations

The minor blockage of the Clinton Creek channel, and the subsequent release of the blockage, could result in the degradation of downstream aquatic habitat due to the deposition of waste rock and granular materials, as described above. These substances would be considered to be "deleterious substances" per the Act. Section 36 of the Act states that *"No person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish"*. Due to the limited scale of the deposition and anticipated impact on aquatic habitat, it is likely that EC, the body responsible for enforcing the Act, may issue a warning letter rather than an order or direction.

This scenario was assigned a 'Minor' consequence classification.

Consequence Costs

The material causing the blockage of the channel would require removal, if it has not been mobilized by the creek, and stabilization of the channel embankment and channel reconstruction may be required. Costs associated with this work could be as high as $500,000 depending on the extent of the damage to the channel.

This scenario was assigned a 'Minor' consequence classification.

Human Health and Safety

Objective but reversible disability / impairment and/or injuries requiring hospitalization could occur as a result of the release of a channel blockage if an unauthorized recreational user or worker were located immediately at or downstream of the blockage at the time of its release. Injuries sustained could be the result of being struck by mobilized material, ingesting sediment laden water, or a loss of stable footing. The likelihood that a person would be located immediately at or downstream of the blockage at the time of the release of the blockage was considered to be relatively low.

This scenario was assigned a 'Minor' consequence classification. The likelihood of this scenario was considered to be 'Unlikely'.

Risk Statement

A minor blockage of the Clinton Creek channel is summarized in the following risk event statement:

"Accelerated waste rock dump slope movement, down-cutting of the channel, the conveyance of an extreme flow, or the collection of debris; beaver activity; or an large slope failure creates a minor blockage across a portion of the Clinton Creek channel which, following the rapid release of the blockage, could result in the minor degradation of local aquatic habitat, issuance of a warning letter by EC, repair costs as high as $500,000, and/or minor injuries."

4.2.5 Major Channel Blockage

A major channel blockage could be triggered by any of the failure mechanisms presented in Section 4.2.2.

Likelihood Classification

The likelihood of a major channel blockage was classified as 'Possible' given that blockages of this nature have occurred at the Site (i.e., the slope failures that blocked the Clinton Creek and Wolverine Creek valleys) with the material coming to rest at a shallower slope angle and the current slope instability located adjacent to the closed portion of the site access road.

Consequence Scenarios

The scenarios associated with a major blockage of the Clinton Creek Channel are summarized in Appendix 2 and Table L.

Table L Consequence Classifications - Major Blockage of Clinton Creek Channel

Category	Classification	Descriptor
Environmental Impact	Moderate	Significant impact on valued ecosystem downstream
Legal Obligations	Moderate	Order or direction issued by EC or Compliance, Monitoring, and Inspection (Energy, Mines and Resources) Yukon
Consequence Costs	Moderate	Between $500,000 and $2.5 million
Human Health and Safety	Moderate	Moderate irreversible disability or impairment to one or more people

Environmental Impact

The major blockage of the Clinton Creek channel could result in the mobilization of waste rock materials upon the release of the blockage. The deposition of these materials could cause an acute degradation of downstream aquatic habitat due to infilling of runs and pools impacting fish passage as well the loss of gravels and cobbles available for spawning and shelter along the creek channel. It is anticipated that the extent of the degradation could extend downstream and that rehabilitation works may be required to restore the impacted habitat.

This scenario was assigned a ‘Moderate’ consequence classification.

Legal Obligations

A major blockage of the Clinton Creek channel, and the subsequent release of the blockage, could result in the degradation of downstream aquatic habitat due to the deposition of waste rock and granular materials, as described above. These substances would be considered to be “deleterious substances” per the Act. Section 36 of the Act states that *“No person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish”*. Due to the limited scale of the deposition and anticipated impact on aquatic habitat, it is possible that EC, the body responsible for enforcing the Act, may issue an order or direction.

This scenario was assigned a ‘Moderate’ consequence classification.

Consequence Costs

The material causing the blockage of the channel would require removal, if it has not been mobilized by the creek, and stabilization of the channel embankment and channel reconstruction would likely be required. Costs associated with this work could be as high as $1.0 million depending on the extent of the damage to the channel.

This scenario was assigned a 'Moderate' consequence classification.

Human Health and Safety

Objective but reversible disability / impairment and/or injuries requiring hospitalization could occur as a result of the release of a channel blockage if an unauthorized recreational user or worker were located immediately at or downstream of the blockage at the time of its release. Injuries sustained could be the result of being struck by mobilized material, ingesting sediment laden water, or a loss of stable footing. The probability that a person would be located immediately at or downstream of the blockage at the time of the release of the blockage was considered to be relatively low.

This scenario was assigned a 'Minor' consequence classification. The likelihood of this scenario was considered to be 'Unlikely'.

Risk Statement

A major blockage of the Clinton Creek channel is summarized in the following risk event statement:

"Accelerated waste rock dump slope movement, down-cutting of the channel, the conveyance of an extreme flow, or the collection of debris; beaver activity; or an large slope failure creates a major blockage across the Clinton Creek channel which, following its rapid release, could result in the degradation of valued ecosystems downstream, issuance of an order or direction by EC, repair costs as high as $1.0 million, and/or moderate injuries."

4.2.6 Overall Risk Rating

The consequence and likelihood classifications presented in the preceding sections were used to assign the qualitative risk ratings summarized in Table M. A complete list of these ratings can be found in Appendix 2.

Table M Risk Ratings for Upper Drop Structures

Consequence Category	Localized Slope Failure	Minor Channel Blockage	Major Channel Blockage
Environmental	Low	Moderate	Moderately High
Legal Obligations	Low	Moderate	Moderately High
Consequence Costs	Low	Moderate	Moderately High
Human Health and Safety	Low	Low	Low

4.2.7 Preventative Measures

The following preventative measures are in place to reduce the likelihood and/or severity of localized slope failures as well as major and minor blockages of the Clinton Creek channel:

- Bi-annual inspection and topographic survey of the Clinton Creek channel (by consultant);
- Monthly inspection during the summer (by AAM staff);
- Security measures that limit access to the site (e.g., locked security gate at site entrance, warning signs) to discourage access by unauthorized recreational users; and
- Safety measures to prohibit workers and staff from accessing the channel during periods of high flow without a detailed safety plan approved by AAM.

The following recommended preventative measure should be implemented to reduce the likelihood of major and minor blockages of the Clinton Creek channel:

- Ensure that the boom structure at Hudgeon Lake is in place each summer and well maintained so that it collects debris and reduces the likelihood of a dislodgement of a potential blockage of the outlet (i.e., withstand hydrostatic pressure and flows that could dislodge the blockage).

4.2.8 Triggers

Existing and new triggers for the Clinton Creek channel downstream of DS4 are presented in Table N. The new triggers are based on the observations made following the 2010 extreme flow event. They are based on current site conditions and should not be applied to historical data (i.e., though the trigger values may have been exceeded during previous timeframes, the recommended action should only be taken if the trigger value is exceeded during future monitoring periods).

Table N Clinton Creek Channel Triggers

ID	Description	Value	Action	Status
CC-1 (R22)	Channel downcut over the 50 m channel segment downstream of DS4 to Sta. 0+250	>0.5 m (from 2006 baseline)	Begin planning for channel and waste rock stabilization	Triggered in 2010 site-wide remediation planning underway
CC-2 (R22)	Channel downcut over a measurable (>50m) stretch of the channel downstream of Sta. 0+250	>1.5 m (from 2006 baseline)	Begin planning for channel and waste rock stabilization	Triggered in 2010 site-wide remediation planning underway
CC-3 (new)	Channel deposition downstream of DS4 over channel segment (minimum length of 50 m)	>0.3 m from previous monitoring period	Develop localized mitigation plan	N/A
CC-4 (new)	Mid creek channel centreline shifts south, into the waste rock dump	>5 m from previous monitoring period	Develop localized mitigation plan	N/A

4.2.9 Conclusions and Recommendations

Conclusions

The highest overall risk rating estimated for the Clinton Creek channel was 'Moderately High'. This rating was assigned to a major blockage of the channel applied to the environmental, legal obligations, and consequence cost scenario.

Based on the observations made at the Site, the results of the 2014 survey, and this assessment, the triggers provided in the 2005 LTMP report (R22, UMA 2006b) remain valid and the appropriate action has been taken (i.e., begin planning for site wide remediation).

Recommendations

The recommendations relevant to the Clinton Creek channel are summarized in Table O.

Table O Clinton Creek Channel Recommendations

ID	Description	Implementation	Validity
CC-A (R51)	Environmental assessment to determine impacts of stabilization measures at Clinton Creek channel	Not completed	Valid - should be completed prior to site-wide remediation
CC-B (R51)	Inspect and survey the Clinton Creek channel on an annual basis (R104)	Inspection and survey completed in 2014	Valid - practice should continue
CC-C (R104)	Survey of cross-sections A-E along Clinton Creek should be completed on a biennial basis	Survey completed in 2014	Valid - practice should continue
CC-D (R104)	Install additional monitoring pins adjacent to where Clinton Creek has relocated closer to the waste rock area	Not completed	Valid - refer to recommendation CC-G below
CC-E (R104)	Complete geotechnical investigation of Clinton Creek waste rock dump	Not completed	Valid - should be completed prior to site wide remediation
CC-F (new)	Survey of Cross-Section F along Clinton Creek should be completed on a biennial basis	Should be completed in subsequent LTMPs	Survey required to compare cross-section to previous years and identify geomorphological / topographical changes
CC-G (new)	AAM should consider installing monitoring pins along south slope of Clinton Creek near Stations 0+700, 0+800, and 0+900	Should be implemented as part of 2016 LTMP survey	Will provide additional movement monitoring pins at critical locations along waste rock toe

4.3 Hudgeon Lake Outlet

The Hudgeon Lake Outlet is located at the upper end of the Clinton Creek channel and controls and conveys discharge from Hudgeon Lake. The outlet consists of two metal abutments (complete with riprap armouring) located on the north and south sides of the Clinton Creek channel. Starting in 2015, a PVC boom will be attached to the abutments during the summer to intercept and retain debris.

The failure mode assessed for the Hudgeon Lake outlet included the following:

- Damage to the outlet - damage to one or several of the outlet components (e.g., channel material, embankments, boom, and abutments) causing the erosion of waste rock, loss of discharge control (i.e. rapid release of a portion of Hudgeon Lake), and debris entering the channel;
- Unauthorized access - access to the lake by an unauthorized user could result in accidental drowning; and
- Complete failure - the complete failure of the Hudgeon Lake outlet, resulting in the rapid draw down of the lake and generation of a large flood flow, was previously assessed (WorleyParsons 2014a) and is not discussed in this report.

4.3.1 Current Condition

During the site visit, the Hudgeon Lake outlet appeared to be in stable condition; however, the PVC boom had not yet been installed.

Changes to the Hudgeon Lake outlet were difficult to ascertain as previous monitoring programs did not report extensively on the condition of the outlet, and the boom abutments were installed following the completion of the previous survey program in 2012. Results of the 2014 survey indicate that there may be insufficient freeboard between the top of the abutment rock armouring and the extreme water surface elevation caused by the 2010 outlet blockage.

Based on the observations made during the site visit and the results of the survey, the Hudgeon Lake outlet was considered stable and should be capable of conveying normal and seasonal high flows; however, due to a lack of freeboard at the abutment armouring, it is possible that the boom abutments could be damaged or destabilized due to the conveyance of extreme flows through the outlet.

4.3.2 Failure Mechanisms

Failure of the Hudgeon Lake outlet components could be triggered by the failure mechanisms presented in the following section.

Elevated Lake Level

A blockage at the Hudgeon Lake outlet (potentially caused by a land slide on the slopes above Hudgeon Lake) or periods of extreme discharge, generated by freshet or intense precipitation, would result in elevated water levels. If the water level rose sufficiently, discharge could flow around the boom abutments, scouring the unarmoured portions of the channel bank. This scouring could destabilize the boom abutments or alter the channel section.

Destabilization of Boom Abutments

Frost heave, scouring at the abutments, large debris impacting or resting on the boom, or accelerated waste rock movement could result in the destabilization of the boom abutments. This could potentially impact the performance of the boom and the channel armouring.

Failure of the Boom

Debris impacts could damage the boom such that it becomes disconnected from the boom abutments and is conveyed downstream through the channel. This could potentially impact the performance of downstream channel infrastructure (e.g., drop structures) and could endanger people located in or near the channel.

Unauthorized Access

Recreational users accessing the lake for swimming could be at risk of drowning.

4.3.3 Damage to the Outlet

Likelihood Classification

The likelihood of a failure involving damage to the Hudgeon Lake outlet components was classified as ‘Possible’ given that failures of this nature have occurred at similar sites.

Consequence Classifications

The scenarios associated with damage to the Hudgeon Lake outlet are summarized in Appendix 2 and Table P.

Table P Consequence Classifications - Damage to Hudgeon Lake Outlet

Category	Classification	Descriptor
Environmental Impact	Very Low	No environmental impact
Legal Obligations	Very Low	No action taken by regulatory agency
Consequence Costs	Very Low	Less than $100,000
Human Health and Safety	Minor	Objective but reversible disability / impairment and/or injuries requiring hospitalization

Environmental Impact

The damage to the Hudgeon Lake outlet components could expose a portion of the waste rock and granular materials in the channel to erosion. These materials could be mobilized and deposited downstream; however, this would not likely result in the degradation of downstream aquatic habitat as the concentrations of sediment would likely be relatively low.

This scenario was assigned a 'Very Low' consequence classification.

Legal Obligations

As the erosion at the Hudgeon Lake outlet described above would not likely present a risk to the environment, it is unlikely that any action would be taken by regulatory agencies.

This scenario was assigned a 'Very Low' consequence classification.

Consequence Costs

Minor repairs would likely be required to address the damage to the Hudgeon Lake outlet. This could include the replacement of armouring, re-grading the channel, stabilization of the boom abutments, or repair to the boom. It is anticipated that the associated costs could be as high as $100,000.

This scenario was assigned a 'Very Low' consequence classification.

Human Health and Safety

Objective but reversible disability / impairment and/or injuries requiring hospitalization could occur as a result of damage to the Hudgeon Lake outlet if an unauthorized recreational user or worker were located on the north side of Clinton Creek and the crossing at Hudgeon Lake becomes impassable. Injuries sustained could be the result of exposure to the elements or a failed attempt to use the crossing. The probability that a person would be located north of Clinton Creek at the time of failure was considered to be low.

This scenario was assigned a 'Minor' consequence classification. The likelihood of this scenario was considered to be 'Unlikely'.

Risk Statement

The failure of components of the Hudgeon Lake outlet is summarized in the following risk event statement:

"Elevated water levels or destabilization of the boom abutments causes the failure of components of the Hudgeon Lake outlet which would likely have no environmental impact or action taken by a regulatory agency but could result in repair costs as high as $100,000, damage downstream channel infrastructure (as a result of the release and subsequent mobilisation of the boom), and/or minor injuries".

4.3.4 Unauthorized Access

Likelihood Classification

The likelihood of a drowning incident at Hudgeon Lake was classified as 'Unlikely' given that access to the Site is limited by security measures and the Site is isolated.

Consequence Classifications

The scenarios associated with damage to the Hudgeon Lake outlet are summarized in Appendix 2 and Table Q.

Table Q Consequence Classifications - Unauthorized Access

Category	Classification	Descriptor
Environmental Impact	Very Low	No environmental impact
Legal Obligations	Very Low	No action taken by regulatory agency
Consequence Costs	Very Low	Less than $100,000
Human Health and Safety	Major	Single Fatality

Environmental Impact

Unauthorized access to Hudgeon Lake would have no impact on the environment.

This scenario was assigned a 'Very Low' consequence classification.

Legal Obligations

Due to the lack of environmental impact, it is unlikely that action will be taken by a regulatory agency; however, it is possible that legal action could be taken by those harmed by the drowning.

This scenario was assigned a 'Very Low' consequence classification.

Consequence Costs

There would likely be no capital costs associated with a drowning at Hudgeon Lake.

This scenario was assigned a 'Very Low' consequence classification.

Human Health and Safety

A single fatality or severe, irreversible disability / impairment and/or injuries requiring hospitalization due to drowning could occur as a result of unauthorized access to Hudgeon Lake.

This scenario was assigned a 'Major' consequence classification.

Risk Statement

Unauthorized access to Hudgeon Lake is summarized in the following risk event statement:

"Unauthorized access to Hudgeon Lake would likely not result in an impact to the environment or action taken by regulatory agencies but could result in legal action and/or a single fatality or serious injury due to drowning."

4.3.5 Overall Risk Rating

The consequence and likelihood classifications presented in the preceding sections were used to assign the qualitative risk ratings summarized in Table R. A complete list of these ratings can be found in Appendix 2.

Table R Risk Ratings for Hudgeon Lake Outlet

Consequence Category	Damage to Outlet Components	Unauthorized Access
Environmental	Low	Low
Legal Obligations	Low	Low
Consequence Costs	Low	Low
Human Health and Safety	Low	Moderately High

4.3.6 Preventative Measures

The following preventative measures are in place to reduce the likelihood of damage to the Hudgeon Lake outlet:

- Bi-annual inspection and topographic survey of the Hudgeon Lake outlet (by consultant);
- Monthly inspection during the summer (by AAM staff);
- Security measures that limit access to the site (e.g., locked security gate at site entrance, warning signs) to discourage access by unauthorized recreational users; and

- Safety measures to prohibit workers and staff from accessing the channel, including the crossing, during periods of high flow without a detailed safety plan approved by AAM.

The following recommended preventative measure should be implemented to reduce the likelihood of damage to the Hudgeon Lake outlet:

- Engage consultant to inspect the boom structure (including boom, abutments, and rock armouring) annually, prior to boom installation following freshet;
- Engage consultant to inspect the boom structure when damage is identified during AAM inspections;
- Install and remotely monitor a water level gauge at the Hudgeon Lake outlet to notify AAM of high water levels that may indicate a blockage;
- Install a camera capable of remotely transmitting photos of the Hudgeon Lake outlet once per hour;
- Develop a protocol to define water depths in Hudgeon Lake above which AAM staff are sent to site to investigate and determine if the channel is blocked and, if so, the urgency with which the blockage should be removed based on its severity; and
- Extend the rock armouring around the boom abutments from approximately 412.5 m to a minimum elevation of 413.14 masl, to provide 600 mm of freeboard from the estimated extreme water surface elevation (WSEL) observed following the 2010 extreme flow event (estimated WSEL of 412.54 masl) .

4.3.7 Triggers

No triggers were established for the Hudgeon Lake outlet in previous reports; however, new triggers are presented in Table S.

Table S New Hudgeon Lake Triggers

ID	Description	Value	Action
HL-1 (new)	Lake water surface critical elevation	412.0 masl[1]	Mobilize to site to check outlet for blockage, remove blockage if present, and inspect downstream infrastructure (e.g., drop structures and channel). Refer to recommendation HL-A
HL-2 (new)	Movement of boom abutment structures from previous monitoring period	Horizontal: 0.30 m less reported average horizontal accuracy of abutment shots, and/or Vertical: 0.10 m less reported vertical accuracy of abutment shots[2]	Investigate base structure and develop mitigation plan as required

ID	Description	Value	Action
HL-3 (new)	Loss of rock armouring at the boom abutment structures from previous monitoring period	10% surface area from previous monitoring period[3]	Review riprap diameter and extents and develop mitigation plan as required

[1]Critical water surface elevation selected based on reported water level during 2014 LTMP survey of 411.643 masl and water surface elevation corresponding to 2010 blockage of 412.54 masl.

[2]Horizontal and vertical precision of survey should not be greater than ±5 cm.

[3]Taking into consideration changes to water level and the resulting exposure of the rock.

4.3.8 Conclusions and Recommendations

Conclusions

The highest overall risk rating estimated for the Hudgeon Lake outlet was Low. This rating was assigned to all consequence scenarios.

Recommendations

The recommendations relevant to the Hudgeon Lake outlet are summarized in Table T.

Table T Hudgeon Lake Recommendations

ID	Description	Implementation	Validity
HL-A (R104)	Monitor outlet for debris accumulations and damage to boom (annually and following major rainfall or flood event)	Ongoing	Valid - practice should continue
HL-B (R104)	Consider installation of automated remote water level monitor to notify AAM when lake water level rises indicating possible blockage of outlet	Not implemented	Valid - should be implemented in 2015
HL-C (R104)	Complete additional topographic survey to confirm freeboard	Completed in 2014	Completed
HL-D (new)	Inspect abutments (including condition of rock armouring) monthly during summer by AAM staff and annually by a consultant (preferably following freshet)	Should be implemented in 2015	Required to monitor condition of abutments and rock armouring
HL-E (new)	Assess abutment rock protection (including rock gradation, durability, specific weight, and hardness, as well as a scour analysis) if signs of deterioration of the rock armouring are noted	To be implemented as required	May be required to address rock armouring issues
HL-F (R104)	Review feasibility of reducing Hudgeon Lake water levels and removing the gabion drop structures	Completed by WorleyParsons in 2014	Completed

ID	Description	Implementation	Validity
HL-G (R104)	Conduct a geotechnical investigation / assessment and an environmental assessment to estimate impacts of stabilization measures	Not completed	Valid - assessments should be completed prior to site-wide remediation
HL-H (R05)	Remove former water intake at Hudgeon Lake	Completed based on site observations	Completed

4.4 Clinton Creek Site Access Road

The Clinton Creek site access road connects the site to the Top of the World highway via the village of Forty Mile. It traverses the site, linking the various site components, including the former mill site, and crosses Clinton Creek at two locations. A portion of the access road adjacent to the Clinton Creek channel and extending from Station 0+340 to Station 0+410 was closed due to the presence of extensive tension cracks and slope failures. A vehicle gate is located on the access road, near the confluence of Clinton Creek and Wolverine Creek; however, during the site visit it was observed that the lock and chain had been tampered with, preventing the gate from being secured.

The following failure modes were assessed for the Clinton Creek site access road:

- Slope failure at closed portion of access road - ongoing destabilization of the channel embankment adjacent to the closed portion of the access road results in an extended slope failure with a significant volume of material coming to rest in the channel;
- Minor Damage - damage to the road surface reduces traction, limiting site accessibility during wet weather;
- Major damage - damage to the road surface make the road impassable and the site, or portions thereof, inaccessible; and
- Clinton Creek road crossings become inaccessible - elevated water levels, high flow velocities, or downcutting due to erosion in the creek make the road crossing inaccessible.

4.4.1 Current Condition

During the site visit, the Clinton Creek site access road appeared to be in good condition, with the exception of the closed portion of the site access road. The access road from the village of Forty Mile up to the former mill site, including the Clinton Creek crossings, appeared to be passable. Some minor rill erosion damage (i.e., surface gravels partially washed out over a length of road <5 m) was observed periodically along the route.

Only the closed portion of the access road was surveyed in 2014. Results from this survey were compared to results from the 2012 survey program to estimate changes to the top of bank, tension cracks, and a baseline established in 2012 which is comprised of metal survey markers.

The results indicate that the baseline has shifted north by an average of 1.6 cm/y while the embankment edge has been cut back by an average of 0.47 cm/y. Additional tension cracks were identified based on a visual comparison of the results; however, these additional cracks could not be quantified due to the survey methodology used to record their location.

Based on the observations made during the site visit and the results of the survey, the Clinton Creek site access road was considered to be stable and capable of maintaining site access by authorized workers. Damage to the gate observed during the site visit indicates that the site is being accessed by unauthorized users.

4.4.2 Failure Mechanisms

Failure of the Clinton Creek site access road components could be triggered by the failure mechanisms presented in the following sections.

Extreme Flow

The conveyance of an extreme flow through the Clinton Creek channel could further destabilize the toe of the south channel embankment causing a slope failure. Any sections of the Clinton Creek access road located at or near the top of the embankment could be impacted (e.g., formation of tension cracks) or destroyed.

The conveyance of an extreme flow would also impact the accessibility of the Clinton Creek road crossings due to elevated water levels and increased flow velocities. These conditions have been observed by AAM staff during site investigations and have prevented staff from accessing the site.

Accelerated Slope Movement

Accelerated slope movement could cause buckling, differential settlement / displacement, barriers to access as a result of mobilized waste rock, and the formation of cracks on the waste rock dump surface. These issues could result in a loss of drivability of the access road.

Slope Failure Adjacent to Site Access Road

A portion of the site access road is located near the top of the Clinton Creek channel embankment. Slope failures of this embankment, adjacent to the site access road could damage the road shoulder.

Wet Weather Conditions

Sheet flow and concentrated rill flows would likely develop during periods of precipitation or snow melt. These flows can cause erosion and wash out of road gravels during extreme conditions, resulting in loss of traction and reduced drivability of the site access road.

Wet weather conditions would cause the saturation and destabilization of slope material, potentially resulting in a slope failure.

Using the access road during wet weather conditions could exacerbate damage to the road surface as poor traction could result in the rapid rotation of vehicle tires causing the dispersal of road gravels.

Isolated Landslides

The site access road is generally aligned on or at the bottom of sloping terrain, particularly between the village of Forty Mile and the site access gate. Isolated landslides could occur on the slopes above the site access road with material coming to rest across the road, creating a barrier to access.

Downstream Channel Obstruction

A channel obstruction downstream of one of the Clinton Creek road crossings could result in elevated water levels at the road crossings, making vehicle passage unsafe and making the site inaccessible.

4.4.3 Slope Failure at Closed Portion of Site Access Road

A slope failure of the Clinton Creek channel embankment (potentially triggered by extreme flow in the channel, accelerated slope movement of the waste rock dump, or weather conditions) could result in the loss of a portion of the site access road. Though this could occur on any portion of the site access road located adjacent to the channel, a slope failure adjacent to the closed portion of the site access road was considered to be the most likely scenario. It was selected as the worst case scenario associated with the failure of a portion of the site access road associated with a channel embankment failure.

Likelihood Classification

The likelihood of a slope failure at the closed portion of the site access road was classified as 'Likely' given the unstable slope conditions observed during the site visit and quantified by the survey results.

Consequence Classifications

The scenarios associated with a slope failure at the closed portion of the site access road are summarized in Appendix 2 and Table U.

Table U Consequence Classifications - Slope Failure at Closed Portion of Site Access Road

Category	Classification	Descriptor
Environmental Impact	Minor	Acute degradation of local aquatic habitat
Legal Obligations	Minor	Warning letter issued by EC for release of deleterious material causing degradation of aquatic habitat
Consequence Costs	Minor	Between $100,000 and $500,000
Human Health and Safety	Major	Single fatality or severe, irreversible disability / impairment

Environmental Impact

A slope failure at the closed portion of the site access road could result in a significant volume of waste rock and other granular materials entering the channel. The mobilization and deposition of these materials could cause an acute degradation of downstream aquatic habitat due to infilling of runs and pools impacting fish passage as well the loss of gravels and cobbles available for spawning and shelter along the creek channel. It is anticipated that the extent of the degradation would be localized and that the habitat would recover following the removal of the material from the channel.

This scenario was assigned a 'Minor' consequence classification.

Legal Obligations

The slope failure could result in the degradation of downstream aquatic habitat as described above due to the deposition of waste rock and granular materials. These substances would be considered to be "deleterious substances" per the Act, as previously stated. Due to the limited scale of the deposition and anticipated impact on aquatic habitat, it is likely that EC may issue a warning letter rather than an order or direction.

This scenario was assigned a 'Minor' consequence classification.

Consequence Costs

The waste rock and granular material that entered the channel would require removal, if it has not been mobilized by the creek, and stabilization of the channel embankment and channel reconstruction could be required. Reconstruction or stabilization of the portion of the site access road, relocated upslope following the closure of this portion of the site access road, could also be required. Costs associated with this work could be as high as $500,000 depending on the extent of the damage to the embankment.

This scenario was assigned a 'Minor' consequence classification.

Human Health and Safety

A single fatality or severe, irreversible disability / impairment and/or injuries requiring hospitalization could occur as a result of the slope failure if an unauthorized recreational user or worker were in the vicinity (i.e., within approximately 50 m) of the closed portion of the site access road at the time of failure. If located at the bottom of the embankment, the person could be struck by or buried beneath waste rock material. If located at the top of the embankment, the mobilized material could cause a loss of footing, resulting in the person falling down the embankment.

As signage has been installed notifying of the closure and due to the obvious unstable slope conditions, it is very unlikely that anybody would be near the slope at the time of failure.

This scenario was assigned a 'Major' consequence classification. The likelihood of this scenario was considered to be 'Very Unlikely'.

Risk Statement

A slope failure at the closed portion of the site access road is summarized in the following risk event statement:

"Extreme flow in the Clinton Creek channel or accelerated slope movement of the waste rock dump causes a significant slope failure along the closed portion of the Clinton Creek access road which could result in the minor degradation of local aquatic habitat, issuance of a warning letter by EC, damage to or destabilization of a portion of the site access road located upslope of the closed portion, repair costs as high as $500,000, and/or a single fatality or serious injury".

4.4.4 Minor Damage

Minor damage to the road surface, sufficient to impact the drivability of the site access road, could be triggered by a slope failure adjacent to the road, accelerated slope movement of the waste rock dump, or wet weather conditions.

Likelihood Classification

The likelihood of minor damage to the site access road surface was classified as 'Likely' given the rill erosion observed during the site visit.

Consequence Classifications

The scenarios associated with minor damage to the Clinton Creek site access road are summarized in Appendix 2 and Table V.

Table V Consequence Classifications - Minor Damage to Clinton Creek Site Access Road

Category	Classification	Descriptor
Environmental Impact	Very Low	No environmental impact
Legal Obligations	Very Low	Informal advice from a regulatory agency (e.g., EC)
Consequence Costs	Very Low	Less than $100,000
Human Health and Safety	Very Low	Low-level short term subjective symptoms with no measureable physical effect and no medical treatment required

Environmental Impact

Minor damage to the site access road surface, by itself, would have no impact on the environment.

This scenario was assigned a 'Very Low' consequence classification.

Legal Obligations

As minor damage to the site access road would not likely present a risk to the environment, it is unlikely that any action would be taken by regulatory agencies.

This scenario was assigned a 'Very Low' consequence classification.

Consequence Costs

Minor damage to the site access road could likely be addressed through minor repairs, including placement of new or additional surface gravel, re-grading, or improvements to roadside drainage infrastructure. It is anticipated that the associated repair costs could be as high as $100,000.

This scenario was assigned a 'Very Low' consequence classification.

Human Health and Safety

It is not anticipated that minor damage to the site access road would result in any injuries.

This scenario was assigned a 'Very Low' consequence classification.

Risk Statement

Minor damage to the site access road is summarized in the following risk event statement:

"Slope failures adjacent to the road, accelerated slope movement of the waste rock dump, or wet weather conditions cause minor damage to the site access road, impacting the drivability of the road, which would likely not cause any environmental impact, action taken by regulatory agencies, or injuries and could result in repair costs as high as $100,000."

4.4.5 Major Damage

Major damage to the road surface, sufficient to make the site access road impassable, could be triggered by a slope failure adjacent to the road, accelerated slope movement of the waste rock dump, wet weather conditions, or landslides.

Likelihood Classification

The likelihood of major damage to the site access road surface was classified as 'Possible' given current site conditions and closure of a portion of the site access road.

Consequence Classifications

The scenarios associated with major damage to the Clinton Creek site access road are summarized in Appendix 2 and Table W.

Table W Consequence Classifications - Major Damage to Clinton Creek Site Access Road

Category	Classification	Descriptor
Environmental Impact	Very Low	No environmental impact
Legal Obligations	Very Low	Informal advice from a regulatory agency (e.g., EC)
Consequence Costs	Minor	Between $100,000 and $500,000
Human Health and Safety	Minor	Objective but reversible disability / impairment and/or injuries requiring hospitalization

Environmental Impact

Major damage to the site access road surface, by itself, would have no impact on the environment.

This scenario was assigned a 'Very Low' consequence classification.

Legal Obligations

As major damage to the site access road would not likely present a risk to the environment, it is unlikely that any action would be taken by regulatory agencies.

This scenario was assigned a 'Very Low' consequence classification.

Consequence Costs

Major damage to the site access road would likely require repairs or removal of material blocking the access road. Costs associated with this work could be as high as $500,000 depending on the extent of the damage access road.

This scenario was assigned a 'Minor' consequence classification.

Human Health and Safety

Objective but reversible disability / impairment and/or injuries requiring hospitalization could occur as a result of major damage to the site access road if an unauthorized recreational user or worker were stranded at the site due to the impassability of the site access road. Injuries sustained could be the result of exposure to the elements or an accident cause by trying to drive around or over the damaged section of road. Injuries could also be sustained due to mobilized waste rock striking a person while on foot or by vehicle. The likelihood that a person would be located at the site at the time of failure was considered to be low.

This scenario was assigned a 'Minor' consequence classification. The likelihood of this scenario was considered to be 'Unlikely'.

Risk Statement

Major damage to the Clinton Creek site access road is summarized in the following risk event statement:

"Slope failures adjacent to the road, accelerated slope movement of the waste rock dump, wet weather conditions, or landslides cause major damage to the site access road, making the road impassable and the site inaccessible, which would likely not cause any environmental impact or action taken by regulatory agencies and could result in minor injuries and repair costs as high as $500,000."

4.4.6 Clinton Creek Road Crossings

Flow conditions at the Clinton Creek site access road crossings that make the site inaccessible could be triggered by extreme flow conditions or channel obstruction downstream of the crossing.

Likelihood Classification

The likelihood of the Clinton Creek site access road crossings being inaccessible was classified as 'Likely' given the observations made by AAM staff.

Consequence Classifications

The scenarios associated with the Clinton Creek site access road crossings being inaccessible are summarized in Appendix 2 and Table X.

Table X Consequence Classifications - Clinton Creek Road Site Access Road Crossings

Category	Classification	Descriptor
Environmental Impact	Very Low	No environmental impact
Legal Obligations	Very Low	Informal advice from a regulatory agency (e.g., EC)
Consequence Costs	Very Low	Less than $100,000
Human Health and Safety	Minor	Objective but reversible disability / impairment and/or injuries requiring hospitalization

Environmental Impact

The inaccessibility of the Clinton Creek site access road crossing(s), by itself, would have no impact on the environment.

This scenario was assigned a 'Very Low' consequence classification.

Legal Obligations

As the inaccessibility of the Clinton Creek site access road crossings would not likely present a risk to the environment, it is unlikely that any action would be taken by regulatory agencies.

This scenario was assigned a 'Very Low' consequence classification.

Consequence Costs

As the inaccessibility of the Clinton Creek site access road crossings would most likely be temporary, repairs would not be required or would be minor (less than $100,000).

This scenario was assigned a 'Very Low' consequence classification.

Human Health and Safety

Objective but reversible disability / impairment and/or injuries requiring hospitalization could occur if an unauthorized recreational user or worker were stranded at the site due to the impassability of the Clinton Creek road crossing(s). Injuries sustained could be the result of exposure to the elements or an accident caused by trying to drive through the crossing during high flows or by trying to drive around or over the damaged section. The probability that a person would be located at the site at the time of failure was considered to be low.

This scenario was assigned a 'Minor' consequence classification. The likelihood of this scenario was considered to be 'Unlikely'.

Risk Statement

The inaccessibility of the Clinton Creek road crossing(s) is summarized in the following risk event statement:

"The conveyance of extreme flows in Clinton Creek or a downstream channel obstruction result in the elevated water levels and/or increased flow velocities making the Clinton Creek road crossings impassable which would likely not cause any environmental impact or action taken by regulatory agencies but could cause minor injuries and minor repair costs up to $100,000."

4.4.7 Overall Risk Rating

The consequence and likelihood classifications presented in the preceding sections were used to assign the qualitative risk ratings summarized in Table Y. A complete list of these ratings can be found in Appendix 2.

Table Y Risk Ratings for Clinton Creek Site Access Road

Consequence Category	Slope Failure at Closed Portion of Site Access Road	Minor Damage	Major Damage	Clinton Creek Site Access Road Crossings
Environmental	Moderate	Low	Low	Low
Legal Obligations	Moderate	Low	Low	Low
Consequence Costs	Moderate	Low	Moderate	Low
Human Health and Safety	Moderate	Low	Low	Low

4.4.8 Preventative Measures

The following preventative measures are in place to reduce the likelihood of a failure of the Clinton Creek site access road:

- Annual inspection of the closed portion of the site access road, including topographic survey, and inspection of the site access road every two years (by consultant);
- Monthly inspections during the summer (by AAM staff);
- Damaged areas are promptly repaired;
- Security measures that limit access to the site (e.g., locked security gate at site entrance, warning signs) to discourage access by unauthorized recreational users; and
- Barriers and signage installed at the closed portion of the site access road to prevent vehicular access and discourage access by foot.

The following recommended preventative measure could be implemented to reduce the likelihood of damage to the Clinton Creek site access road:

- Monitor the gate to determine if improvements made to the gate in 2014 have made it more tamper-resistant. If tampering persists, consider the installation of a tamper-resistant forestry gate at the site entrance, specifically a style of gate that does not leave chains or locks exposed, limiting the ability of unauthorized users from cutting or striking lock components; and
- Add a mark to the staff gauge located at Clinton Creek Ford Crossing No. 1 indicating the water level below which it is safe to cross (typically 0 mm to 450 mm above the ford invert).

4.4.9 Triggers

No triggers were established for the closed portion of the Clinton Creek site access road in previous reports; however, new triggers are presented in Table Z.

Table Z Clinton Creek Site Access Road (Closed Portion) Triggers

ID	Description	Value	Action
AR-1 (new)	Average horizontal movement of baseline from previous year	10 cm less the average reported accuracy of baseline shots[1]	Develop mitigation plan
AR-2 (new)	Loss of embankment based on offset from previous year	1.0 m	Develop mitigation plan
AR-3 (new)	Total length of observed tension cracks[2]	Increase by 20% from previous year	Develop mitigation plan
AR-4 (new)	Average number of cracks observed perpendicular to each baseline pins	Increase by 20% from previous year	Develop mitigation plan

[1]Horizontal precision of the baseline survey not to exceed ±5 cm.

[2]Trigger AR-3 requires the implementation of recommendation AR-D

4.4.10 Conclusions and Recommendations

Conclusions

The highest overall risk rating estimated for the Clinton Creek site access road was 'Moderate'. This rating was assigned to the slope failure at the closed portion of the site access road failure mode, applying to all consequence scenarios, and the major damage to the road surface failure mode, applying to the Consequence Cost consequence scenario.

Recommendations

The monitoring recommendations relevant to the Clinton Creek site access road are presented in Table AA. There are no new monitoring recommendations for the Clinton Creek site access road; however, AAM should consider the revision to recommendation AR-H.

Table AA Clinton Creek Site Access Road Recommendations

ID	Description	Implementation	Validity
AR-A (R51)	Monitor (i.e., inspect and survey) the tension cracks along the closed portion of the site access road on an annual basis	Inspection and survey data collection completed in 2014	Valid- practice should continue
AR-B (R104)	Install depth gauge at Clinton Creek ford	Completed based on visual observations	Completed
AR-C (new)	Extend the baseline to the north and south by 15 m	Should be implemented as part of 2015 Long-Term monitoring program (LTMP) survey	To improve monitoring of the embankment
AR-D (new)	Survey points recorded at the start, end, and changes in direction (greater than 30 deg.) of each tension crack	Should be implemented as part of 2015 LTMP survey	To facilitate measurement of the tension cracks
AR-E (new)	Add a mark to the staff gauge located at Clinton Creek Ford Crossing No. 1 indicating the water level below which it is safe to cross	Should be implemented in 2015	To facilitate safe passage of the crossing
AR-F (R104)	Improve stream crossing on the Wolverine Access Road to enable safe off-road vehicle access	Not implemented	Valid - implementation should be considered as part of site wide remediation
AR-G (R104)	Close the site access road adjacent to the upper portion of Clinton Creek with 1.5 m earth berm and erect signs to restrict foot traffic	Implemented; however, lock blocks and chain used at east end of road	Completed

ID	Description	Implementation	Validity
AR-H (R104)	Install slide hazard and no stopping signs and scale loose rock at Slide No. 3 along the wet active area of the site access road from Forty Mile Bridge to Wolverine Creek	Implemented based on discussion with AAM staff	Completed
AR-I (R104)	Flag shoulder failure locations along the Snowshoe and Porcupine Pit roads by erecting warning signs with “Hazard Warning - Unstable Shoulders. Keep Clear”	Implemented based on discussion with AAM staff	Completed
AR-J (R104)	Dislodge large boulder perched above the main site access road	Implemented based on discussion with AAM staff	Completed
AR-K (R104)	Complete a survey of the site access roads to determine current drainage patterns and re-grade the road to improve surface water management	Not completed	Valid - should be completed prior to site-wide remediation or if a drainage issue is identified that needs to be addressed

4.5 Clinton Creek Waste Rock Dump

The Clinton Creek waste rock dump is located south of the upper portion of the Clinton Creek channel and east of Hudgeon Lake. The waste rock is comprised of weak argillite material composed primarily of sand and gravel sized rock fragments with some cobbles and boulders. The results of a stability analysis completed in 2002 indicate that the ongoing waste rock movement is the result of a very weak foundation layer and the thawing of permafrost underneath the waste rock (R47, UMA 2002).

The following failure modes were assessed for the Clinton Creek waste rock dump:

- Encroachment - encroachment into the Clinton Creek channel resulting from ongoing slope movement of the waste rock; and
- Sudden failure - abrupt failure (i.e., mass wasting) of the waste rock slope with material coming to rest such that it blocks the Clinton Creek channel.

4.5.1 Current Condition

During the site visit, no significant tension cracking was observed through the waste rock dump.

The 2014 survey included recording the coordinates of 54 monitoring pins distributed throughout the waste rock dump in upper, mid, and lower zones. The following average movement rates were calculated based on the 2014 and 2012 survey results:

- Upper slope - 3.31 cm/y

- Mid slope - 3.24 cm/y
- Lower slope - 2.51 cm/y

The movement rates provided above were less than the movement rates calculated based on the 2010 (September) and 2012 survey results, except through the upper slope. Movement rates calculated for the upper slope may have been skewed by the addition of four monitoring points installed through the upper slope in 2012 (WorleyParsons 2014b). Previous reports (R09, UMA 2006a) have indicated that the waste rock dump exhibits the characteristics of a creep failure with accelerating movement rates serving as a predictor for potentially imminent large waste rock movements.

Based on observations made during the site visit and the results of the 2014 survey the waste rock dump was considered to be relatively stable with decelerating movement rates.

4.5.2 Failure Mechanisms

Failure of the waste rock dump could be triggered by the failure mechanisms presented in the following sections.

Ongoing Slope Movement

As indicated above, the lower slope of the waste rock dump is moving north, towards Clinton Creek, at an average rate of 2.51 cm/y. While the Clinton Creek channel is also shifting north, it is likely that the channel embankment, primarily consisting of waste rock, is being scoured at its toe with granular material being mobilized and deposited downstream.

Frost Heave and Erosion

Frost heave and erosion can mobilize waste rock, potentially resulting in a rockfall down the waste rock slope posing a risk to unauthorized users and workers at the site.

Saturation of Waste Rock

The saturation of the waste rock dump can exacerbate the ongoing creep slope. As the waste rock dump is composed almost entirely of coarse graded materials with no vegetative cover, a significant portion of rainfall is infiltrating into the waste rock rather than being conveyed along the surface as runoff. During extended periods of intense precipitation or as a result of snow melt, the waste rock could become fully saturated, potentially accelerating slope movement.

Saturation of the waste rock toe can destabilize the slope by decreasing the resisting force acting against the movement of the waste rock dump. As the waste rock toe is located adjacent to Clinton Creek, this may occur during extreme flow events.

Failure of Other Site Components

Failure of other site components (e.g., the drop structures or the Clinton Creek channel) could impact the stability of the waste rock dump by contributing to the destabilization of the waste rock toe. For example, if one of the drop structures failed, the underlying waste rock would be exposed and could be scoured significantly reducing the resisting force acting to restrain the movement of the waste rock dump.

Seismic Event

Earthquakes can trigger slope failures, particularly if the slope is unstable or contains variations in its near-surface geotechnical parameters. As the waste rock dump satisfies both these conditions, it is likely that a significant earthquake could result in accelerated slope movement or a slope failure.

Change to Surface Loading

Changes to surface loading patterns including ice / snow build up or construction activity, could contribute to the destabilization of the waste rock dump due to additional forces acting on the waste rock slope.

4.5.3 Encroachment

The ongoing encroachment of waste rock material into the Clinton Creek channel could be triggered by saturation of the waste rock toe, frost heave, erosion, saturation of the waste rock toe, failure of other site components, a seismic event, changes to surface loading, and/or ongoing slope movement.

Likelihood Classification

The likelihood of the encroachment failure was classified as ‘Almost Certain’ given that it is ongoing.

Consequence Classifications

The scenarios associated with ongoing encroachment into Clinton Creek are summarized in Appendix 2 and Table BB.

Table BB Consequence Classifications - Ongoing Encroachment into Clinton Creek

Category	Classification	Descriptor
Environmental Impact	Very Low	No environmental impact
Legal Obligations	Very Low	Informal advice from a regulatory agency (e.g., EC)
Consequence Costs	Moderate	Between $500,000 and $2.5 million
Human Health and Safety	Very Low	Low-level short term subjective symptoms with no measureable physical effect and no medical treatment required

Environmental Impact

It was assumed that the ongoing encroachment of waste rock into the Clinton Creek channel is not having a significant environmental impact (i.e., concentrations of total suspended solids (TSS) are at background levels).

This scenario was assigned a 'Very Low' consequence classification.

Legal Obligations

As the ongoing encroachment does not likely present a risk to the environment, it is unlikely that any action would be taken by regulatory agencies.

This scenario was assigned a 'Very Low' consequence classification.

Consequence Costs

It was assumed that stabilization of the waste rock would not be required unless survey results indicate accelerating slope movement. Works to stabilize the waste rock dump could be extensive, between $500,000 and $2.5 million; however it was assumed that stabilization of the waste rock would not be required unless survey results indicate accelerating slope movement (not taking into account any planned site wide remediation works to stabilize the waste rock). As such, the likelihood of any stabilization works being implemented was considered to be relatively low.

This scenario was assigned a 'Moderate' consequence classification. The likelihood of this scenario was considered to be 'Very Unlikely'.

Human Health and Safety

It is not anticipated that the ongoing encroachment would result in any injuries. The likelihood that a person would be located at the site at the time of failure was considered to be relatively low.

This scenario was assigned a 'Very Low' consequence classification. The likelihood of this scenario was considered to be 'Unlikely'.

Risk Statement

Ongoing encroachment of waste rock into the Clinton Creek channel is summarized in the following risk event statement:

"Saturation of the waste rock, frost heave, erosion, saturation of the waste rock toe, failure of other site components, a seismic event, changes to surface loading, and/or ongoing slope movement cause ongoing encroachment of waste rock material into the Clinton Creek channel which is likely not causing any significant environmental impact and will not likely result in any action taken by regulatory agencies or injuries and, although very unlikely, could result in repair costs as high as $2.5 million."

4.5.4 Sudden Failure

The sudden failure of the waste rock dump could be triggered by saturation of the waste rock, failure of other site components (e.g., drop structures or Clinton Creek channel), a seismic event, or changes to surface loading patterns.

Likelihood Classification

The likelihood of a significant sudden failure of the waste rock slope (with waste rock material coming to rest blocking the Clinton Creek channel) was classified as 'Possible' given the site conditions and the occurrence of this type of slope failure at similar sites.

Consequence Classifications

The scenarios associated with a sudden failure of the waste rock dump are summarized in Appendix 2 and Table CC.

Table CC Consequence Classifications - Sudden Failure of Waste Rock Dump

Category	Classification	Descriptor
Environmental Impact	Moderate	Significant impact on valued ecosystem component
Legal Obligations	Moderate	Breach of regulations, permits, or approvals with an order or direction issued by a regulatory agency (e.g., EC)
Consequence Costs	Moderate	Between $500,000 and $2.5 million
Human Health and Safety - People on or below the waste rock dump	Major	Single fatality or serious injury
Human Health and Safety - People near the waste rock dump	Minor	Objective but reversible disability / impairment and/or injuries requiring hospitalization

Environmental Impact

The sudden failure of the waste rock dump would result in geomorphological changes to the channel as well as erosion and deposition downstream beyond the site boundaries.

This scenario was assigned a 'Moderate' consequence classification.

Legal Obligations

Due to the degradation of aquatic and terrestrial habitat described above, it is likely that the EC would issue an order or direction requiring the mitigation of the degraded habitat. It is also likely that Compliance, Monitoring and Inspection (EMR) Yukon could become involved if the concentration of constituents (e.g., metals and TSS) in water discharging from the site exceeded CCME guidelines.

This scenario was assigned a 'Moderate' consequence classification.

Consequence Costs

Mitigation of the failure of the waste rock dump could include the reconstruction of the channel, re-grading of the waste rock material, and the implementation of slope stabilization infrastructure. It is anticipated that if mitigation costs exceeded $2.5 million, the AAM and AANDC would consider accelerating the site-wide remediation schedule.

This scenario was assigned a 'Moderate' consequence classification.

Human Health and Safety

A single fatality or severe, irreversible disability / impairment and/or injuries requiring hospitalization could occur as a result of the sudden failure of the waste rock dump if an unauthorized recreational user or worker were on or below the waste rock slope at the time of failure. The person could be buried underneath the mobilized material or lose their footing, resulting in a fall down the slope.

This scenario was assigned a 'Major' consequence classification. The likelihood of this scenario was considered to be 'Unlikely'.

Objective but reversible disability / impairment and/or injuries requiring hospitalization could occur as a result of the sudden failure of one the waste rock dump if an unauthorized recreational user or worker were located near the waste rock slope at the time of failure. Injuries sustained could be the result of being struck by mobilized cobbles, ingesting sediment laden water, or a loss of stable footing.

This scenario was assigned a 'Minor' consequence classification. The likelihood of this scenario was considered to be 'Possible'.

Risk Statement

A sudden failure of the waste rock dump is summarized in the following risk event statement:

"Saturation of the waste rock, failure of other site components, a seismic event, or changes to surface loading patterns cause a sudden slope failure of the waste rock dump with material coming to rest blocking the Clinton Creek channel, which could result in a significant impact on terrestrial and aquatic habitat at the site, issuance of an order or direction by EC or Government of Yukon, reconstruction costs as high as $2.5 million, and/or serious injuries or a fatality."

4.5.5 Overall Risk Rating

The consequence and likelihood classifications presented in the preceding sections were used to assign the qualitative risk ratings summarized in Table DD. A complete list of these ratings can be found in Appendix 2.

Table DD Risk Ratings for Waste Rock Dump

Consequence Category	Ongoing Encroachment	Sudden Failure
Environmental	Low	Moderately High
Legal Obligations	Low	Moderately High
Consequence Costs	Low	Moderately High
Human Health and Safety - Person located on or below waste rock dump	Low	Moderately High
Human Health and Safety - Person located near the waste rock dump	N/A	Moderate

4.5.6 Preventative Measures

The following preventative measures are in place to reduce the likelihood of a failure of the waste rock dump:

- Bi-annual inspection of the waste rock dump, including survey of monitoring points (by consultant);
- Monthly inspections during the summer (by AAM staff);
- Security measures that limit access to the site (e.g., locked security gate at site entrance, warning signs) to discourage access by unauthorized recreational users.

Although other preventative measures could be implemented to reduce the likelihood of a failure of the waste rock dump (e.g., installation of a clay cap or re-grading of the waste rock toe), they were considered to be cost prohibitive and unnecessary given that the slope instability will be addressed during planned site-wide remediation activities.

4.5.7 Triggers

Triggers associated with the waste rock dump are presented in Table EE.

Table EE Waste Rock Dump Triggers

ID	Description	Value	Action	Status
WR-1 (new)	Average monitoring point horizontal movement rate - per slope section	Movement rate (cm/y) > than movement rate from previous monitoring cycle	If movement rate increase is between 0% and 30%, monitoring points should be surveyed the following year. If movement rate increase is 30% or greater or if movement rate has increased over two consecutive years, begin planning for a geotechnical assessment (including drilling and modelling) to determine whether stabilization is required	Potentially triggered for upper slope between 2012 and 2014 - to be confirmed with survey in 2015

[1]Refer to the 2014 LTMP report for discussion (WorleyParsons 2014b).

4.5.8 Conclusions and Recommendations

Conclusions

The highest overall risk rating estimated for the Clinton Creek waste dump was 'Moderately High'. This rating was assigned to the sudden failure of the waste rock slope and applies to all consequence scenarios.

Recommendations

The recommendations relevant to waste rock dump are summarized in Table FF.

Table FF Waste Rock Dump Recommendations

ID	Description (Reference Document)	Implementation	Validity
WR-A (R51)	Visual inspection of the waste rock dump should be completed on an annual basis with survey completed on a biennial basis	Inspection and survey completed in 2014	Valid - practice should continue
WR-B (R104)	Trigger level for waste rock monitors should be further investigated and implemented	Included in 2014 report	Completed
WR-C (new)	Survey upper slope monitoring points in 2015 and compare to 2014 data	Should be completed as part of 2015 LTMP survey	Required to determine if upper slope waste rock movement is accelerating
WR-D (R05)	Demolish crusher building including tram line tower and equipment. Landfill all asbestos fibres and structure materials	Completed (R09, UMA 2006)	Completed
WR-E (R05)	Demolish and landfill ANFO fertilizer storage tank and landfill tank, conveyors, and tank loading area	Completed (R09, UMA 2006)	Completed
WR-F (R05)	Decommission drill and shovel (i.e., recover fluids and filters)	Unknown	Valid

5. WOLVERINE CREEK COMPONENTS

5.1 Wolverine Creek Tailings Pile

The Wolverine Creek tailings pile is located west of the upper and mid portions of the Wolverine Creek channel and east of the former mill site. The tailings slope is comprised of silty sand reject from the former crushing operation and are coarser than traditional tailings. The results of a stability analysis completed in 2003 indicate that the mode of failure was a translational slide (resulting from a steep foundation slope and buildup of pore water pressure) with the failure plane located within the overburden and/or weathered argillite layers (R21, UMA 2003).

The following failure modes were assessed for the Wolverine Creek tailings pile:

- Encroachment - encroachment into the Wolverine Creek channel resulting from ongoing slope movement of the tailings;
- Sudden failure - abrupt failure (i.e., mass wasting) of the tailings slope with material coming to rest such that it blocks the Wolverine Creek channel; and
- Safety concerns - rock falls and the release of airborne and waterborne asbestos fibres.

5.1.1 Current Condition

During the site visit, large tension cracks were observed throughout the tailings pile.

The 2014 survey included recording the coordinates of 53 monitoring pins distributed throughout the north and south tailings lobes in upper, mid, and lower zones. The following average movement rates were calculated based on the 2014 and 2012 survey results:

- North lobe upper slope - 4.08 cm/y
- North lobe mid slope - 5.27 cm/y
- North lobe lower slope - 3.08 cm/y
- South lobe upper slope - 2.23 cm/y
- South lobe mid slope - 22.8 cm/y
- South lobe lower slope - 15.2 cm/y

The movement rates provided above, with the exception of the north lobe upper slope, were less than the movement rates calculated based on the 2010 (September) and 2012 survey results. Based on observations made during the site visit and the results of the 2014 survey the tailings was considered to be relatively stable with generally decelerating movement rates.

5.1.2 Failure Mechanisms

Failure of the tailings pile could be triggered by the following failure mechanisms presented in Section 4.5.2 in addition to the failure mechanisms presented below:

- Ongoing slope movement;
- Saturation of tailings;
- Failure of other site components (e.g., Wolverine Creek channel, Wolverine Creek tailings pile ponds);
- Seismic event; and/or
- Change to surface loading.

Wind and Construction Activity

Wind and construction activity damage the weather layer of the tailings pile, resulting in the release asbestos fibres from the tailings pile causing them to become airborne or waterborne. These fibres can pose a risk to unauthorized users and workers at the site, by way of inhalation, and potentially aquatic species downstream.

5.1.3 Encroachment

The ongoing encroachment of tailings material into the Wolverine Creek channel could be triggered by saturation of the tailings pile toe, frost heave, erosion, saturation of the waste rock toe, failure of other site components, a seismic event, changes to surface loading, wind / construction activity, and/or ongoing slope movement.

Likelihood Classification

The likelihood of the encroachment failure was classified as ‘Almost Certain’ given that it is ongoing.

Consequence Classifications

The scenarios associated with ongoing encroachment into Wolverine Creek are summarized in Appendix 2 and Table GG.

Table GG Consequence Classifications - Ongoing Encroachment into Wolverine Creek

Category	Classification	Descriptor
Environmental Impact	Very Low	No environmental impact
Legal Obligations	Very Low	Informal advice from a regulatory agency (e.g., EC)
Consequence Costs	Moderate	Between $500,000 and $2.5 million
Human Health and Safety	Very Low	Low-level short term subjective symptoms with no measureable physical effect and no medical treatment required

The consequence classifications associated with encroachment of tailings material into Wolverine Creek, presented above, are similar to those associated with encroachment of waste rock material into Clinton Creek. For more information related to these classifications, refer to Section 4.5.3.

Risk Statement

Ongoing encroachment of tailings into the Wolverine Creek channel is summarized in the following risk event statement:

"Saturation of the tailings pile, frost heave, erosion, saturation of the tailing, failure of other site components, a seismic event, changes to surface loading, wind / construction activity, and/or ongoing slope movement cause ongoing encroachment of tailings material into the Wolverine Creek channel which is likely not causing any significant environmental impact and will not likely result in any action taken by regulatory agencies or injuries and, although very unlikely, could result in repair costs as high as $2.5 million."

5.1.4 Sudden Failure

The sudden failure of the tailings pile could be triggered by saturation of the tailings, failure of other site components (e.g., Wolverine Creek channel, Wolverine Creek tailings pile ponds), a seismic event, or changes to surface loading patterns.

Likelihood Classification

The likelihood of a sudden failure was classified as 'Possible' given the site conditions and the occurrence of this type of slope failure at similar sites.

Consequence Classifications

The scenarios associated with a sudden failure of the tailings pile are summarized in Appendix 2 and Table HH.

Table HH Consequence Classifications - Sudden Failure of Tailings Pile

Category	Classification	Descriptor
Environmental Impact	Moderate	Significant impact on valued ecosystem component
Legal Obligations	Moderate	Breach of regulations, permits, or approvals with an order or direction issued by a regulatory agency (e.g., EC)
Consequence Costs	Moderate	Between $500,000 and $2.5 million
Human Health and Safety - Person on or below the tailings pile	Major	Single fatality or serious injury
Human Health and Safety - People near the tailings pile	Minor	Objective but reversible disability / impairment and/or injuries requiring hospitalization

The consequence classifications associated with the sudden failure of the tailings pile presented above, are similar to those associated with the sudden failure of the waste rock dump. For more information related to these classifications, refer to Section 4.5.4.

Risk Statement

A sudden failure of the tailings pile is summarized in the following risk event statement:

"Saturation of the tailings, failure of other site components (e.g., Wolverine Creek channel, Wolverine Creek tailings pile ponds, a seismic event, or changes to surface loading patterns cause a sudden slope failure of the tailings pile with material coming to rest blocking the Wolverine Creek channel, which could result in a significant impact on terrestrial and aquatic habitat at the site, issuance of an order or direction by EC or Government of Yukon, reconstruction costs as high as $2.5 million, and/or serious injuries or a fatality."

5.1.5 Safety Concerns

The sudden failure of the tailings pile could be triggered by ongoing slope movement, frost heave, erosion, wind, or construction activity.

Likelihood Classification

The likelihood of the ongoing safety concerns was classified as 'Likely' given the site conditions and composition of the tailings pile.

Consequence Classifications

The scenarios associated with safety concerns are summarized in Appendix 2 and Table II.

Table II Consequence Classifications - Safety Concerns

Category	Classification	Descriptor
Environmental Impact	Very Low	No environmental impact
Legal Obligations	Very Low	Informal advice from a regulatory agency (e.g., EC)
Consequence Costs	Very Low	No repairs or infrastructure required to address
Human Health and Safety - 'Moderate'	Moderate	'Moderate' irreversible disability or impairment to one or more people due to the inhalation of asbestos fibres
Human Health and Safety - 'Minor'	Minor	Objective but reversible disability / impairment and/or injuries requiring hospitalization due to being struck by rockfall

Environmental Impact

Per a risk assessment completed for airborne asbestos at the site (R09, UMA 2004), it is unlikely that the release of asbestos fibres from the tailings pile into the surrounding environment would substantially impact terrestrial and aquatic species.

This scenario was assigned a 'Very Low' consequence classification.

Legal Obligations

As the release of asbestos fibres is not expected to have any significant environmental impact, it is not anticipated that any action will be taken by regulatory agencies.

This scenario was assigned a 'Very Low' consequence classification.

Consequence Costs

It is not anticipated that any repairs or infrastructure will be required to address the tailings pile safety concerns as they do not pose a significant threat to public safety or stability of the tailings pile.

This scenario was assigned a 'Very Low' consequence classification.

Human Health and Safety

'Moderate' irreversible disability or impairment to one or more people could occur due to the inhalation of asbestos fibres or being struck by a rockfall (cobble sized or larger). Per the 2004 asbestos risk assessment report, a person would need to be on site eight hours a day, for three months a year, over a span of 10 years in order for the estimated cancer risk *de minimus* value for airborne asbestos established by Health Canada (incremental lifetime cancer risk <1 x 10-5) was exceeded (R09, UMA 2004). As activity at the site is infrequent, the likelihood that a person would be at the site with this regularity and over this duration is 'Very Low'.

This scenario was assigned a 'Moderate' consequence classification. The likelihood of this scenario was considered to be 'Very Unlikely'.

Objective but reversible disability / impairment and/or injuries requiring hospitalization could occur if an unauthorized recreational user or worker were located on or near the tailings pile and were struck by a rockfall (cobble sized or smaller).

This scenario was assigned a 'Minor' consequence classification. The likelihood of this scenario was considered to be 'Unlikely'.

Risk Statement

Safety concerns related to rockfalls and the release of asbestos fibres from the tailings pile is summarized in the following risk event statement:

"Ongoing slope movement, frost heave, erosion, wind, or construction activity cause a rockfall or the release of asbestos fibres, which would likely have no environment impact, or associated consequence costs, or result in any action taken by regulatory agencies and could result in minor and/or moderate injuries."

5.1.6 Overall Risk Rating

The consequence and likelihood classifications presented in the preceding sections were used to assign the qualitative risk ratings summarized in Table JJ. A complete list of these ratings can be found in Appendix 2.

Table JJ Risk Ratings for Tailings Pile

Consequence Category	Ongoing Encroachment	Sudden Failure	Safety Concerns
Environmental	Low	Moderately High	Low
Legal Obligations	Low	Moderately High	Low
Consequence Costs	Low	Moderately High	Low
Human Health and Safety - Person located on or below waste rock dump	Low	Moderately High	Low
Human Health and Safety - Person located near the waste rock dump	N/A	Moderate	Low

5.1.7 Preventative Measures

The following preventative measures are in place to reduce the likelihood of a failure of the tailings pile:

- Bi-annual inspection of the tailings pile, including survey of monitoring points (by consultant);
- Monthly inspections during the summer (by AAM staff);
- Security measures that limit access to the site (e.g., locked security gate at site entrance, warning signs) to discourage access by unauthorized recreational users.

Though other preventative measures could be implemented to reduce the likelihood of a failure of the tailings pile (e.g., installation of a clay cap or stabilization infrastructure at the toe), they were considered to be cost prohibitive and unnecessary given that the slope instability will be addressed during planned site-wide remediation activities.

5.1.8 Triggers

Triggers associated with the tailings pile are presented in Table KK.

Table KK Tailings Pile Triggers

ID	Description	Value	Action	Status
TP-1 (new)	Average monitoring point horizontal movement rate - per slope section	Movement rate (cm/y) > than movement rate from previous monitoring cycle	If movement rate increase is between 0 and 50%, monitoring points should be surveyed the following year. If movement rate increase is greater than 50% or if movement rate has increased over two consecutive years, begin planning for a geotechnical assessment (including drilling and modelling) to determine whether stabilization is required	The trigger level was exceeded for the north lobe, upper slope; however, the movement rate through this slope section (4.08 cm/y) was relatively small and the RPC (49%) was less than the trigger value. This slope section should be surveyed in 2015 to confirm the result

5.1.9 Conclusions and Recommendations

Conclusions

The highest overall risk rating estimated for the Wolverine Creek tailings pile was ‘Moderately High’. This rating was assigned to the sudden failure of the tailings slope and applies to all consequence scenarios.

Recommendations

The recommendations relevant to tailings pile are summarized in Table LL.

Table LL Tailings Pile Recommendations

ID	Description	Implementation	Validity
TP-A (R104)	Visual inspection and survey of the Wolverine Creek tailings pile should be completed on a biennial basis	Inspection and survey completed in 2014	Valid - practice should continue
TP-B (R104)	Complete geotechnical investigation and assessment of the north and south lobes of the Wolverine Creek tailings pile	Not completed	Valid - required to improve understanding of variance in average movement rates between north and south lobes
TP-C (new)	Visual inspection of the Wolverine Creek tailings pile should be completed on an annual basis	Should be completed as part of future LTMPs	Required to identify visible tension cracks and slumping to determine if further investigation is required in that year

ID	Description	Implementation	Validity
TP-D (new)	Survey of the Wolverine Creek tailings pile should be completed on a biennial basis	Should be completed as part of future LTMPs	Required to monitor movement rates through the tailings pile
TP-E (R05)	Assess stability of tailings pile movement	Completed	Completed
TP-F (R05)	Complete air monitoring program to determine levels of fugitive asbestos dust	Completed (R09, UMA 2006)	Completed
TP-G (R05)	Decommission mill components	Completed based on visual observations	Completed
TP-H (R05)	Remove timber deck and ladder from Tram Towers Nos. 1 to 12 and cover asbestos at base of tower as required	Completed based on discussion with AAM	Completed
TP-I (R05)	Demolish tram terminus structure	Partially completed with some towers still standing based on discussion with AAM	Valid - towers should be demolished as part of site-wide remediation

5.2 Wolverine Creek Channel

The Wolverine Creek channel collects and conveys discharge from the tailings pile, Wolverine ponds and the drainage catchment to the north. Rock weirs have been installed along the mid portion of the channel, over the tailings, to control flow velocities and reduce erosion. The channel flows from north to south to the confluence with Clinton Creek.

The following failure modes were assessed for the Wolverine Creek channel:

- Localized slope failure - an abrupt slope collapse along a section of the channel less than 10 m in length with material coming to rest at the bottom of the embankment;
- Minor channel blockage - embankment material or debris located across a portion of the channel, restricting or obstructing flow followed by the release and mobilization of the blockage material; and
- Major channel blockage - embankment material, debris, or beaver activity located across the entire channel (i.e., embankment toe to embankment toe), restricting or obstructing flow followed by the release and mobilization of the blockage material.

5.2.1 Current Condition

During the site visit, the lower and mid portion of the Wolverine Creek channel appeared to be in stable condition with no slope failures or damage to the rock weirs observed. The upper portion of the Wolverine Creek was not accessed in 2014; however, WorleyParsons conducted a site visit in 2013 during which it was observed that the west embankment of the upper portion of the Wolverine Creek channel, adjacent to the tailings, was oversteepened.

The results of the 2014 survey indicate that between 2012 and 2014, the upper channel (Stations 1+025 to 1+300) shifted west by an average of 0.25 m and was downcut by an average of 5.82 cm/y (a 220% increase over the downcutting recorded between 2003 and 2012). Over the same timeframe, the mid channel (Stations 0+655 to 1+025) shifted east by an average of 1.2 m and was downcut by an average of 20.1 cm/y. Between 2003 and 2014, the lower channel (Stations 0+000 to 0+655) shifted east by an average of 1.5 m over this timeframe and was downcut by an average of 1.17 cm/y.

Based on the observations made during the site visit and the results of the survey, the upper and mid portions of the Wolverine Creek channel were considered to be unstable due to the increasing rate of downcutting and the oversteepening of the tailings embankment (upper portion only). It is likely that downcutting and scour of the tailings embankment will persist potentially resulting in slope failures. The lower portion of the channel was considered to be stable.

5.2.2 Failure Mechanisms

Failure of the tailings pile could be triggered by the following failure mechanisms, presented in Section 4.2.2:

- Accelerated slope movement;
- Down-cutting of the channel;
- Extreme flow event; and/or
- Collection of debris, beaver activity, or large slope failure.

Failure of the Wolverine Creek channel could be triggered by the failure mechanisms presented in Section 4.2.2.

5.2.3 Localized Slope Failure

Localized slope failures could be triggered by accelerated slope movement of the waste rock, down-cutting of the channel bed, or the conveyance of an extreme flow.

Likelihood Classification

The likelihood of a localized slope failure was classified as ‘Likely’ based on the site conditions.

Consequence Scenarios

The scenarios associated with localized slope failure along the Wolverine Creek channel are summarized in Appendix 2 and Table MM.

Table MM Consequence Classifications - Localized Slope Failure along Wolverine Creek Channel

Category	Classification	Descriptor
Environmental Impact	Very Low	No environmental impact
Legal Obligations	Very Low	Informal advice from a regulatory agency (e.g., EC)
Consequence Costs	Minor	Between $100,000 and $500,000
Human Health and Safety	Minor	Objective but reversible disability / impairment and/or injuries requiring hospitalization

The consequence classifications associated with localized slope failures along the Wolverine Creek channel, presented above, are similar to those associated with localized slope failures along the Clinton Creek channel. For more information related to these classifications, refer to Section 4.2.3.

Risk Statement

A localized slope failure along the Wolverine Creek channel is summarized in the following risk event statement:

"Accelerated slope movement of the tailings pile, down-cutting of the channel, or the conveyance of an extreme flow causes a localized slope failure along the Wolverine Creek channel which would likely have no environmental impact and could result in the provision of informal advice from a regulatory agency, repair costs as high as $500,000 and/or minor injuries."

5.2.4 Minor Channel Blockage

A minor channel blockage could be triggered by accelerated slope movement of the waste rock, down-cutting of the channel bed, the conveyance of an extreme flow, collection of debris or beaver activity in the channel, or a large slope failure of the channel embankment. Likelihood Classification

The likelihood of a minor channel blockage was classified as 'Likely' given the site conditions and history of blockages across the Wolverine Creek channel.

Consequence Scenarios

The scenarios associated with a minor blockage of the Wolverine Creek Channel are summarized in Appendix 2 and Table NN.

Table NN Consequence Classifications - Minor Blockage of Wolverine Creek Channel

Category	Classification	Descriptor
Environmental Impact	Minor	Acute degradation of local aquatic habitat
Legal Obligations	Minor	Warning letter issued by EC for release of deleterious material causing degradation of aquatic habitat
Consequence Costs	Minor	Between $100,000 and $500,000
Human Health and Safety	Minor	Objective but reversible disability / impairment and/or injuries requiring hospitalization

The consequence classifications associated with a minor blockage of the Wolverine Creek channel, presented above, are similar to those associated with minor blockage of the Clinton Creek channel. For more information related to these classifications, refer to Section 4.2.4.

Risk Statement

A minor blockage of the Wolverine Creek channel is summarized in the following risk event statement:

"Accelerated slope movement of the tailings pile, down-cutting of the channel, the conveyance of an extreme flow, or the collection of debris; beaver activity; or an extended slope failure creates a minor blockage across a portion of the Wolverine Creek channel which could result in the minor degradation of local aquatic habitat, issuance of a warning letter by EC, repair costs as high as $500,000, and/or minor injuries."

5.2.5 Major Channel Blockage

A major channel blockage could be triggered by accelerated slope movement, down-cutting of the channel, an extreme flow event, collection of debris or beaver activity within the channel, and/or a large slope failure of the Wolverine Creek channel embankment.

Likelihood Classification

The likelihood of a major channel blockage was classified as 'Possible' given the site conditions and the history of blockages across the Wolverine Creek channel.

Consequence Scenarios

The scenarios associated with a major blockage of the Wolverine Creek Channel are summarized in Appendix 2 and Table OO.

Table OO Consequence Classifications - Major Blockage of Wolverine Creek Channel

Category	Classification	Descriptor
Environmental Impact	Moderate	Significant impact on valued ecosystem downstream
Legal Obligations	Moderate	Order or direction issued by EC or Compliance, Monitoring, and Inspection (Energy, Mines and Resources) Yukon
Consequence Costs	Moderate	Between $500,000 and $2.5 million
Human Health and Safety	Minor	Objective but reversible disability / impairment and/or injuries requiring hospitalization

The consequence classifications associated with a major blockage of the Wolverine Creek channel, presented above, are similar to those associated with major blockage of the Clinton Creek channel. For more information related to these classifications, refer to Section 4.2.5.

Risk Statement

A major blockage of the Wolverine Creek channel is summarized in the following risk event statement:

"Accelerated slope movement of the tailings pile, down-cutting of the channel, the conveyance of an extreme flow, or the collection of debris; beaver activity; or an extended slope failure creates a major blockage across Wolverine Creek channel which could result in the minor degradation of local aquatic habitat, issuance of a warning letter by EC, repair costs as high as $1.0 million, and/or minor injuries."

5.2.6 Overall Risk Rating

The consequence and likelihood classifications presented in the preceding sections were used to assign the qualitative risk ratings summarized in Table PP. A complete list of these ratings can be found in Appendix 2.

Table PP Risk Ratings for Wolverine Creek Channel

Consequence Category	Localized Slope Failure	Minor Channel Blockage	Major Channel Blockage
Environmental	Low	Moderate	Moderately High
Legal Obligations	Low	Moderate	Moderately High
Consequence Costs	Low	Moderate	Moderately High
Human Health and Safety	Low	Low	Low

5.2.7 Preventative Measures

The following preventative measures are in place to reduce the likelihood and/or severity of localized slope failures as well as major and minor blockages of the Wolverine Creek channel:

- Bi-annual inspection and topographic survey of the Wolverine Creek channel (by consultant);
- Monthly inspection during the summer (by AAM staff);
- Security measures that limit access to the site (e.g., locked security gate at site entrance, warning signs) to discourage access by unauthorized recreational users;
- Removal of blockages caused by beaver activity;
- Removal of in-channel vegetation as required; and
- Safety measures to prohibit workers and staff from accessing the channel during periods of high flow without a detailed safety plan approved by AAM.

Although other preventative measures could be implemented to reduce the likelihood of a slope failure or blockage along the Wolverine Creek channel (e.g., re-grading of the tailings pile, additional armouring), they were considered to be cost prohibitive and unnecessary given that the tailings pile slope instability, will be addressed during planned site-wide remediation activities.

5.2.8 Triggers

Triggers associated with the Wolverine Creek are presented in Table QQ.

Table QQ Wolverine Creek Channel Triggers

ID	Description	Value	Action	Status
WC-1 (R22)	Channel downcut over a measurable stretch of the channel from Sta. 1+025 to 1+300	>1.0 m from baseline	Begin planning for channel stabilization works	Not triggered in 2014
WC-2 (R22)	Channel downcut over a measurable stretch of the channel from Sta. 0+655 to 1+025	>0.5 m from baseline	Begin planning for channel stabilization works	Trigger exceeded in 2014. Site-wide remediation planning is underway
WC-3 (R22)	Visual observations of channel instability	Indications of erosion at top of channel bank or channel re-alignment	Begin planning for channel stabilization works	Not triggered in 2014
WC-4 (new)	Average channel deposition through upper / mid / lower creek section	>0.3 m from previous monitoring period	Develop localized mitigation plan	N/A
WC-5 (new)	Channel centreline shift	>5 m (average) from previous monitoring period	Develop localized mitigation plan	N/A

5.2.9 Conclusions and Recommendations

Conclusions

The highest overall risk rating estimated for the Wolverine Creek channel was ‘Moderately High’. This rating was assigned to a major blockage of the channel applied to the environmental impact, legal obligations, and consequence cost scenarios.

Based on the observations made at the Site, the results of the 2014 survey, and this assessment, the triggers provided in the 2005 LTMP report (R22 UMA 2006b) remain valid and the appropriate action has been taken (i.e., begin planning for site wide remediation).

Recommendations

The recommendations relevant to the Wolverine Creek channel and Wolverine Creek tailings pile ponds are summarized in Table RR.

Table RR Wolverine Creek Channel Recommendations

ID	Description	Implementation	Validity
WC-A (R104)	Visual inspection and survey of the rock lined channel and weirs on Wolverine Creek should be completed on a biennial basis	Inspection and survey completed in 2014	Valid - but clarification required, refer to recommendations WC-B and WC-C below
WC-B (new)	Visual inspection of the Wolverine Creek channel from the confluence with Clinton Creek to the outlet at the south pond, from the inlet of the south pond to the outlet of the north pond, and approximately 100 m north of the north pond inlet should be completed on an annual basis	Should be completed as part of future LTMPs	Required to identify potential and existing failures of creek channel components and provide a recommendation regarding potential repair strategy
WC-C (new)	Survey of the Wolverine Creek channel (as described above) should be completed on a biennial basis	Should be completed as part of future LTMPs	To facilitate monitoring of channel movement (e.g., downcutting) between monitoring periods
WC-D (new)	Establish secondary control point above Wolverine Creek with line of sight to the 200 m portion of the creek extending downstream from the outlet of the south pond	Should be implemented as part of 2016 survey	To reduce survey signal interference from trees and improve survey accuracy
WP-A	Visual inspection of the Wolverine ponds should be completed on an annual basis with survey completed on a biennial basis	Inspection and survey completed in 2014	Valid - required to check for debris accumulation and blockage
WP-B (R104)	Clear debris caused by beaver activity	Completed	Completed
WP-C (R104)	Continue to monitor debris accumulations on a regular basis	Ongoing	Valid - practice should continue
WP-D (R104)	Install log booms upstream of inlet to collect debris	Not implemented	Recommend that implementation of log booms is considered if debris collects in the channel and is regularly identified during monthly AAM inspections
WP-E (R05)	Install meteorological station	Completed	Completed

6. PIT COMPONENTS

Porcupine Pit and Snowshoe Pit were assessed as a single site component.

Porcupine Pit is located southeast of the waste rock dump upper slope. The open pit occupies a footprint of approximately 35 ha, with pit walls extending approximately 70 m high. Snowshoe Pit is located east of Porcupine Pit.

The following failure modes were assessed for Porcupine Pit and Snowshoe Pit:

- Fall hazard - falls from the rim around the pit; and
- Pit wall - slumping or mass movement of a significant segment of the pit wall(s).

6.1 Current Condition

During the site visit, both pits appeared to be in stable condition. No indications of recent slope failures were observed at either pit; however, tension cracks were observed along the north wall of Porcupine Pit. Tension cracks, slumping, and recent small slides were observed during a 2003 site visit conducted as part of a previous hazard assessment. The associated report stated that the risk of pit wall failure and rockfalls would increase with time due to weathering with stability achieved once the pit walls reach a stable angle (R05, UMA 2004).

The 2014 survey included recording the coordinates of six monitoring pins surrounding Porcupine Pit. An average movement rates of 1.31 cm/y was calculated based on the 2014 and 2012 survey results. This rate was less than the average movement rate of 3.49 cm/y calculated based on the 2012 and 2010 (September) survey results.

Based on the observations made during the site visit (e.g., evidence of tension cracks, previous small slides), Porcupine Pit and Snowshoe Pit were considered to be unstable.

6.2 Failure Mechanisms

Failure of the pit walls at Porcupine Pit and Snowshoe Pit could be triggered by the failure mechanisms presented in the following sections.

6.2.1 Loss of Footing

In spite of warning signs, it is possible that unauthorized users at the site may approach the edge of the pit either due to lack of awareness of the danger or unsafe behaviour. A loss of footing at the edge could result in a fall into the pit, potentially from a significant height.

6.2.2 Saturation of Pit Walls

During periods of intense precipitation or snowmelt, runoff could infiltrate into the ground around the pit and saturate the pit walls, potentially resulting in the failure of the pit wall due to increased pore pressure.

6.2.3 Seismic Event

Earthquakes can trigger slope failures, particularly if the slope is unstable. As the pit wall satisfies this condition, it is likely that a significant earthquake could result in a failure of the pit wall.

6.2.4 Unauthorized Access

Recreational users accessing the pit for swimming could be at risk of drowning.

6.3 Fall Hazard

A fall from the top of Porcupine Pit or Snowshoe Pit could be triggered by loss of footing at or near the top of the pit.

6.3.1 Likelihood Classification

The likelihood of the fall hazard failure was classified as 'Unlikely' given the warning signs posted around the pits and the site closure signs posted near the site entrance as well as barriers to site entrance (e.g., barrier gate at the site entrance).

6.3.2 Consequence Classifications

The scenarios associated with a fall from the top of Porcupine Pit or Snowshoe Pit are summarized in Appendix 2 and Table SS.

Table SS Consequence Classifications - Fall Hazard at Porcupine Pit or Snowshoe Pit

Category	Classification	Descriptor
Environmental Impact	Very Low	No environmental impact
Legal Obligations	Very Low	No action taken by regulatory agency
Consequence Costs	Very Low	No cost associated
Human Health and Safety	Major	Single fatality or serious injury

Environmental Impact

A fall from the top of Porcupine Pit or Snowshoe Pit would have no environmental impact.

This scenario was assigned a 'Very Low' consequence classification.

Legal Obligations

Due to the lack of environmental impact, it is unlikely that action will be taken by a regulatory agency; however, it is possible that legal action could be taken by those harmed by the fall.

This scenario was assigned a 'Very Low' consequence classification.

Consequence Costs

There would likely be no capital costs associated with a fall from the top of Porcupine Pit or Snowshoe Pit.

This scenario was assigned a 'Very Low' consequence classification.

Human Health and Safety

A single fatality or severe, irreversible disability / impairment and/or injuries requiring hospitalization could occur as a result of a fall from the top of the Porcupine Pit or Snowshoe Pit.

This scenario was assigned a 'Major' consequence classification.

6.3.3 Risk Statement

A fall from the top of Porcupine Pit or Snowshoe Pit is summarized in the following risk event statement:

"Loss of footing causes a fall from the top of Porcupine Pit or Snowshoe Pit which will likely not result in an impact to the environment or action taken by regulatory agencies but could result in legal action, and/or a single fatality or serious injury."

6.4 Pit Wall

A significant pit wall failure could be triggered by the saturation of the pit wall or a seismic event.

6.4.1 Likelihood Classification

The likelihood of a significant pit wall failure was classified as 'Possible' as significant pit wall failures have occurred at other similar sites and minor pit wall failures occur frequently at the site.

6.4.2 Consequence Classifications

The scenarios associated with a significant pit wall failure are summarized in Appendix 2 and Table TT.

Table TT Consequence Classifications - Significant Pit Wall Failure

Category	Classification	Descriptor
Environmental Impact	Very Low	No environmental impact
Legal Obligations	Minor	Warning letter issued by EC for release of deleterious material causing degradation of aquatic habitat
Consequence Costs	Minor	Between $100,000 and $500,000
Human Health and Safety	Major	Single fatality or serious injury

Environmental Impact

A pit wall failure would have no environmental impact. This scenario was assigned a 'Very Low' consequence classification.

Legal Obligations

Due to the lack of environmental impact, it is unlikely that action will be taken by a regulatory agency.

This scenario was assigned a 'Minor' consequence classification.

Consequence Costs

Stabilization methods may be required to reinforce the segment of the pit wall that failed and/or repairs may be required to site infrastructure damaged by rapid discharge of water from the pit (i.e., flood wave). Costs associated with this work could be as high as $500,000 depending on the extent of the damage to the embankment.

This scenario was assigned a 'Minor' consequence classification.

Human Health and Safety

A single fatality or severe, irreversible disability / impairment and/or injuries requiring hospitalization could occur as a result of a pit wall failure if a person was in the pit and was struck or buried by pit wall material. Due to security measures in place to restrict access to the pits, the probability that someone would be in the pit at the time of failure was considered to be relatively low.

This scenario was assigned a 'Major' consequence classification. The likelihood of this scenario was considered to be 'Unlikely'.

6.4.3 Risk Statement

A pit wall failure at Porcupine Pit or Snowshoe Pit is summarized in the following risk event statement:

"Saturation of pit walls or a seismic event causes a pit wall failure at Porcupine Pit or Snowshoe Pit which could result in the minor degradation of local habitat, issuance of a warning letter by EC, stabilization costs as high as $500,000, and/or a single fatality or serious injury."

6.5 Overall Risk Rating

The consequence and likelihood classifications presented in the preceding sections were used to assign the qualitative risk ratings summarized in Table UU. A complete list of these ratings can be found in Appendix 2.

Table UU Risk Ratings for Porcupine and Snowshoe Pits

Consequence Category	Fall Hazard	Pit Wall Failure
Environmental	Low	Low
Legal Obligations	Low	Low
Consequence Costs	Low	Moderate
Human Health and Safety	Moderately High	Moderately High

6.6 Preventative Measures

The following preventative measures are in place to reduce the likelihood and/or severity of fall hazards and pit wall failures at Porcupine Pit and Snowshoe Pit:

- Bi-annual inspection and topographic survey of the pits (by consultant);
- Monthly inspection during the summer (by AAM staff);
- Security measures that limit access to the site (e.g., locked security gate at site entrance, warning signs) to discourage access by unauthorized recreational users; and
- Security measures to limit vehicle access to the pits and signage to discourage foot traffic around the pits.

6.7 Triggers

Triggers associated with Porcupine Pit are presented in Table VV.

Table VV Porcupine Pit Triggers

ID	Description	Value	Action	Status
PP-1 (new)	Average monitoring point horizontal movement rate	Movement rate (cm/y) > than movement rate from previous monitoring cycle	If movement rate increase is between 0% and 30%, monitoring points should be surveyed the following year. If movement rate increase is 30% or greater or if movement rate has increased over two consecutive years, begin planning for a geotechnical assessment (including drilling and modelling) to determine whether stabilization is required	Not triggered in 2014

6.8 Conclusions and Recommendations

6.8.1 Conclusions

The highest overall risk rating estimated for Porcupine Pit and Snowshoe Pit was 'Moderately High'. This rating was assigned to the Human Health and Safety consequence scenario for both the fall hazard and pit wall failure modes.

6.8.2 Recommendations

The recommendations relevant to Porcupine Pit and Snowshoe Pit are summarized in Table WW.

Table WW Porcupine Pit and Snowshoe Pit Recommendations

ID	Description	Implementation	Validity
PP-A (new)	Inspect Porcupine Pit and Snowshoe Pit on an annual basis and survey Porcupine Pit monitoring points on a biennial basis	Survey and inspection completed in 2014	Required to monitor pit conditions and movement rates
PP-B (new)	Establish four monitoring points around Snowshoe Pit	Should be implemented as part of 2016 survey	Required to monitor movement rates in and around Snowshoe Pit
PP-C (R05)	Temporarily block access to the Porcupine, Snowshoe, and Creek pits until mine closure works are complete, then provide permanent blockage	In progress: temporary measures are in place	Valid - permanent barriers should be installed following site-wide remediation
PP-D (R104)	Install vehicle barricades or berms to prevent vehicles from entering the pit and post notices of safety risk and restrict entry to all but essential personnel	Completed	Completed

7. SUMMARY

The overall risk ratings assigned to the Clinton Creek site components were between 'Low' and 'Moderately High', with the exception of DS4 (discussed in the Clinton Creek Engineering Review and Assessment - Part 1 report) which was assigned a 'High' risk rating. The following site components were assigned a 'Moderately High' risk rating:

- Clinton Creek channel - due to the environmental impact, legal obligation, and consequence cost elements associated with a major blockage of the channel;
- Waste rock dump - due to the environmental impact, legal obligation, consequence cost, and health and human safety elements associated with a sudden failure of the waste rock slope with material blocking the Clinton Creek channel;
- Wolverine Tailings Pile - due to the environmental impact, legal obligation, consequence cost, and health and human safety elements associated with a sudden failure of the tailings slope with material blocking the Wolverine Creek channel;
- Wolverine Creek channel - due to the environmental impact, legal obligation, and consequence cost elements associated with a major blockage of the channel;
- Porcupine Pit - due to the human health and safety elements associated with a fall from the top of the pit or a pit wall failure; and
- Snowshoe Pit - due to the human health and safety elements associated with a fall from the top of the pit or a pit wall failure.

Though additional mitigation of these components to reduce the likelihood and/or severity of the associated consequences is not recommended at this time, AAM should continue to monitor the stability of these elements and consider re-assessment following any significant changes (e.g., acceleration of waste rock dump or tailings pile movement).

8. REFERENCES

AECOM (2011). *R94 Former Clinton Creek Mine - Emergency Drop Structure Repairs* (construction activity report).

AECOM (2010). *Former Clinton Creek Asbestos Mine - Site Inspection on 23 August, 2010* (R100 letter).

Associated Engineering (2012). *R104 Former Clinton Creek Asbestos Mine - Long-Term Performance Monitoring.*

UMA Engineering (2006a). *R09 Former Clinton Creek Asbestos Mine - Summary of 2004 Hazard Mitigation Work, Monitoring, and a Screening Level Risk Assessment for Airborne*.

UMA Engineering (2006b). *R22 Former Clinton Creek Asbestos Mine - Long-Term Monitoring Program.*

UMA Engineering (2004). *R05 Hazard Assessment*.

UMA Engineering (2002). *R47 Stability Analysis.*

WorleyParsons (2014a). *Clinton Creek Engineering Review and Assessment - Part 1.*

WorleyParsons (2014b). *Clinton Creek Long-Term Monitoring Program - 2014 Survey Results.*

Appendix 1 Site Photographs

Photo 1: Access Road north of Porcupine Pit looking east.

Photo 2: Access Road north of Porcupine Pit looking south.

Photo 3: Access Road east of DS4 looking north.

Photo 4: Access Road east of DS4 looking east.

Photo 5: Access road north of Snowshoe Pit looking northwest.

Photo 6: Access road north of Snowshoe Pit looking west.

Photo 7: Access road north of Snowshoe Pit looking west.

Photo 8: **Decommissioned access road and Clinton Creek east of DS4 looking west.**

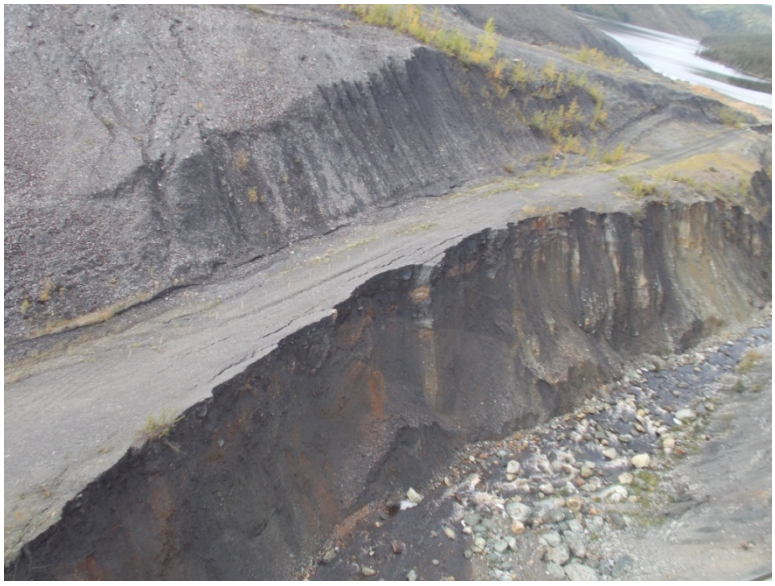

Photo 9: Decommissioned access road east of DS4 looking southwest.

Photo 10: Decommissioned access road east of DS4 looking southwest.

Photo 11: Decommissioned access road and Clinton Creek east of DS4 looking west.

Photo 12: Decommissioned access road and Clinton Creek east of DS4 looking west.

Photo 13: Decommissioned access road east of DS4 looking north.

Photo 14: Decommissioned access road east of DS4 looking east.

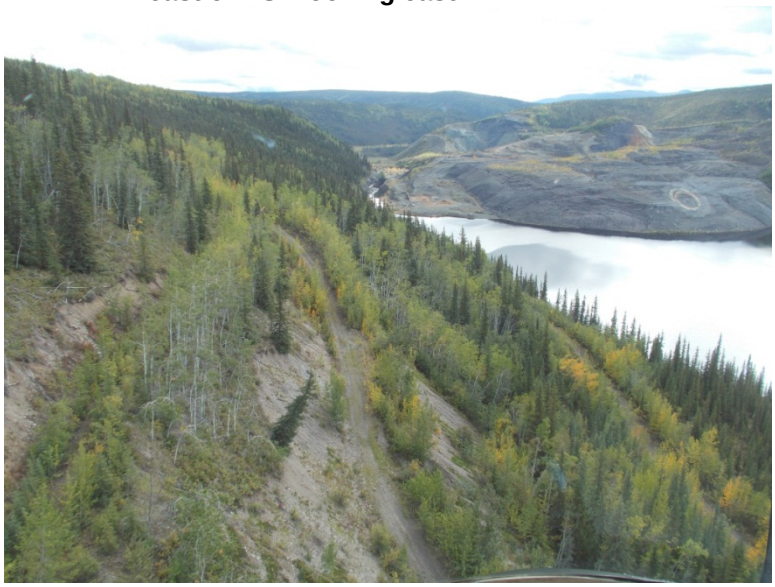

Photo 15: Mill access road north of Hudgeon Lake looking east.

Photo 16: Mill access road north of Hudgeon Lake looking east.

Photo 17: Mill access road north of Clinton Creek looking northeast.

Photo 18: Access Road at Primary Ford Crossing looking south.

Photo 19: Access road west of confluence of Clinton Creek and Wolverine Creek looking northeast.

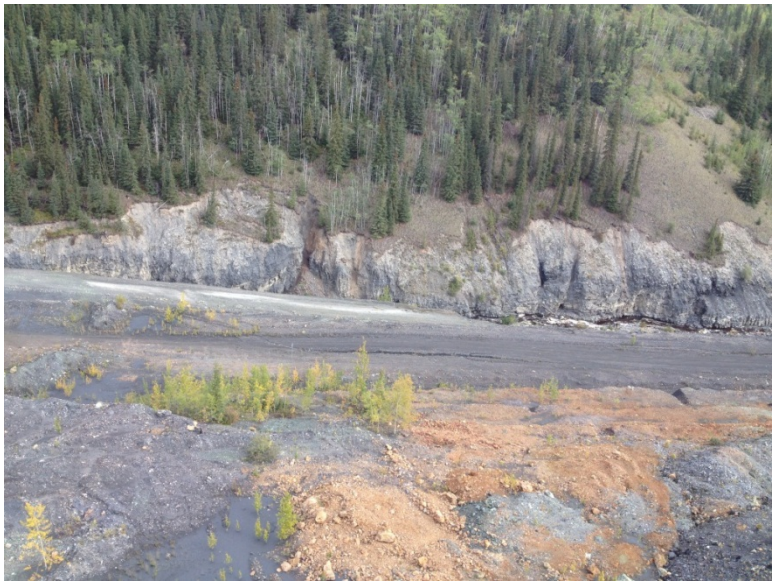

Photo 20: Access road north of Snowshoe Pit looking north.

Photo 21: Access road north of Snowshoe Pit looking northwest.

Photo 22: Access road at confluence of Clinton Creek and Wolverine Creek looking southwest.

Photo 23: Access road at primary ford crossing looking south.

Photo 24: DS1 looking north.

Photo 25: DS1 looking north.

Photo 26: Tension cracks located along south bank of DS1 looking east (downstream).

Photo 27: DS2 looking northwest.

Photo 28: DS3 looking north.

Photo 29: Vertically displaced gabion basket at DS3 looking northeast.

Photo 30: DS3 looking northwest.

Photo 31: DS3 looking northwest.

Photo 32: Vertically displaced gabion basket at DS3 looking north.

Photo 33: DS4 looking north.

Photo 34: DS4 looking north.

Photo 35: Failed gabion basket downstream (east) of DS4.

Photo 36: Tension cracks along south bank of DS4 looking west (upstream).

Photo 37: DS4 looking northwest.

Photo 38: DS4 looking north.

Photo 39: DS4 looking northwest.

Photo 40: DS4 looking northwest.

Photo 41: DS4 in 2013 looking north.

Photo 42: DS4 in 2013 looking north.

Photo 43: Drop structures looking northwest.

Photo 44: Drop structures looking east.

Photo 45: Drop structures looking north.

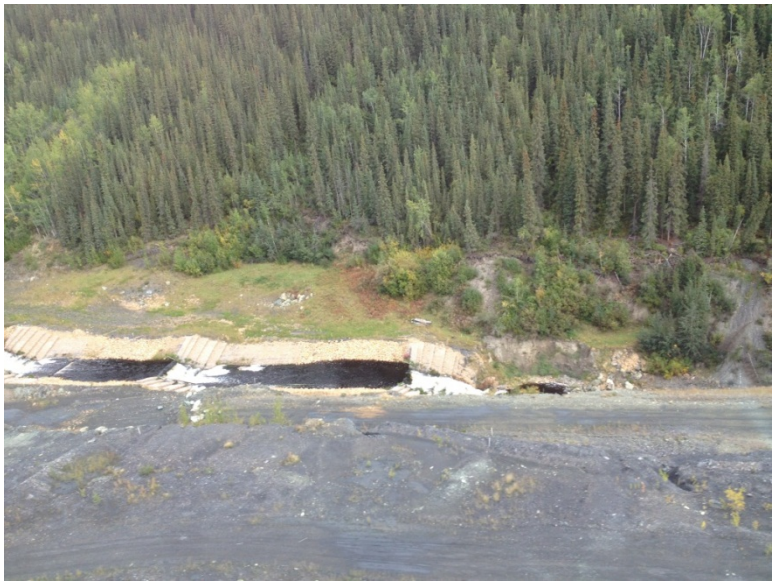

Photo 46: Drop structures looking north.

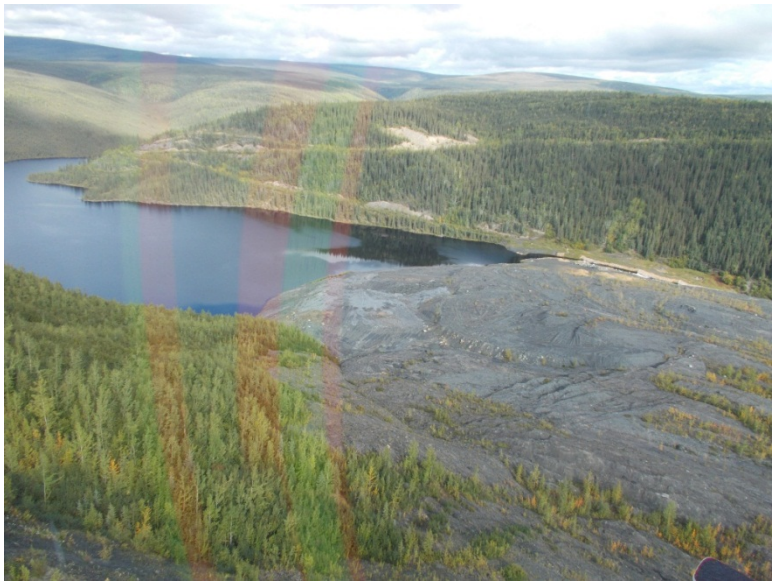

Photo 47: Waste dump looking northwest.

Photo 48: Waste dump looking southeast.

Photo 49: Hudgeon Lake outlet looking northwest.

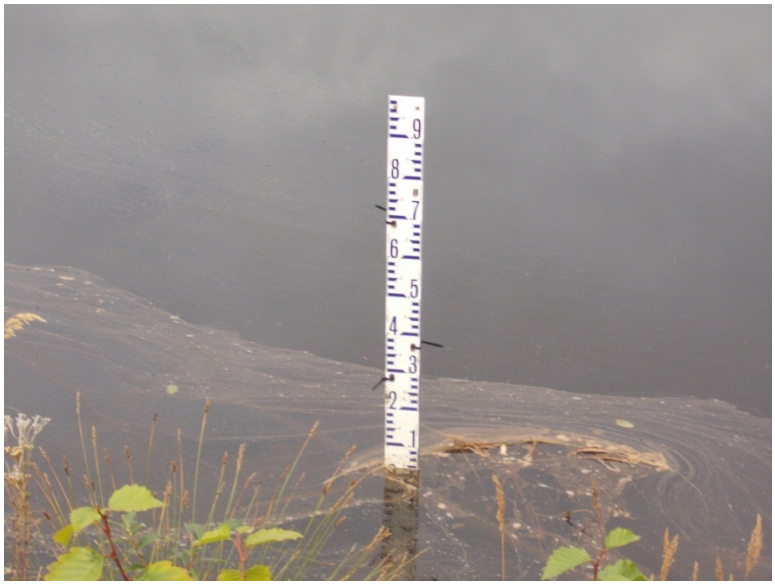

Photo 50: Hudgeon Lake water level gauge looking west.

Photo 51: Hudgeon Lake water level gauge looking west.

Photo 52: Porcupine Pit looking southwest.

Photo 53: Porcupine Pit looking northeast.

Photo 54: Snowshoe Pit looking south.

Photo 55: Tailings slope looking north.

Photo 56: Tailings slope looking west.

Photo 57: Tailings slope looking southeast.

Photo 58: Tailings slope and Wolverine Creek looking southeast.

Photo 59: Tailings slope looking northwest.

Photo 60: Tailings slope looking northwest.

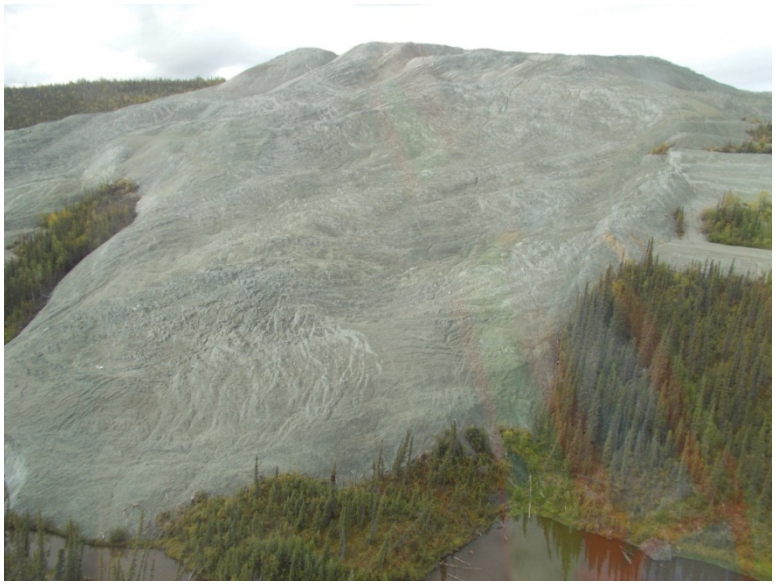

Photo 61: Tailings slope looking west.

Photo 62: Tailings slope looking southwest.

Photo 63: Tailings slope and tailings pond looking west.

Photo 64: Tailings slope and tailings pond looking west.

Photo 65: Tailings slope and tailings pond looking south.

Photo 66: Tailings slope looking southwest.

Photo 67: Mill site looking south.

Photo 68: Wolverine Creek looking southeast.

Photo 69: Wolverine Creek at confluence with Clinton Creek looking east.

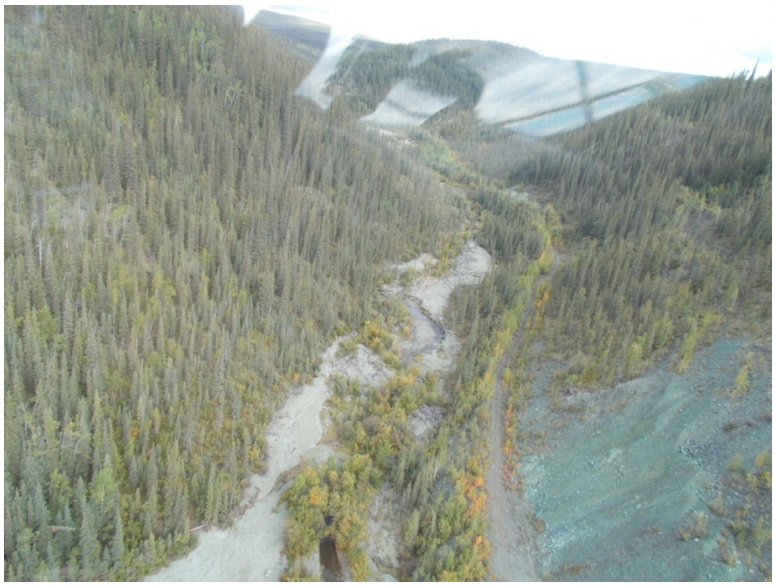

Photo 70: Wolverine Creek looking southeast.

Photo 71: Wolverine Creek at confluence with Clinton Creek looking southeast.

Photo 72: Wolverine Creek near confluence with Clinton Creek looking south (downstream toward access road).

Photo 73: Wolverine Creek north of confluence with Clinton Creek looking north.

Photo 74: Wolverine Creek north of confluence with Clinton Creek looking northeast (upstream).

Photo 75: Wolverine Creek north of confluence with Clinton Creek looking north (upstream).

Photo 76: Wolverine Creek north of confluence with Clinton Creek looking east.

Photo 77: Wolverine Creek north of confluence with Clinton Creek looking east.

Photo 78: Wolverine Creek north of confluence with Clinton Creek looking east.

Photo 79: Wolverine Creek north of confluence with Clinton Creek looking east.

Photo 80: Wolverine Creek north of confluence with Clinton Creek looking northeast.

Photo 81: Wolverine Creek tailings ponds looking southeast.

Appendix 2 Risk Assessment

Drop Structures 1, 2, and 3

Number	Event	Existing Preventative Measures	Assumed Failure Trigger(s)	Likelihood of Failure	Consequence Type and Description	Risk Severity		
						Likelihood	Consequence	Risk Rating
1	Partial failure of one of drop structures 1, 2, or 3 in isolation	• Annual inspection, including topographic survey, of drop structures by consultant and monthly inspections by AAM staff during the summer. • Security measures to limit access by unauthorized users. • Safety measures to prohibit workers and staff from accessing drop structures or working downstream during periods of high flow without a detailed safety plan approved by AAM. • PVC boom at the outlet structure to collect debris and withstand hydrostatic forces acting against the blockage until the blockage can be cleared. • Periodic debris removal from the channel and from the log boom.	• Deterioration of the gabion baskets (e.g., metal fatigue of the basket wire, failure of the connectors); • Erosion of base materials due to typical erosion; • Accelerated slope movement of the waste rock; • Significant seismic event; • Extreme flow event (due to blockage of Hudgeon Lake outlet, freshet, or period of intense precipitation); or • Damage from debris travelling through the Clinton Creek channel.	*Likely*	Environmental Impact - no impact as only a small amount of granular material would be expected to be mobilized and deposited downstream	Likely	Very Low	*Low*
2					Legal Obligations - informal advice from a regulatory agency	Likely	Very Low	*Low*
3					Consequence Costs - the partial failure or deformation of one of drop structures 1, 2, or 3 would require minor repairs. Costs for the repair could be as high as $100,000	Likely	Very Low	*Low*
4					Human Health and Safety - objective but reversible disability / impairment and / or injuries requiring hospitalization if worker or recreational user is located downstream of the drop structure at time of failure	Likely	Minor	*Moderate*
5	Complete failure of one of drop structures 1, 2, or 3 in isolation (i.e., collapse of the gabion baskets exposing underlying granular materials to erosion and destabilization of the channel embankment)	Same as partial failure	Same as partial failure	*Possible*	Environmental Impact - downstream deposition of granular materials as a direct result of the failure of the drop structures (i.e., release of subgrade material and waste rock below and behind the drop structures) and increased erosion of Clinton Creek channel and embankment material resulting in minor or short-term impacts to the local ecosystem	Possible	Minor	*Moderate*
6					Legal Obligations - technical / administrative non-compliance with permit, approval, or regulatory requirements and the issuance of a warning letter	Possible	Minor	*Moderate*
7					Consequence Costs - the complete failure of one of drop structures 1, 2, or 3 would require reconstruction of the drop structure. Costs for the reconstruction could be as high as $250,000	Possible	Minor	*Moderate*
8					Human Health and Safety a) Major - single fatality or severe, irreversible disability / impairment if a worker or recreational user is in the vicinity of the drop structure at time of failure. Given that persons are rarely in the vicinity of the drop structures, the likelihood of this scenario was considered to be Very *Unlikely* based on a reduced probability that a person would be present at the exact time of failure	Very Unlikely	Major	*Moderate*
9					Human Health and Safety b) Minor - objective but reversible disability / impairment and / or injuries requiring hospitalization if worker or recreational user is located downstream of the drop structure at time of failure	Possible	Minor	*Moderate*

Clinton Creek Channel

Number	Event	Existing Preventative Measures	Assumed Failure Trigger(s)	Likelihood of Failure	Consequence Type and Description	Risk Severity		
						Likelihood	Consequence	Risk Rating
1	Localized slope failure of the channel banks causing mobilization of granular material and waste rock downstream as well as impacting site accessibility	• Biennial inspection, including topographic survey, of the channel by consultant and monthly inspections by AAM staff during the summer. • Security measures to limit access by unauthorized users. • Safety measures to prohibit workers and staff from accessing channel during periods of high flow without a detailed safety plan approved by AAM.	• Accelerated slope movement of the waste rock or natural slope to the north; • Down-cutting of the channel through ongoing erosion; or • Extreme flow event (due to blockage of Hudgeon Lake, freshet, or period of intense precipitation)	*Almost Certain*	Environmental Impact - downstream deposition of granular materials resulting in minor or short-term impacts to the local ecosystem	Almost Certain	Very Low	*Low*
2					Legal Obligations - informal advice from a regulatory agency	Almost Certain	Very Low	*Low*
3					Consequence Costs - localized slope failures could potentially require regrading and/or installation of stabilizing materials (e.g., slope armouring). The costs to stabilize the slope would likely be in the range of $100,000 to $500,000, depending on the size, accessibility, and severity of the failure	Unlikely	Minor	*Low*
4					Human Health and Safety - objective but reversible disability / impairment and / or injuries requiring hospitalization if worker or recreational user is located at the slope failure at the time of failure	Unlikely	Minor	*Low*
5	Minor blockage of the channel followed by the release of the blockage causing the mobilization of granular material and waste rock as well as impacting site accessibility	Same as localized slope failure in addition to: • PVC boom at the outlet structure to collect debris and withstand hydrostatic forces acting against the blockage until the blockage can be cleared. • Periodic debris removal from the channel and from the log boom.	• Accelerated slope movement; • Down-cutting of the channel through ongoing erosion; • Extreme flow event; or • Collection of debris, beaver activity, or large slope failure.	*Likely*	Environmental Impact - downstream deposition of granular materials resulting in minor or short-term impacts to the local ecosystem	Likely	Minor	*Moderate*
6					Legal Obligations - technical / administrative non-compliance with permit, approval, or regulatory requirements and the issuance of a warning letter	Likely	Minor	*Moderate*
7					Consequence Costs - the portion of the channel that was blocked may require reconstruction or the implementation of slope stabilization measures. The associated costs would likely be in the range of $100,000 to $500,000, depending on the extent of the damage to the channel	Likely	Minor	*Moderate*
8					Human Health and Safety - objective but reversible disability / impairment and / or injuries requiring hospitalization if worker or recreational user is located in the channel at the time the blockage was released	Unlikely	Minor	*Low*
9	Major blockage of the channel followed by the release the blockage causing the mobilization of granular material and waste rock downstream as well as impacting site accessibility	Same as Minor Blockage	Same as Minor Blockage	*Possible*	Environmental Impact - significant impact on valued ecosystem downstream	Possible	Moderate	*Moderately High*
10					Legal Obligations - breach of regulations, permits, or approvals resulting in the issuance of an order or direction	Possible	Moderate	*Moderately High*
11					Consequence Costs - the portion of the channel that was blocked may require reconstruction or the implementation slope stabilization measures. Clean up activities or remediation may be required to mitigate damage to downstream areas. The associated costs would likely be in the range of $500,000 to $2.5 million, depending on the extent of the damage to the channel	Possible	Moderate	*Moderately High*
12					Human Health and Safety - objective but reversible disability / impairment and / or injuries requiring hospitalization if worker or recreational user is located in the channel at the time the blockage was released	Unlikely	Moderate	*Moderate*

Hudgeon Lake Outlet

Number	Event	Existing Preventative Measures	Assumed Failure Trigger(s)	Likelihood of Failure	Consequence Type and Description	Risk Severity		
						Likelihood	Consequence	Risk Rating
1	Damage to Hudgeon Lake outlet components (channel, embankments, boom, abutments) causing the erosion of waste rock and debris entering the channel	• Biennial inspection, including topographic survey, of the channel by consultant and monthly inspections by AAM staff during the summer. • Security measures to limit access by unauthorized users. • Safety measures to prohibit workers and staff from using channel crossing during periods of high flow without a detailed safety plan approved by AAM.	• Lake level elevated due to a blockage of the outlet or extreme flow with discharge flowing around the boom abutments; • Boom abutments destabilized due to freeze thaw action or accelerated slope movement; or • Damage to the boom causes it to disconnect from the abutments with the boom conveyed downstream.	*Possible*	Environmental Impact - no impact as only a small amount of granular material would be expected to be mobilized and deposited downstream	Possible	Very Low	*Low*
2					Legal Obligations - informal advice from a regulatory agency	Possible	Very Low	*Low*
3					Consequence Costs - the outlet may require regrading or stabilization of the boom abutments. Associated costs could be less than $100,000	Possible	Very Low	*Low*
4					Human Health and Safety - objective but reversible disability / impairment and / or injuries requiring hospitalization if worker or recreational user is stranded on the north side of Clinton Creek should the crossing at Hudgeon Lake becomes impassable	Unlikely	Minor	*Low*
5	Unauthorized access to the lake could result in accidental drowning	• Security measures to limit access by unauthorized users.	• Unauthorized access to the lake by recreational users.	*Possible*	Environmental Impact - no impact	Unlikely	Very Low	*Low*
6					Legal Obligations - no advice from a regulatory agency	Unlikely	Very Low	*Low*
7					Consequence Costs - no capital costs	Unlikely	Very Low	*Low*
8					Human Health and Safety a) Major - single fatality or severe, irreversible disability / impairment if a recreational user drowns.	Unlikely	Major	*Moderately High*

Clinton Creek Site Access Road

Number	Event	Existing Preventative Measures	Assumed Failure Trigger(s)	Likelihood of Failure	Consequence Type and Description	Risk Severity		
						Likelihood	Consequence	Risk Rating
1	Slope failure at the closed portion of the site access road due to ongoing destabilization of the channel embankment resulting in an extended slope failure with a significant volume of material coming to rest in the channel	• Annual inspection, including topographic survey, of the top of the embankment by consultant and monthly inspections by AAM staff during the summer. • Security measures to limit access by unauthorized users (e.g., site gate, barriers, and signage).	• Extreme flow in the channel causing erosion at the toe; • Accelerated slope movement; or • Wet weather conditions.	*Likely*	Environmental Impact - downstream deposition of granular materials resulting in minor or short-term impacts to the local ecosystem	Likely	Minor	*Moderate*
2					Legal Obligations - technical / administrative non-compliance with permit, approval, or regulatory requirements and the issuance of a warning letter	Likely	Minor	*Moderate*
3					Consequence Costs - slope failure could potentially require regrading and/or installation of stabilizing materials (e.g., slope armouring). The costs to stabilize the slope would likely be in the range of $100,000 to $500,000, depending on the size, accessibility, and severity of the failure	Likely	Minor	*Moderate*
4					Human Health and Safety - single fatality or severe, irreversible disability / impairment if a worker or recreational user is at the top of the embankment at time of failure. Given that people are rarely in the vicinity of DS4 due to its high instability, the likelihood of this scenario was considered to be*Very Unlikely* based on a reduced probability that a person would be present at the exact moment of failure	Very Unlikely	Major	*Moderate*
5	Minor damage to the site access road impacting site accessibility	• Security measures to limit access by unauthorized users; or • Monthly inspections by AAM staff during the summer.	• Accelerated slope movement; • Slope failure adjacent to road; or • Wet weather conditions causing rill erosion, soil saturation, and loss of traction.	*Likely*	Environmental Impact - no impact	Likely	Very Low	*Low*
6					Legal Obligations - no action taken by regulatory agencies	Likely	Very Low	*Low*
7					Consequence Costs - minor repairs to the road surface may be required to improve site accessibility. The associated costs would likely be less than $100,000, depending on the extents and severity of the damage	Likely	Very Low	*Low*
8					Human Health and Safety - low-level short term subjective symptoms with no measureable physical effect and no medical treatment required	Likely	Very Low	*Low*
9	Major Damage to site access road making the road impassable and the Site inaccessible	• Security measures to limit access by unauthorized users; or • Monthly inspections by AAM staff during the summer.	• Accelerated slope movement; • Slope failure adjacent to road; • Wet weather conditions causing rill erosion, soil saturation, and loss of traction; or • Isolated landslides.	*Possible*	Environmental Impact - no impact	Possible	Very Low	*Low*
10					Legal Obligations - no action taken by regulatory agencies	Possible	Very Low	*Low*
11					Consequence Costs - repairs to the road and road surface or removal of material blocking the road may be required to restore Site accessibility. The associated costs would likely be in the range of $100,000 to $500,000, depending on the extents and severity of the landslide	Possible	Minor	*Moderate*
12					Human Health and Safety - objective but reversible disability / impairment and / or injuries requiring hospitalization if worker or recreational user becomes stranded at the site due to the blockage of the access road	Unlikely	Minor	*Low*
13	Clinton Creek site access road crossings become inaccessible due to elevated water levels and / or flow velocities	• Security measures to limit access by unauthorized users; or • Monthly inspections by AAM staff during the summer.	• Extreme flow in the channel. • Downstream constriction due to channel obstruction.	*Likely*	Environmental Impact - no impact	Likely	Very Low	*Low*
14					Legal Obligations - no action taken by regulatory agencies	Likely	Very Low	*Low*
15					Consequence Costs - minor repairs are not likely required to repair the crossing	Likely	Very Low	*Low*
16					Human Health and Safety - objective but reversible disability / impairment and / or injuries requiring hospitalization if worker or recreational user becomes stranded at the site due to the inaccessibility of the crossings	Unlikely	Minor	*Low*

Waste Rock Dump

Number	Event	Existing Preventative Measures	Assumed Failure Trigger(s)	Likelihood of Failure	Consequence Type and Description	Risk Severity		
						Likelihood	Consequence	Risk Rating
1	Ongoing encroachment of material into the Clinton Creek channel	• Biennial inspection, including survey of monitoring points distributed throughout the waste rock pile by consultant to monitor movement rates and monthly inspection by AAM staff during the summer • Security measures that limit access to the site	• Ongoing slope movement; • Saturation of waste rock; • Frost heave and erosion; • Failure of other site components; • Seismic event; or • Changes to surface loading.	*Almost Certain*	Environmental Impact - no additional impact to local environment	Almost Certain	Very Low	*Low*
2					Legal Obligations - informal advice from a regulatory agency	Almost Certain	Very Low	*Low*
3					Consequence Costs - it is unlikely that this ongoing issue will require repair in the foreseeable future. Associated repair costs could be in the range of $500,000 to $2.5 million, depending on the extents of the repair	Very Unlikely	Moderate	*Low*
4					Human Health and Safety - low-level short term subjective symptoms with no measureable physical effect and no medical treatment required.	Unlikely	Very Low	*Low*
5	Sudden failure of the dump with waste rock partially blocking the Clinton Creek channel or site access road	Same as Ongoing Encroachment	• Saturation of waste rock; • Frost heave and erosion; • Failure of other site components; • Seismic event; or • Changes to surface loading.	*Possible*	Environmental Impact - downstream deposition of granular materials resulting in significant impact on valued ecosystem component	Possible	Moderate	*Moderately High*
6					Legal Obligations -Breach of regulations, permits, or approvals with an order or direction issued by EC	Possible	Moderate	*Moderately High*
7					Consequence Costs - sudden slope failure could potentially require regrading and/or installation of stabilizing materials (e.g., slope armouring). The costs to stabilize the slope would likely be in the range of $500,000 to $2.5 million, depending on the size, accessibility, and severity of the failure	Possible	Moderate	*Moderately High*
8					Human Health and Safety a) Major - single fatality or severe, irreversible disability / impairment if a worker or recreational user is in the vicinity of the waste rock dump at time of failure. Given that persons are infrequently at the site, the likelihood of this scenario was considered to be*Unlikely* based on a reduced probability that a person would be present at the exact time of failure	Unlikely	Major	*Moderately High*
9					Human Health and Safety b) Minor - objective but reversible disability / impairment and / or injuries requiring hospitalization if worker or recreational user is located downstream of the drop structure at time of failure	Possible	Minor	*Moderate*

Wolverine Creek Tailings Pile

Number	Event	Existing Preventative Measures	Assumed Failure Trigger(s)	Likelihood of Failure	Consequence Type and Description	Risk Severity		
						Likelihood	Consequence	Risk Rating
1	Ongoing encroachment of material into the Wolverine Creek channel	• Biennial inspection, including survey of monitoring points distributed throughout the tailings pile by consultant to monitor movement rates; • Monthly inspection by AAM staff during the summer; and • Security measures that limit access to the site.	• Ongoing slope movement; • Saturation of waste rock; • Frost heave and erosion; • Failure of other site components (e.g., Wolverine Creek channel, Wolverine Creek tailings pile ponds); • Seismic event; or • Changes to surface loading.	*Almost Certain*	Environmental Impact - no additional impact to local environment	Almost Certain	Very Low	*Low*
2					Legal Obligations - informal advice from a regulatory agency	Almost Certain	Very Low	*Low*
3					Consequence Costs - it is unlikely that this ongoing issue will require repair in the foreseeable future. Associated repair costs could be in the range of $500,000 to $2.5 million, depending on the extents of the repair	Very Unlikely	Moderate	*Low*
4					Human Health and Safety - low-level short term subjective symptoms with no measureable physical effect and no medical treatment required.	Almost Certain	Very Low	*Low*
5	Sudden failure of the pile with tailings partially blocking the Wolverine Creek channel	Same as Ongoing Encroachment	• Saturation of waste rock; • Frost heave and erosion; • Failure of other site components (e.g., Wolverine Creek channel, Wolverine Creek tailings pile ponds); • Seismic event; or • Changes to surface loading.	*Possible*	Environmental Impact - downstream deposition of granular materials resulting in significant impact on valued ecosystem component	Possible	Moderate	*Moderately High*
6					Legal Obligations -Breach of regulations, permits, or approvals with an order or direction issued by EC	Possible	Moderate	*Moderately High*
7					Consequence Costs - sudden slope failure could potentially require regrading and/or installation of stabilizing materials (e.g., slope armouring). The costs to stabilize the slope would likely be in the range of $500,000 to $2.5 million, depending on the size, accessibility, and severity of the failure	Possible	Moderate	*Moderately High*
8					Human Health and Safety a) Major - single fatality or severe, irreversible disability / impairment if a worker or recreational user is in the vicinity of the tailings pile at time of failure. Given that persons are infrequently at the site, the likelihood of this scenario was considered to be *Unlikely* based on a reduced probability that a person would be present at the exact time of failure	Unlikely	Major	*Moderately High*
9					Human Health and Safety b) Minor - objective but reversible disability / impairment and / or injuries requiring hospitalization if worker or recreational user is located downstream of the drop structure at time of failure	Possible	Minor	*Moderate*
5	Safety concerns related to rock falls and the release of asbestos fibres	Same as Ongoing Encroachment	• Ongoing slope movement; • Saturation of tailings; • Frost heave or erosion exposing larger rocks and cobbles; or • Wind and construction activity exposing and releasing asbestos fibres.	*Likely*	Environmental Impact - no additional impact to local environment	Likely	Very Low	*Low*
6					Legal Obligations - informal advice from a regulatory agency	Likely	Very Low	*Low*
7					Consequence Costs - it is not anticipated that isolated rockfalls or releases of asbestos fibres will require immediate attention but will be addressed during site wide remediation	Likely	Very Low	*Low*
8					Human Health and Safety a) Major - moderate irreversible disability or impairment to one or more people due to asbestos related injury. Due to the relatively low concentration of asbestos, this condition is considered to be *Very Unlikely*	Very Unlikely	Moderate	*Low*
9					Human Health and Safety - objective but reversible disability / impairment and / or injuries requiring hospitalization if worker or recreational user is located downstream of the drop structure at time of failure	Unlikely	Minor	*Low*

Wolverine Creek Channel

Number	Event	Existing Preventative Measures	Assumed Failure Trigger(s)	Likelihood of Failure	Consequence Type and Description	Risk Severity		
						Likelihood	Consequence	Risk Rating
1	Localized slope failure of the channel banks causing mobilization of granular material and tailings downstream	• Biennial inspection, including topographic survey, of the channel by consultant and monthly inspections by AAM staff during the summer. • Security measures to limit access by unauthorized users. • Safety measures to prohibit workers and staff from accessing channel during periods of high flow without a detailed safety plan approved by AAM. • Removal of blockages caused by beaver activity. • Removal of in-channel vegetation as required.	• Accelerated slope movement of the waste rock or natural slope to the north; • Down-cutting of the channel through ongoing erosion; or • Extreme flow event (due to blockage of Hudgeon Lake, freshet, or period of intense precipitation)	*Almost Certain*	Environmental Impact - downstream deposition of granular materials resulting in minor or short-term impacts to the local ecosystem	Likely	Very Low	*Low*
2					Legal Obligations - informal advice from a regulatory agency	Likely	Very Low	*Low*
3					Consequence Costs - localized slope failures could potentially require regrading and/or installation of stabilizing materials (e.g., slope armouring). The costs to stabilize the slope would likely be in the range of $100,000 to $500,000, depending on the size, accessibility, and severity of the failure	Unlikely	Minor	*Low*
4					Human Health and Safety - objective but reversible disability / impairment and / or injuries requiring hospitalization if worker or recreational user is located at the slope failure at the time of failure	Unlikely	Minor	*Low*
5	Minor blockage of the channel followed by the release of the blockage causing the mobilization of granular material and tailings downstream as well as impacting site accessibility	Same as Localized slope Failure	• Accelerated slope movement of the waste rock or natural slope to the north; • Extreme flow event; • Down-cutting of the channel through ongoing erosion; or • Collection of debris, beaver activity, or large slope failure.	*Likely*	Environmental Impact - downstream deposition of granular materials resulting in minor or short-term impacts to the local ecosystem	Likely	Minor	*Moderate*
6					Legal Obligations - technical / administrative non-compliance with permit, approval, or regulatory requirements and the issuance of a warning letter	Likely	Minor	*Moderate*
7					Consequence Costs - the portion of the channel that was blocked may require reconstruction or the implementation of slope stabilization measures. The associated costs would likely be in the range of $100,000 to $500,000, depending on the extent of the damage to the channel	Likely	Minor	*Moderate*
8					Human Health and Safety - objective but reversible disability / impairment and / or injuries requiring hospitalization if worker or recreational user is located in the channel at the time the blockage was released	Unlikely	Minor	*Low*
9	Major blockage of the channel followed by the release of the blockage causing the mobilization of granular material and tailings downstream as well as impacting site accessibility	Same as Localized slope Failure	Same as Minor Blockage	*Possible*	Environmental Impact - significant impact on valued ecosystem downstream	Possible	Moderate	*Moderately High*
10					Legal Obligations - breach of regulations, permits, or approvals resulting in the issuance of an order or direction	Possible	Moderate	*Moderately High*
11					Consequence Costs - the portion of the channel that was blocked may require reconstruction or the implementation slope stabilization measures. Clean up activities or remediation may be required to mitigate damage to downstream areas. The associated costs would likely be in the range of $500,000 to $2.5 million, depending on the extent of the damage to the channel	Possible	Moderate	*Moderately High*
12					Human Health and Safety - objective but reversible disability / impairment and / or injuries requiring hospitalization if worker or recreational user is located in the channel at the time the blockage was released	Unlikely	Minor	*Low*

Porcupine and Snowshoe Pits

Number	Event	Existing Preventative Measures	Assumed Failure Trigger(s)	Likelihood of Failure	Consequence Type and Description	Risk Severity		
						Likelihood	Consequence	Risk Rating
1	Fall hazard around the rim of the pits	• Biennial inspection, including topographic survey, of monitoring points around Porcupine pit by consultant. • Monthly inspections by AAM staff during the summer • Security measures to limit site access by unauthorized users. • Security measures to limit vehicle access to the pits and signage to discourage foot traffic around the pits	• Loss of footing while at or near the top of the pit	*Unlikely*	Environmental Impact - no impact to local environment	Unlikely	Very Low	*Low*
2					Legal Obligations - no action taken by regulatory agency	Unlikely	Very Low	*Low*
3					Consequence Costs - no associated capital costs	Unlikely	Very Low	*Low*
4					Human Health and Safety single fatality or severe, irreversible disability / impairment due to fall	Unlikely	Major	*Moderately High*
5	Failure of a significant segment of the pit wall	Same as above	• Saturation of pit walls due to intense precipitation or snowmelt; or • Seismic event.	*Possible*	Environmental Impact - no environmental impact	Possible	Very Low	*Low*
6					Legal Obligations -issuance of warning letter from regulatory agency	Possible	Very Low	*Low*
7					Consequence Costs - pit wall instability could require stabilization works with associated costs as high as $500,000	Unlikely	Minor	*Moderate*
8					Human Health and Safety single fatality or severe, irreversible disability / impairment as a result of being struck or buried by pit wall material	Unlikely	Major	*Moderately High*

Appendix 3 Compilation of Triggers

APPENDIX 3
COMPILATION OF TRIGGERS

Table 1 Previously Reported Triggers

ID (Source Document)	Description	Trigger Value	2014 Value	Action	Status	Discussion
AR-1 (new)	Average horizontal movement of baseline from previous year	10 cm less than the average reported accuracy of baseline shots (precision not to exceed ±5cm)	1.6 cm	Develop mitigation plan	N/A	N/A
AR-2 (new)	Loss of embankment based on horizontal offset from previous year	1.0 m	0.15 m	Develop mitigation plan	N/A	N/A
HL-1 (new)	Lake water surface critical elevation	412.0 masl	411.643 masl (at time of survey)	Mobilize to site to check outlet for blockage, remove blockage if present, and inspect downstream infrastructure (e.g., drop structures and channel)	N/A	Installation of automated remote water level monitor is required
HL-2 (new)	Movement of boom abutment structures from previous monitoring period	Horizontal: 0.30 m less than the reported average horizontal accuracy of abutment shots, and/or Vertical: 0.10 m less reported vertical accuracy of abutment shots (precision not to exceed ±5 cm)	N/A	Investigate base structure and develop mitigation plan as required	N/A	N/A
HL-3 (new)	Loss of rock armouring at the boom abutments from previous monitoring period	10% surface area from previous monitoring period (Taking into consideration changes to water level and the resulting exposure of the rock)	N/A	Review riprap diameter and extents and develop mitigation plan as required	N/A	N/A

ID (Source Document)	Description	Trigger Value	2014 Value	Action	Status	Discussion
DS-1 (R22)	Change to drop structure geometry: steepened side slope	<2H:1V	2.7H:1V to 4.1H:1V	Develop mitigation plan for drop structures at which trigger has been exceeded	Not triggered in 2014	N/A
DS-2 (R22)	Change to drop structure geometry: minimum freeboard at design flow (R22)	<0.20 m	1.52 m to 1.34 m	Develop mitigation plan for drop structures at which trigger has been exceeded	Not triggered in 2014	Recommend that the trigger level is changed to <1.0 m freeboard during conveyance of the 50-year return period flood flow
DS-3 (R22)	Change to drop structure geometry: width at drawdown or width at end sill decreased from baseline	>0.50 m	0.0 m to 1.9 m	Develop mitigation plan for drop structures at which trigger has been exceeded	Triggered at DS3 and DS4 in 2014	DS4 repair plan should be implemented as soon as practically possible. Repair of DS3 is dependent on the risk rating assigned during the Engineering Review and Assessment portion of the program
DS-4 (R22)	Water flowing below the gabion baskets or undermining piping between DS1 and DS4	Visual evidence	N/A	Immediate appropriate repair prior to the end of the construction season	Triggered at DS4 based on observations made during 2014 inspection	DS4 repair plan should be implemented as soon as practically possible.
DS-5 (R22)	Damage to gabion mesh	Visual evidence	N/A	Repair wire mesh and SPENAX rings as appropriate prior to the end of construction season	Triggered at DS1, DS3, and DS4 based on observations made during 2014 inspection	DS4 repair plan (including minor repairs to DS1 and DS3) should be implemented as soon as practically possible.
DS-6 (new)	Change to cross-sectional end area since previous monitoring period	>10% RPC	-7.2% to 1.1%	Develop mitigation plan for drop structures at which trigger has been exceeded	N/A	N/A

ID (Source Document)	Description	Trigger Value	2014 Value	Action	Status	Discussion
CC-1 (R22)	Channel downcut over the 50 m channel segment downstream of DS4 to Station 0+250	>0.5 m (from 2006 baseline)	2.5 m to 4.0 m (approximately)	Begin planning for channel and waste rock stabilization	Triggered in 2010	Site-wide remediation planning is underway
CC-2 (R22)	Channel downcut over a measurable (>50 m) stretch of channel downstream of Station 0+250	>1.5 m (from 2006 baseline)	2.5 m to 1.0 m (approximately)	Planning for channel and waste rock stabilization	Triggered in 2010	Site-wide remediation planning is underway
CC-3 (new)	Average channel deposition through upper / mid / lower creek section	>0.3 m from previous monitoring period	0.01 m to 0.03 m (approximately)	Develop localized mitigation plan	N/A	N/A
CC-4 (new)	Mid creek channel centreline shifts south, into the waste rock dump	>5 m (average) from previous monitoring period	1.2 m - north	Develop localized mitigation plan	N/A	N/A
WR-1 (new)	Average monitoring point horizontal movement rate - per slope section	Movement rate (cm/y) > than movement rate from previous cycle	Upper slope: +20% Mid slope: -5% Lower slope: -10%	If movement rate increase is between 0% and 30%, monitoring points should be surveyed the following year. If movement rate increase is 30% or greater or if movement rate has increased over two consecutive years, begin planning for a geotechnical assessment (including drilling and modelling) to determine whether stabilization is required	Potentially triggered for mid slope between 2012 and 2014	Due to skewing of upper slope data resulting from the addition of four monitoring points, the increased movement rate is to be confirmed with 2015 survey data

ID (Source Document)	Description	Trigger Value	2014 Value	Action	Status	Discussion
PP-1 (new)	Average horizontal movement rate of monitoring points	Movement rate (cm/y) > than movement rate from previous cycle	If movement rate increase is between 0% and 30%, monitoring points should be surveyed the following year.	If movement rate increase is between 0% and 30%, monitoring points should be surveyed the following year.	Not triggered in 2014	N/A
WC-1 (R22)	Channel downcut over a measurable stretch of channel from Station 1+025 to 1+300	>1.0 m from baseline	0.43 m total (based on average measurements) since 2003	Begin planning for channel stabilization works	Not triggered in 2014	N/A
WC-2 (R22)	Channel downcut over a measurable stretch of channel from Station 0+655 to 1+025	>0.5 m from baseline	0.62 m total (based on average measurements) since 2003	Begin planning for channel stabilization works	Triggered in 2014	Site-wide remediation planning is underway
WC-3 (R22)	Visual observations of channel instability	Indications of erosion at top of channel bank or channel re-alignment	N/A	Begin planning for channel stabilization works	Not triggered in 2014	N/A
WC-4 (new)	Average channel deposition through upper / mid / lower creek section	>0.3 m from previous monitoring period	0.005 m to 0.025 m (approximately)	Develop localized mitigation plan	N/A	N/A
WC-5 (new)	Channel centreline shift	>5 m (average) from previous monitoring period	0.2 m - east	Develop localized mitigation plan	N/A	N/A

ID (Source Document)	Description	Trigger Value	2014 Value	Action	Status	Discussion
TP-1 (R22)	Average monitoring point horizontal movement rate - per slope section	Movement rate (cm/y) > than movement rate from previous cycle	North Lobe: 79% to 49% South Lobe: -53% to -29%	If movement rate increase is between 0 and 50%, monitoring points should be surveyed the following year. If movement rate increase is greater than 50% or if movement rate has increased over two consecutive years, begin planning for a geotechnical assessment (including drilling and modelling) to determine whether stabilization is required	Triggered for north upper slope in 2014	The trigger level was exceeded for the north lobe, upper slope; however, the movement rate through this slope section (4.08 cm/y) and RPC (49%) were relatively small - this slope section should be surveyed in 2015 to confirm the result
WP-1 (new)	Pond surface area	>25% from previous monitoring period	N/A	Develop localized mitigation plan	N/A	N/A
WP-2 (new)	Pond outlet width	>15% reduction from previous monitoring period	N/A	Develop localized mitigation plan	N/A	N/A
WP-3 (new)	Pond outlet invert elevation	±0.5 m from previous monitoring period	N/A	Develop localized mitigation plan	N/A	N/A

Appendix 4 Compilation of Recommendations

APPENDIX 4
COMPILATION OF RECOMMENDATIONS

Table 1 Compilation of Recommendations

ID	Description	Implementation	Validity
DS-A (R51)	Monitor (i.e., inspect and survey) drop structures on an annual basis	Ongoing - inspection and survey of all drop structures completed in 2013 and 2014	Valid - practice should continue
DS-B (R104)	Undertake further geotechnical investigation and evaluation to provide a more in-depth discussion on possible causes for differing movement rates between the gabion monitors and waste rock dump monitors	Not implemented	Valid - should be completed prior to site-wide remediation
DS-C (new)	Install additional monitoring points along the waste rock dump toe aligned with the drop structures. A total of eight points should be installed with each point located 20 m south of the monitoring point on the south creek embankment	Should be implemented during 2015 LTMP survey	Improve understanding of influence of waste rock movement on drop structures
DS-D (new)	Establish new monitoring points and cross-section downstream of DS4 that can be safely accessed	Should be implemented during 2015 LTMP survey	Existing monitoring cross-section at downstream end of DS4 can no longer be safely accessed
DS-E (new)	Future survey should include the clear and explicit identification of break points (e.g., toe and top of embankment) through drop structure cross-sections and the edges of each course of gabion baskets along the drop structure centerline	Should be implemented during 2015 LTMP survey	To facilitate the measurement of drop structure cross-section parameters and the review of drop structure profiles
DS-F (new)	Change trigger DS-2 from <0.2 m freeboard to <0.3 m freeboard during conveyance of the 50-year peak flow and adopt revised design flows shown on Figure Nos. 1009 to 1012, Appendix 1	Included on 2014 LTMP drawings	To reflect revised peak flow depth and current hydraulic design practices
DS-G (new)	Change trigger DS3 to measure the drop structure width between the upstream and downstream monitoring points rather than at the upstream drawdown weir and between the downstream monitoring points	Should be implemented as part of 2015 LTMP	Only DS1 was installed with a drawdown weir.
DS-H (R51)	Repair the drop structures damaged by the August 2010 precipitation event	Partially complete: DS3 repaired, DS4 left as is	Valid - DS4 to be repaired in 2015
DS-I (R104)	Develop a stabilization plan and implement to provide long term stability to the site	Ongoing - Remediation strategy developed in 2014 by WorleyParsons	Valid - planning for site wide remediation should continue

ID	Description	Implementation	Validity
CC-A (R51)	Environmental assessment to determine the impacts of stabilization measures at Clinton Creek Channel	Not completed	Valid - should be completed prior to site-wide remediation
CC-B (R51)	Inspect and survey the Clinton Creek channel on an annual basis	Inspection and survey completed in 2014	Valid - practice should continue
CC-C (R104)	Survey of cross-sections A-E along Clinton Creek should be completed on a biennial basis	Survey completed in 2014	Valid - practice should continue
CC-D (R104)	Install additional monitoring pins adjacent to where Clinton Creek has relocated closer to the waste rock area	Not Completed	Valid - refer to recommendation CC-G below
CC-E (R104)	Complete geotechnical investigation of Clinton Creek waste rock dump	Not completed	Valid - should be completed prior to site wide remediation
CC-F (new)	Survey of Cross-Section F along Clinton Creek should be completed on a biennial basis	Should be completed in subsequent LTMPs	Survey required to compare cross-section to previous years and identify geomorphological / topographical changes
CC-G (new)	AAM should consider installing monitoring pins along south slope of Clinton Creek near Station Nos. 0+700, 0+800, and 0+900	Should be implemented as part of 2016 LTMP survey	Will provide additional movement monitoring pins at critical locations along waste rock toe
HL-A (R104)	Monitor outlet for debris accumulations and damage to boom (annually and following major rainfall or flood event)	Ongoing	Valid - practice should continue
HL-B (R104)	Consider installation of automated remote water level monitor to notify AAM when lake water level rises indicating possible blockage of outlet	Not implemented	Valid - should be implemented in 2015
HL-C (R104)	Complete additional topographic survey to confirm freeboard	Completed in 2014	Improve understanding of hydraulic conditions at the outlet
HL-D (new)	Inspect abutments (including condition of rock armouring) monthly during summer by AAM staff and annually by a consultant (preferably following freshet)	Should be implemented in 2015	Required to monitor condition of abutments and rock armouring
HL-E (new)	Assess abutment rock protection (including rock gradation, durability, specific weight, and hardness, as well as a scour analysis) if signs of deterioration of the rock armouring are noted	To be implemented as required	May be required to address rock armouring issues
HL-F (R104)	Review feasibility of reducing Hudgeon Lake water levels and removing the gabion drop structures	Completed by WorleyParsons in 2014	Completed
HL-G (R104)	Conduct a geotechnical investigation / assessment and an environmental assessment to estimate impacts of stabilization measures	Not completed	Valid - assessments should be completed prior to site wide remediation

ID	Description	Implementation	Validity
HL-H (R05)	Remove former water intake at Hudgeon Lake	Completed based on site observations	Completed
AR-A (R51)	Monitor (i.e., inspect and survey) the tension cracks along the closed portion of the site access road on an annual basis	Inspection and survey completed in 2014	Valid - practice should continue
AR-B (R104)	Install depth gauge at Clinton Creek ford	Completed	Completed
AR-C (new)	Extend the baseline to the north and south by 15 m	Should be implemented as part of 2015 Long-Term monitoring program (LTMP) survey	To improve monitoring of the embankment
AR-D (new)	Survey points recorded at the start, end, and changes in direction (greater than 30 deg.) of each tension crack	Should be implemented as part of 2015 LTMP survey	To facilitate measurement of the tension cracks
AR-E (new)	Add a mark to the staff gauge located at Clinton Creek Ford Crossing No. 1 indicating the water level below which it is safe to cross	Should be implemented in 2015	To facilitate safe passage of the crossing
AR-F (R104)	Improve stream crossing on the Wolverine Access Road to enable safe off-road vehicle access	Not implemented	Valid - implementation should be considered as part of site wide remediation
AR-G (R104)	Close the site access road adjacent to the upper portion of Clinton Creek with 1.5 m earth berm and erect signs to restrict foot traffic	Partially implemented (lock blocks and chain used at east end of road)	Completed
AR-H (R104)	Install slide hazard and no stopping signs and scale loose rock at Slide No. 3 along the wet active area of the access road from Forty Mile Bridge to Wolverine Creek	Implemented based on discussion with AAM staff	Completed
AR-I (R104)	Flag shoulder failure locations along the Snowshoe and Porcupine Pit roads by erecting warning signs with “Hazard Warning - Unstable Shoulders. Keep Clear”	Implemented based on discussion with AAM staff	Completed
AR-J (R104)	Dislodge large boulder perched above the main site access road	Implemented based on discussion with AAM staff	Completed
AR-HK (R104)	Complete a survey of the site access roads to determine current drainage patterns and re-grade the road to improve surface water management	Not completed	Valid - should be completed prior to site wide remediation
WR-A (R51)	Visual inspection of the waste rock dump should be completed on an annual basis with survey completed on a biennial basis	Inspection and survey completed in 2014	Valid - practice should continue
WR-B (R104)	Trigger level for waste rock monitors should be further investigated and implemented	Included in 2014 report	Completed

ID	Description	Implementation	Validity
WR-C (new)	Survey upper slope monitoring points in 2015 and compare to 2014 data	Should be completed as part of 2015 LTMP survey	Required to determine if upper slope waste rock movement is accelerating
WR-D (R05)	Demolish crusher building including tram line tower and equipment. Landfill all asbestos fibres and structure materials	Completed	Completed
WR-E (R05)	Demolish and landfill ANFO fertilizer storage tank and landfill tank, conveyors, and tank loading area	Completed	Completed
WR-F (R05)	Decommission drill and shovel (e.g., recover fluids and filters)	Unknown	Valid
TP-A (R104)	Visual inspection and survey of the Wolverine Creek tailings pile should be completed on a biennial basis	Inspection and survey completed in 2014	Valid - practice should continue
TP-B (R104)	Complete geotechnical investigation and assessment of the north and south lobes of the Wolverine Creek tailings pile	Not completed	Valid - required to improve understanding of variance in average movement rates between north and south lobes
TP-C (new)	Visual inspection of the Wolverine Creek tailings pile should be completed on an annual basis	Should be completed as part of future LTMPs	Required to identify visible tension cracks and slumping to determine if further investigation is required in that year
TP-D (new)	Survey of the Wolverine Creek tailings pile should be completed on a biennial basis	Should be completed as part of future LTMPs	Required to monitor movement rates through the tailings pile
TP-E (R05)	Assess stability of tailings pile movement	Completed	Completed
TP-F (R05)	Complete air monitoring program to determine levels of fugitive asbestos dust	Completed	Completed
TP-G (R05)	Decommission mill components	Completed	Completed
TP-H (R05)	Remove timber deck and ladder from tram towers 1-12 and cover asbestos at base of tower as required	Completed	Completed
TP-I (R05)	Demolish tram terminus structure	Partially completed with some towers still standing	Valid - towers should be demolished as part of site wide remediation
WC-A (R104)	Visual inspection and survey of the rock lined channel and weirs on Wolverine Creek should be completed on a biennial basis	Inspection and survey completed in 2014	Valid - but clarification required, refer to recommendations WC-B and WC-C below

ID	Description	Implementation	Validity
WC-B (new)	Visual inspection of the Wolverine Creek channel from the confluence with Clinton Creek to the outlet at the south pond, from the inlet of the south pond to the outlet of the north pond, and approximately 100 m north of the north pond inlet should be completed on an annual basis	Should be completed as part of future LTMPs	Required to identify potential and existing failures of creek channel components and provide a recommendation regarding potential repair strategy
WC-C (new)	Survey of the Wolverine Creek channel (as described above) should be completed on a biennial basis	Should be completed as part of future LTMPs	To facilitate monitoring of channel movement (e.g., downcutting) between monitoring periods
WC-D (new)	Establish secondary control point above Wolverine Creek with line of sight to the 200 m portion of the creek extending downstream from the outlet of the south pond	Should be implemented as part of 2016 survey	To reduce survey signal interference from trees and improve survey accuracy
WP-A (R104)	Visual inspection of the Wolverine ponds should be completed on an annual basis with survey completed on a biennial basis	Inspection and survey completed in 2014	Valid - required to check for debris accumulation and blockage
WP-B (R104)	Clear debris caused by beaver activity	Completed	Completed
WP-C (R104)	Continue to monitor debris accumulations on a regular basis	Ongoing	Valid - practice should continue
WP-D (R104)	Install log booms upstream of inlet to collect debris	Not implemented	Valid - feasibility of installation, including preliminary cost estimates should be reviewed
WP-E (R05)	Install meteorological station	Completed	Completed
PP-A (new)	Inspect Porcupine Pit and Snowshoe Pit on an annual basis and survey Porcupine Pit monitoring points on a biennial basis	Survey and inspection completed in 2014	Required to monitor pit conditions and movement rates
PP-B (new)	Establish four monitoring points around Snowshoe Pit	Should be implemented as part of 2016 survey	Required to monitor movement rates in and around Snowshoe Pit
PP-C (R05)	Temporarily block access to the Porcupine, Snowshoe, and Creek pits until mine closure works are complete, then provide permanent blockage	In progress: temporary measures are in place	Valid - permanent barriers should be installed following site-wide remediation
PP-D (R104)	Install vehicle barricades or berms to prevent vehicles from entering the pit and post notices of safety risk and restrict entry to all but essential personnel	Completed	Completed