

**APPENDIX 9-B
KSM PROJECT GEOHAZARD
RISK REDUCTION SUMMARY: REV B**



BGC ENGINEERING INC.

AN APPLIED EARTH SCIENCES COMPANY

Suite 500 - 1045 Howe Street, Vancouver, British Columbia, Canada. V6Z 2A9
Telephone (604) 684-5900 Fax (604) 684-5909

BGC Project Memorandum

To:	Seabridge Gold	Doc. no:	
Attention:	Brent Murphy	cc:	MJ, MP
From:	K. Holm, B. Gould	Date:	July 10, 2012
Subject:	KSM Project Geohazard Risk Reduction Summary: Rev B		
Project no:	0638-013		

1.0 INTRODUCTION

BGC Engineering Inc. (BGC) provided Seabridge Gold Inc. (Seabridge) with a landslide and snow avalanche geohazard and risk assessment for the KSM Project (BGC 2012a, 2012b). This work included estimation of landslide and snow avalanche geohazard risk to proposed facilities as Low, Moderate, High, or Very High. The primary objective of these ratings was to assist Seabridge in their prioritization of landslide and snow avalanche geohazard mitigation options. Seabridge advised BGC that landslide and snow avalanche geohazard risk estimates categorized as High or Very High are not considered tolerable. Where practical and cost-efficient, further risk reduction could be achieved.

This memorandum summarizes the High and Very High landslide and snow avalanche geohazard risk scenarios identified in BGC (2012a, 2012b), and tabulates mitigation options proposed by BGC or Alpine Solutions Avalanche Services (Alpine Solutions) for each scenario. The purpose of this report is to summarize the geohazard mitigation options described thus far by BGC or Alpine Solutions, as a starting point to review and document geohazard mitigation work completed by the entire project team. Other team members can then determine what, if any, further design work is required by their group to fulfill the proposed geohazard risk reduction at the next level of study.

The term "geohazard" is used exclusively in this memorandum to describe naturally-occurring landslide and snow avalanche processes. Facility names referred to in this memorandum correspond to those in BGC (2012a, 2012b). Reports referenced in this memorandum include BGC's Rev C geohazard risk assessment (BGC 2012a, 2012b), geohazard mitigation designs for the Ore Preparation Complex (2012c), a preliminary geotechnical assessment of the Snowfields Landslide (BGC 2012d), and an overview snow avalanche management plan (Alpine Solutions 2011).

The following information is not provided in this memorandum:

- a summary of the status of geohazard mitigation design where design has been advanced beyond BGC or Alpine Solutions recommendations by other members of the project team;
- geohazard risk assessment for facilities during construction;
- detailed design basis, geometric design and quantities for proposed mitigation measures;
- recommendations for construction scheduling of mitigation measures or discussion of operation and maintenance issues;
- mitigation measures for geohazards resulting from slope modifications during mine development;
- mitigation for geohazards interpreted as resulting in Moderate or lower risk to project facilities; and
- mitigation for the proposed Treaty Creek transmission line. A geotechnical assessment for the proposed transmission line is anticipated to be completed in late August 2012.

2.0 GEOHAZARD RISK SUMMARY

Geohazard risks to proposed KSM project facilities are tabulated in Appendix C of BGC (2012a) and Appendix B of BGC (2012b). Of these, High and Very High risks were identified for the facilities listed in Table 2-1 and tabulated in Appendix A of this memorandum.

Table 2-1. Summary of Facilities Subject to High or Very High Unmitigated Geohazard Risk

Area	Landslide	Snow Avalanche
Coulter Creek Access		
Coulter Creek Access Road		✓
McTagg		
Phase 3 McTagg Inlet East		✓
Phase 3 McTagg Inlet West		✓
Phase 2 McTagg Inlet	✓	✓
McTagg Rock Storage Facility		✓
McTagg Access Road (Road F)		✓
McTagg Diversion Channel Tunnel South Portals (Gingrass Creek)		✓
Mitchell		
Mitchell Pit	✓	✓
Phase 1 Haul Road	✓	✓
Iron Cap Haul Road	✓	✓
North Mitchell Glacier Diversion Ditch	✓	✓
Snowfields ARD Collection Ditch	✓	✓
North Access Road		✓
Ore Preparation Complex and Mitchell-Teigen Tunnel Portal (South)	✓	✓
Sulphurets-Mitchell Conveyor Tunnel Portal (N)	✓	✓
Mitchell Rock Storage Facility	✓	✓
Upper Sulphurets		
Sulphurets Ridge Crusher Access Road (Road K)		✓
Kerr Pit		✓
Kerr Pit Access Road		✓
Ted Morris Creek		
Initial Ice Access (Ted Morris Portion)		✓
Tailings Facility		
TMF North Seepage Collection Dam		✓
TMF North Dam		✓
Splitter Dam		✓
Upper East Diversion Intake		✓
Northeast Diversion Ditch		✓
Northeast Buried Pipeline and Service Road		✓
Southeast Diversion Ditch		✓
Treaty Creek Access		
Treaty Access Road (Km 0-18)		✓
Treaty Access Road (Km 18-32)		
Plant Site Access Road Initial and Ultimate Alignments		
Upper Treaty Lined PAG Pad		
Upper Treaty Treatment Plant		
Upper Treaty NAG Pad		✓

3.0 GEOHAZARD RISK REDUCTION OPTIONS

3.1. Overall Strategy

Risk reduction strategy options can reduce risk in different ways. They can reduce the:

- probability of the geohazard occurring;
- the geohazard magnitude (e.g. volume, peak discharge);
- the geohazard intensity (e.g. runout distance, velocity, impact forces);
- the spatial probability of impact (likelihood that the geohazard will reach or impact the element at risk);
- the temporal probability of impact (likelihood of workers being present in the zone subject to the hazard); and
- the vulnerability (the degree of loss to a given element at risk within the area affected by the snow avalanche or landslide hazard).

The proposed risk reduction options for particular sites will vary according to operational requirements. For example, measures described for the Ore Preparation Complex consider the need for uninterrupted operation, whereas strategies for access roads may tolerate temporary closures for active avalanche control. In other cases, strategies include adjustments to mine planning such as consideration of the Snowfield Landslide in the excavation staging of the Mitchell Pit.

The proposed risk reduction options summarized in this memorandum follow previous efforts by the project team to avoid geohazard exposure at facility locations wherever possible, during facility location planning.

3.2. Specific Strategies

Geohazard risk reduction alternatives for High and Very High risk scenarios are tabulated in Appendix A. Table 3-1 summarizes the information included.

Table 3-1. Description of risk reduction measures

Column	Description
Risk Reduction Type	Overview of risk reduction type
Risk Reduction Description	Reference or brief description of risk reduction measure. References are provided in cases where the risk reduction measures have been previously described.
Assumptions/Uncertainties	Assumptions upon which the risk reduction type is based

4.0 RECOMMENDATIONS

4.1. Review by Project Team

BGC recommends that this memorandum be reviewed by the members of the project team responsible for the design of facilities mentioned in this memorandum. The objectives of this review are:

- Cross-check the geohazard risk reduction measures described in this memorandum with those that may have already included by the project team for proposed facilities;
- identify any changes in facility arrangements since issue of BGC (2012a, 2012b) that render obsolete the risk reduction options described in this memorandum; and
- identify any gaps or inconsistencies that require further work.

Following such review, BGC recommends that this memorandum be revised to provide an updated summary of risk reduction measures undertaken by the Project Team.

4.2. Updated Geohazard Risk Assessment

BGC understands that Rescan is preparing KSM General Arrangements (GA) for three different project stages, including construction, operations, and post-closure mine stages. BGC (2012a, 2012b) considered a single GA (Drawing 10-10-001 KSM Project Overall Site Rev B), dated April 10 2012.

As a first step, BGC recommends updating the site-wide geohazard risk assessment to be consistent with the three GAs included in the EA submission. While this will not be completed in time for EA submission, it will form the basis for geohazard risk reduction design work required at later phases, including project permitting and construction.

Additional landslide and snow avalanche assessments will also be required to obtain the input parameters necessary for more detailed design of geohazard risk reduction measures. BGC recommends that this be addressed for each individual facility, including consideration of post-construction surface topography (cut slopes and fill placement). This work should involve close collaboration between the geohazard specialists and the facility design team.

Further detailed assessments of the large landslides within the project area, including the Snowfields, Kerr, Embayment, and East Catchment landslides, are recommended at the next study level.

4.3. Snow Avalanche Management Plan for Mine Operations

The overview avalanche management plan (Alpine Solutions 2011) was completed for a facility arrangement that has changed since that report issue. The avalanche management plan should be updated to reflect the current project layout prior to implementation of the plan.

During project conception, avalanche observations should also be completed on an intermittent basis (at least once per winter/spring), concurrent with ongoing local weather

observations (data-loggers). A database of at least 3-5 years of observations will greatly increase the precision of avalanche technicians' decisions in the early years of mine construction. This will minimize avalanche-related delays during construction as well as during the first few years of operation.

4.4. Geohazard Risk Reduction Design for Construction

Implementation of landslide and snow avalanche geohazard risk reduction measures will be affected by construction sequencing and the timeline to build and install all fixed protection measures. Previous experience with these types of projects suggests:

- Careful planning of construction sequence will be required to ensure there is limited risk to personnel and facilities during construction.
- The possibility of significant access limitations during the winter months (due to avalanche risk) that could create delays in construction.

BGC recommends that a landslide and snow avalanche geohazard risk reduction plan be completed for the project construction stage. This should include temporary measures to protect facilities exposed to geohazards prior to completion of permanent mitigation measures (e.g. structural barriers). Temporary roads proposed at early stages of mine construction should also be assessed. This plan should be updated as required for operational and closure stages of the project. Some of this work has been completed in BGC's review of geohazard impacts on potential construction delays for pioneer roads (BGC 2012e).

5.0 LIMITATIONS

The key in conceptualizing the risk reduction measures is to reach a confidence that High and Very High risks are reduced to Moderate, which BGC understands is a risk level considered tolerable by Seabridge. Zero risks is not achievable due to the inherent uncertainties in geophysical processes and analytical methods that cause and trigger geohazards. In addition, geohazard risk could cause intermittent operational limitations for any facility throughout the winter season. This may happen during periods of very high or extreme avalanche hazard or during avalanche control missions, and may include temporary road closures, travel or working restrictions within certain areas, and temporary evacuation of facilities in exceptional circumstances. When and for how long these operational limitations occur will be a function of the level of mitigation provided for the facility in question and by a group of snow avalanche technicians that will be required at the mine throughout winter and spring.

BGC's geohazard and risk reports are based on existing ground conditions, naturally occurring geohazards and a particular facilities arrangement. Facility layouts may change, which will require re-evaluation or optimization of geohazard reduction options, including those described in this memorandum.

6.0 CLOSURE

BGC and Alpine Solutions prepared this document for the account of Seabridge Gold. The material in it reflects the judgment of BGC and Alpine Solutions staff in light of the information available to BGC and Alpine Solutions at the time of document preparation. Any use which a third party makes of this document or any reliance on decisions to be based on it is the responsibility of such third parties. BGC and Alpine Solutions accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.

As a mutual protection to our client, the public, and ourselves, all documents and drawings are submitted for the confidential information of our client for a specific project. Authorization for any use and/or publication of this document or any data, statements, conclusions or abstracts from or regarding our documents and drawings, through any form of print or electronic media, including without limitation, posting or reproduction of same on any website, is reserved pending BGC's written approval. If this document is issued in an electronic format, an original paper copy is on file at BGC and that copy is the primary reference with precedence over any electronic copy of the document, or any extracts from our documents published by others.

Yours sincerely,

BGC ENGINEERING INC.

per:

Kris Holm, M.Sc., P.Geo
Senior Geoscientist

Brian Gould, P.Eng
Senior Avalanche Specialist (Alpine Solutions)

Reviewed by:

Mark Pritchard, M.Sc., P.Eng
Senior Geotechnical Engineer

Matthias Jakob, Ph.D., P.Geo.
Senior Geoscientist

Attach:

Appendix A Mitigation Summary for High and Very High Geohazard Risk Scenarios

REFERENCES

Alpine Solutions, 2011. Active Avalanche Management Plan for the KSM Project. Report prepared for BGC Engineering and Seabridge Gold. Dated May 4, 2011.

BGC Engineering, 2011. KSM Project Geohazard Risk Reduction Options: Rev A. Prepared for Seabridge Gold, dated June 1, 2011.

BGC Engineering, 2012a. KSM Project Geohazard and Risk Assessment, Minesite and Coulter Creek Access, Revision C. Prepared for Seabridge Gold, dated June 1, 2012.

BGC Engineering, 2012b. KSM Project Geohazard and Risk Assessment, TMF, Teigen, and Treaty Creek Access, Revision C. Prepared for Seabridge Gold, dated June 1, 2012.

BGC Engineering, 2012c. KSM Geohazards: OPC Pre-Feasibility Geohazards Risk Reduction – Rev C. Prepared for Seabridge Gold, dated February 20, 2012.

BGC Engineering, 2012d. Preliminary Geotechnical Assessment of the Snowfield Landslide. Prepared for Seabridge Gold, dated June 21, 2012.

BGC Engineering, 2012e. KSM Project: Review of Geohazard Impacts on Potential Construction Delays for Pioneer Roads – Draft for Discussion. Prepared for Seabridge Gold Inc., dated February 14, 2012.

APPENDIX A MITIGATION SUMMARY FOR HIGH AND VERY HIGH RISK SCENARIOS

TABLE A-1 MITCHELL CREEK VALLEY RISK REDUCTION

HAZARD IDENTIFICATION			ANNUAL HAZARD FREQ.		ANNUAL PROBABILITY OF UNWANTED OUTCOME					CONSEQUENCE ESTIMATION (OPERATION)					UNMITIGATED	MITIGATION SUMMARY			
Facility	Process/Scenario	Direct Consequence	F (min) ¹	F (max) ¹	P _{S,H}	P _{T,H}	V	P _(min)	P _(max)	Likelihood	Safety	Envir.	Econ.	Reputation	Max Cons.	Risk	Type	Description	Assumptions/Uncertainties
Mitchell Pit	Snow avalanche runout into pit (Size 2-3)	Damage of machinery	1	10	0.5	1	0.5	0.25	2.5	Very Likely	-	5	4	4	4	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	Assumes integration with pit development plan
	Snow avalanche runout into pit (Size 3-4)	Destruction of machinery	0.1	1	1	0.1	1	0.01	0.1	Moderate	-	4	3	3	3	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	Assumes integration with pit development plan
	Snow avalanche runout into pit (Size 3-4)	Fatality	1	1	1	0.1	1	0.01	0.1	Moderate	3	-	-	-	-	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	Assumes integration with pit development plan
	Snow avalanche runout into pit (Size 4)	Destruction of machinery	0.1	1	1	0.1	1	0.01	0.1	Moderate	-	3	2	2	2	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	Assumes integration with pit development plan
	Snow avalanche runout into pit (Size 4)	Multiple fatalities (<10)	0.1	1	1	0.1	1	0.01	0.1	Moderate	2	-	-	-	-	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	Assumes integration with pit development plan
	Rock Fall	Damage of machinery	0.1	1	1	0.5	1	0.05	0.5	Likely	-	6	4	4	4	HIGH	Address as part of pit design and monitoring.	See BGC (2012a, 2012d)	-
	Rock Fall	Fatality	0.1	1	1	0.1	1	0.01	0.1	Moderate	3	-	-	-	-	HIGH	Address as part of pit design and monitoring.	See BGC (2012a, 2012d)	-
	Snowfield Landslide runs into pit (large = > 10 ⁶ m ³)	Destruction of machinery/pit closed	0.0001	0.001	1	1	1	<0.00001	0.001	Very Unlikely	-	3	1	2	1	HIGH	Address as part of pit design and monitoring.	See BGC (2012a, 2012d)	Assumes detailed geotechnical study of Snowfield Landslide
Phase 1 Haul Road	Rock fall from Snowfield Landslide	Vehicle damaged	10	100	0.1	0.1	0.5	0.05	0.5	Likely	-	5	4	4	4	HIGH	Consider as part of haul road design.	-	Assumes additional rockfall size and energy estimates will be made to provide site-specific dimensions for rockfall protection during feasibility design
	Rock fall from Snowfield Landslide	Fatality	10	100	0.1	0.1	0.5	0.05	0.5	Likely	3	-	-	-	-	HIGH	Consider as part of haul road design.	-	Assumes additional rockfall size and energy estimates will be made to provide site-specific dimensions for rockfall protection during feasibility design
	Snow avalanches (Size 3-4)	Vehicle damaged	1	10	1	0.1	0.5	0.05	0.5	Likely	-	5	4	3	3	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	Assumes integration with pit development plan
	Snow avalanches (Size 3-4)	Fatality	1	10	1	0.1	0.5	0.05	0.5	Likely	3	-	-	-	-	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	Assumes integration with pit development plan
	Large-scale detachment of Snowfield Landslide	Multiple fatalities (<10)	0.001	0.01	1	1	1	0.001	0.01	Unlikely	2	-	-	-	-	HIGH	Address as part of pit design and monitoring.	See BGC Engineering (2012d)	Assumes detailed geotechnical study of Snowfield Landslide
Iron Cap Haul Road	Snow avalanches (Size 3-4)	Vehicle damaged	1	10	1	0.1	0.5	0.05	0.5	Likely	-	5	4	3	3	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
	Snow avalanches (Size 3-4)	Fatality	1	10	1	0.1	0.5	0.05	0.5	Likely	3	-	-	-	-	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
	Rock fall impact	Fatality	1	10	0.5	0.01	0.5	0.0025	0.025	Moderate	3	-	-	-	-	HIGH	Consider as part of haul road design.	-	Assumes additional rockfall size and energy estimates will be made to provide site-specific dimensions for rockfall protection during feasibility design
North Mitchell Glacier Diversion Ditch	Snow avalanches (Size 3-4)	Diversion ditch blocked	1	10	1	0.1	0.5	0.05	0.5	Likely	-	5	4	4	4	HIGH	Grated channel cover in gullies	Grated, reinforced concrete or steel intake at gullies, maintenance of ditch through length (clean out) prior to spring melt	-
	Rock fall impact	Diversion ditch blocked	1	10	1	1	0.5	0.5	5	Very Likely	-	5	4	4	4	HIGH	Grated channel cover in gullies	Grated, reinforced concrete or steel intake at gullies, maintenance of ditch through length (clean out)	-
	Debris flow impact (Size 3)	Diversion ditch blocked	0.1	1	1	1	0.5	0.05	0.5	Likely	-	5	4	4	4	HIGH	Grated channel cover in gullies	Grated, reinforced concrete or steel intake at gullies, maintenance of ditch through length (clean out)	-
Snowfields ARD Collection Ditch	Rock fall impact	Diversion ditch blocked	1	10	1	1	0.5	0.5	5	Very Likely	-	5	4	4	4	HIGH	Grated channel cover	Grated, reinforced concrete or steel cover, maintenance of ditch through length (clean out) prior to spring melt	-
	Snow Avalanches (Size 3-4)	Diversion ditch blocked	1	10	1	1	1	1	10	Very Likely	-	5	4	3	3	VERY HIGH	Grated channel cover	Grated, reinforced concrete or steel cover, maintenance of ditch through length (clean out) prior to spring melt	-
	Debris flow impact (Size 2)	Diversion ditch blocked	0.1	1	1	1	1	0.1	1	Very Likely	-	5	4	4	4	HIGH	Grated channel cover	Grated, reinforced concrete or steel cover, maintenance of ditch through length (clean out) prior to spring melt	-
North Access Road	Snow avalanche impact (Size 2-4)	Damage/destruction of vehicles	1	10	1	0.1	0.5	0.05	0.5	Likely	-	4	3	3	3	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
	Snow avalanche impact (Size 2-4)	Fatality	1	10	1	0.1	0.5	0.05	0.5	Likely	3	5	4	3	3	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
Ore Preparation Complex and Mitchell-Teigen Tunnel Portal (South)	Snow avalanche impact (Size 2-4)	Damage/destruction of facilities	1	10	1	1	0.5	0.5	5	Very Likely	-	4	3	3	3	VERY HIGH	OPC Geohazard Risk Reduction Plan; Avalanche Management Plan	See BGC (2012c), Alpine Solutions (2011)	-
	Snow avalanche impact (Size 2-4)	Fatality	1	10	1	1	0.5	0.5	5	Very Likely	3	5	4	3	3	VERY HIGH	OPC Geohazard Risk Reduction Plan; Avalanche Management Plan	See BGC (2012c), Alpine Solutions (2011)	-
	Snow avalanche impact (Size 2-4)	Multiple fatalities (<10)	1	10	1	1	0.5	0.5	5	Very Likely	2	5	2	2	2	VERY HIGH	OPC Geohazard Risk Reduction Plan; Avalanche Management Plan	See BGC (2012c), Alpine Solutions (2011)	-
	Rock fall impact	Fatality	0.1	1	0.5	1	0.5	0.025	0.25	Likely	3	5	4	4	3	HIGH	OPC Geohazard Risk Reduction Plan; Avalanche Management Plan	See BGC (2012c), Alpine Solutions (2011)	-
	Debris flow impact (Size 3)	Damage of facilities	0.1	1	1	1	0.5	0.05	0.5	Likely	-	4	4	4	4	HIGH	OPC Geohazard Risk Reduction Plan; Avalanche Management Plan	See BGC (2012c), Alpine Solutions (2011)	-
	Debris flow impact (Size 3)	Fatality	0.1	1	1	1	0.5	0.05	0.5	Likely	3	-	-	-	-	HIGH	OPC Geohazard Risk Reduction Plan; Avalanche Management Plan	See BGC (2012c), Alpine Solutions (2011)	-
	Debris flow impact (Size 4)	Damage of facilities	0.01	0.1	1	1	0.5	0.005	0.05	Moderate	-	3	3	4	3	HIGH	OPC Geohazard Risk Reduction Plan; Avalanche Management Plan	See BGC (2012c), Alpine Solutions (2011)	-
	Debris flow impact (Size 4)	Multiple fatalities (<10)	0.01	0.1	1	1	0.5	0.005	0.05	Moderate	2	-	-	-	-	HIGH	OPC Geohazard Risk Reduction Plan; Avalanche Management Plan	See BGC (2012c), Alpine Solutions (2011)	-

TABLE A-1 MITCHELL CREEK VALLEY RISK REDUCTION

HAZARD IDENTIFICATION			ANNUAL HAZARD FREQ.		ANNUAL PROBABILITY OF UNWANTED OUTCOME					CONSEQUENCE ESTIMATION (OPERATION)					UNMITIGATED	MITIGATION SUMMARY			
Facility	Process/Scenario	Direct Consequence	F (min) ¹	F (max) ¹	P _{S,H}	P _{T,H}	V	P _(min)	P _(max)	Likelihood	Safety	Envir.	Econ.	Reputation	Max Cons.	Risk	Type	Description	Assumptions/Uncertainties
Sulphurets-Mitchell Conveyor Tunnel Portal (N)	Snow avalanche impact (Size 2/3) Path M-S-6	Entrance blocked	1	10	1	1	1	1	10	Very Likely	-	6	5	6	5	HIGH	Structural protection; also Avalanche Management Plan	Reinforced concrete splitter; also see Alpine Solutions (2011)	-
	Snow avalanche impact (Size 2-4) Path M-S-6	Fatality	1	10	0.5	1	0.5	0.25	2.5	Very Likely	3	5	4	3	3	VERY HIGH	Structural protection; also Avalanche Management Plan	Reinforced concrete splitter; also see Alpine Solutions (2011)	-
	Snow avalanche impact (Size 2-4) Path M-S-6	Multiple fatalities (<10)	1	10	0.5	1	0.5	0.25	2.5	Very Likely	2	5	3	2	2	VERY HIGH	Structural protection; also Avalanche Management Plan	Reinforced concrete splitter; also see Alpine Solutions (2011)	-
	Rock fall impact	Entrance blocked	0.1	1	1	1	0.5	0.05	0.5	Likely	5	5	4	4	4	HIGH	Structural protection	Integrate with snow avalanche protection	-
	Rock fall impact	Fatality during construction	0.1	1	1	0.5	1	0.05	0.5	Likely	3	5	4	4	3	HIGH	Structural protection	Integrate with snow avalanche protection	-
Mitchell Rock Storage Facility	Snow avalanche impact (Size 2-4)	Fatality	1	10	1	1	0.5	0.5	5	Very Likely	3	5	4	4	3	VERY HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
	Rock fall impact	Fatality	1	10	1	0.1	1	0.1	1	Very Likely	3	5	5	5	3	VERY HIGH	Address as part of RSF design and monitoring.	-	-
Construction Period PAG Storage and ARD Treatment	Snow avalanche impact (Size 2-4)	Damage to pad	1	10	1	1	0.5	0.5	5	Very Likely	5	5	5	5	3	VERY HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
	Snow avalanche impact (Size 2-4)	Fatality	1	10	1	0.1	1	0.1	1	Very Likely	3	5	5	5	5	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
North Slope Diversion Ditch	Snow avalanche impact (Size 2-4)	Diversion Ditch blocked	1	10	1	1	0.5	0.5	5	Very Likely	5	5	5	5	5	HIGH	Grated channel cover in gullies	Grated, reinforced concrete or steel intake at gullies, maintenance of ditch through length (clean out) prior to spring melt	-
Mitchell Closure Channel	Snow avalanche impact (Size 2-4)	Closure channel blocked	1	10	1	1	0.5	0.5	5	Very Likely	5	5	5	5	5	HIGH	Address as part of channel design	-	-
Closure Ditch	Snow avalanche impact	Ditch blocked	1	10	1	1	0.5	0.5	5	Very Likely	5	5	5	5	5	HIGH	Address as part of ditch design	-	-
Mitchell South Closure Channel	Snow avalanches	ditch blocked	1	10	1	1	1	1	10	Very Likely	5	5	5	5	5	HIGH	Address as part of channel design	-	-
	Rock fall impact	ditch blocked	0.1	1	1	1	1	0.1	1	Very Likely	5	5	5	5	5	HIGH	Address as part of channel design	-	-
Mitchell Valley Crusher Access Road	Snow avalanche impact (Size 2-3)	Road blocked	1	10	1	1	1	1	10	Very Likely	-	6	5	6	5	HIGH	Avalanche Management Plan + OPC Geohazard Risk Reduction Plan	See BGC (2011), Alpine Solutions (2011)	-
	Snow avalanche impact (Size 2-4)	Fatality	1	10	1	0.01	0.5	0.005	0.05	Moderate	3	6	3	4	3	HIGH	Avalanche Management Plan + OPC Geohazard Risk Reduction Plan	See BGC (2011), Alpine Solutions (2011)	-
Landbridge	Snow avalanche impact (size 2-4)	Fatality	1	10	1	0.1	1	0.1	1	Very Likely	3	5	5	5	3	VERY HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
Water Storage Dam and Water Storage Pond	Snow avalanche impact (size 3,4)	Displacement wave, dam overtopping	0.01	0.1	1	1	0.5	0.005	0.05	Moderate	-	3	3	3	3	HIGH	Dam Freeboard	Covered under dam design	-
	Snow avalanche impact (size 4)	Displacement wave, dam breach; impact of water treatment plant	0.001	0.01	1	1	0.01	0.0001	0.001	Very Unlikely	2	2	1	2	1	HIGH	Dam Freeboard	Covered under dam design	-

TABLE A-2 MCTAGG AND GINGRASS CREEK WATERSHED RISK REDUCTION

HAZARD IDENTIFICATION			ANNUAL HAZARD FREQ.		ANNUAL PROB. OF UNWANTED OUTCOME					CONSEQUENCE ESTIMATION (OPERATION)					UNMITIGATED	MITIGATION SUMMARY			
Facility	Process/Scenario	Direct Consequence	F (min)	F (max)	P _{SL}	P _{T-H}	V	P _(min)	P _(max)	Likelihood	Safety	Envir.	Econ.	Reputation	Max Cons.	Risk	Type	Description	Assumptions/Uncertainties
Phase 3 McTagg Inlet East	Snow avalanche impact	Inlet blocked	1	10	1	1	0.5	0.5	5	Very Likely		5	5	5	5	HIGH	Structural protection, Avalanche Management Plan	Intake to withstand load from accumulation of multiple avalanche deposits; see Alpine Solutions (2011)	Assumes portal cover will be considered as part of portal design.
Phase 3 McTagg Inlet West	Snow avalanche impact	Inlet blocked	1	10	1	1	0.5	0.5	5	Very Likely		5	5	5	5	HIGH	Structural protection, Avalanche Management Plan	Intake to withstand load from accumulation of multiple avalanche deposits; see Alpine Solutions (2011)	Assumes portal cover will be considered as part of portal design.
Phase 2 McTagg Inlet	Snow avalanche impact (Size 2-4)	Inlet blocked	1	10	1	1	0.5	0.5	5	Very Likely		5	5	5	5	HIGH	Structural protection, Avalanche Management Plan	Intake to withstand load from accumulation of multiple avalanche deposits; see Alpine Solutions (2011)	Assumes portal cover will be considered as part of portal design.
	Debris flow impact (Size 3)	Inlet blocked	0.1	1	1	1	1	0.1	1	Very Likely		5	5	5	5	HIGH	Deflection berm	Earth berm with upstream excavation	Assumes temporary storage of material and snow and debris removal.
McTagg Rock Storage Facility	Snow Avalanche (Size 2-4)	Fatality	1	10	1	1	0.5	0.5	5	Very Likely	3	5	4	4	3	VERY HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
McTagg Access Road (Road F)	Snow avalanche impact (Size 2-3)	Road blocked	1	10	1	1	0.5	0.5	5	Very Likely	-	6	5	6	5	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
	Snow avalanche impact (Size 3-4)	Fatality	0.1	1	1	0.1	0.5	0.005	0.05	Moderate	3	5	3	3	3	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
	Snow avalanches (Size 2-4)	Channel blockage and spill	1	10	1	1	0.5	0.5	5	Very Likely	-	5	5	5	5	HIGH	Channel design	Consider snow avalanche deposition in channel design capacity	-
McTagg Diversion Tunnel South Portals (Gingrass Creek Watershed)	Snow avalanches (Size 2-3)	Tunnel blockage and spill	0.1	1	1	1	0.5	0.05	0.5	Likely	-	5	4	5	4	HIGH	Structural protection, Avalanche Management Plan	Outlet to withstand load from accumulation of multiple avalanche deposits.	Assumes portal cover will be considered as part of portal design.

TABLE A3 UPPER SULPHURETS VALLEY RISK REDUCTION

Facility	Process/Scenario	Critical Consequence	ANNUAL HAZARDOUS EVENTS		ANNUAL PROBABILITY OF OCCURRENCE					Likelihood	IMPACT					UNMITIGATED RISK	Mitigation Measure	Mitigation Summary	Assumptions/Uncertainties
			F _{min}	F _{max}	P _H	P _V	P _{M.O}	P _A	Safety		Environment	Economic	Reputation	Mix/Cons.					
Sulphurets Ridge Crusher Access Road	Snow avalanche impact (size 2-3)	Road blockages		10					10	Very likely						HIGH	Site Management Plan	See Alpine Solutions (2011)	Assumes integration with pit development plan
Kerr Pit	Snow avalanche impact (size 3)	Partial		10	0.5	0.1	0.5	0.025	0.25	Light						HIGH	Site Management Plan	See Alpine Solutions (2011)	
Kerr Pit Access Road	Slope deformation and/or small debris flows impacting road	Interruption of access traffic for hours to days	0.1					0.1		Very likely						HIGH	Monitoring and maintenance	Regular site inspections, slope movement instrumentation, remote sensing monitoring (e.g. InSAR as applicable)	
	Snow avalanche impact (size 3-4)	Road closures 1 day		10				0.05	0.05	Very Like						HIGH	Site Management Plan	See Alpine Solutions (2011)	

TABLE A-4 -TED MORRIS VALLEY RISK REDUCTION

HAZARD IDENTIFICATION			ANNUAL HAZARD FREQ.		ANNUAL PROBABILITY OF UNWANTED OUTCOME				CONSEQUENCE ESTIMATION (OPERATION)					UNMITIGATED	MITIGATION SUMMARY				
Facility	Process/Scenario	Direct Consequence	F (min)	f (max)	P _s	P _o	P _j	P _v	Likelihood	Safety	Envir.	Econ.	Reputation	Max Cons.	RISK	Type	Description	Assumptions/Uncertainties	
Temporary Ice Road Access (Ted Morris Portion)	Is now avalanche impact size 314	Multiple fatalities (<10)	11	10	11	o	j	1j	0.00501	0.0051	Moderate	2	5	2	2	2	Avalanche Management Plan	see Alpine Solutions (2011)	

TABLE A-5 - PLANT SITE AND TAILINGS MANAGEMENT FACILITY RISK REDUCTION

HAZARD IDENTIFICATION			ANNUAL HAZARD FREQ.		ANNUAL PROBABILITY OF UNWANTED OUTCOME						CONSEQUENCE ESTIMATION (OPERATION)					UNMITIGATED	MITIGATION SUMMARY		
Facility	Process/Scenario	Direct Consequence	F (min) ¹	F (max) ¹	P _{S,H}	P _{T,H}	V	P _(min)	P _(max)	Likelihood	Safety	Envir.	Econ.	Reputation	Max Cons.	RISK	Type	Description	Assumptions/Uncertainties
TMF North Seepage Collection Dam	Snow avalanche impact (Size 3-4)	Fatality	0.1	1	0.5	1	0.5	0.025	0.25	Likely	3	-	-	-	3	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
TMF North Dam	Snow avalanche impact	Fatality	0.1	1	0.5	0.5	0.5	0.0125	0.125	Likely	3	-	-	-	3	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
Splitter Dam	Snow avalanche impact	Fatality	0.01	0.1	0.5	0.5	0.5	0.00125	0.0125	Moderate	3	-	-	-	3	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
Upper East Diversion Intake	Snow avalanche impact	Fatality	1	10	0.5	0.01	0.5	0.0025	0.025	Moderate	3	-	-	-	3	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
	Snow avalanche impact	Intake blockage and spill	1	10	1	1	0.5	0.5	5	Very Likely	-	6	5	5	5	HIGH	Intake cover to withstand static load from multiple avalanche deposits	Assumes cover considered as part of portal design.	-
Northeast Diversion Ditch	Snow avalanche impact (Size 3/4)	Diversion channel blockage and spill, damage to diversion channel	1	10	1	1	0.5	0.5	5	Very Likely	-	5	5	6	5	HIGH	Grated channel cover	Grated, reinforced concrete or steel cover for channel length.	Assumes temporary spillage of water from the NE Diversion is considered intolerable
	Snow avalanche impact	Fatality	1	10	0.5	0.01	0.5	0.0025	0.025	Moderate	3	-	-	-	3	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
Northeast Buried Pipeline and Service Road	Snow avalanche impact	Fatality	1	10	0.5	0.01	0.5	0.0025	0.025	Moderate	3	-	-	-	3	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
Southeast Diversion Ditch	Snow avalanche impact (Size 3/4)	Div. channel blockage and spill	1	10	1	1	0.5	0.5	5	Very Likely	-	5	5	6	5	HIGH	Grated channel cover	Grated, reinforced concrete or steel cover for channel length.	Assumes temporary spillage of water from the NE Diversion is considered intolerable
	Snow avalanche impact	Fatality	1	10	0.5	0.01	0.5	0.0025	0.025	Moderate	3	-	-	-	3	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-
Southeast Dam	Snow avalanche impact (Size 3/4)	Fatality	0.1	1	0.5	0.5	0.5	0.0125	0.125	Likely	3	-	-	-	3	HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	-

TABLE A-6- COULTER CREEK ACCESS ROAD RISK REDUCTION

HAZARD IDENTIFICATION			ANNUAL HAZARD FREQ.		ANNUAL PROBABILITY OF UNWANTED OUTCOME					CONSEQUENCE ESTIMATION (OPERATION)					UNMITIGATED	MITIGATION SUMMARY			
Facility	Process/Scenario	Direct Consequence	F (min)	F (max)	P _s	P _r	V	P _o	P _o	Likelihood	Safety	Environment	Economic	Reputation	Max Cons.	RISK	Type	Description	Assumptions/Uncertainties
Coulter Creek Access Road	Snow avalanche Impact Size 3/4	Road closures	10	100	1	1	0.5	5	50	Very Likely	3	6	5	5	5	HIGH	Avalanche Management Plan	See Alpine Solutions 2011	
	Snow avalanche Impact Size 3/4	Fatality	10	100	1	0.01	0.5	0.05	0.5	Likely	3	6	4	4	3	HIGH	Avalanche Management Plan	See Alpine Solutions 2011	
	Snow avalanche Impact (Size 3/4)	Multiple fatalities	10	100	1	0.01	0.5	0.05	0.5	Likely	2	5	2	2	2	VERY HIGH	Avalanche Management Plan	See Alpine Solutions (2011)	

TABLE A-7 - TREATY CREEK ACCESS ROADS AND UPPER TREATY CREEK TUNNEL PORTALS AREA RISK REDUCTION

HAZARD IDENTIFICATION			ANNUAL HAZARD FREQUENCY		ANNUAL PROBABILITY OF UNWANTED OUTCOME						CONSEQUENCE ESTIMATION (OPERATION)					UNMITIGATED	MITIGATION SUMMARY		
Facility	Process/Scenario	Direct Consequence	F (min) ¹	F (max) ¹	P _{SH}	P _{TH}	V	P _(min)	P _(max)	Likelihood	Safety	Envir.	Economic	Reputation	Max Cons.	Risk	Type	Description	Assumptions/Uncertainties
Treaty Access Road (Km 0-18)	Snow avalanche impact Size 3-4	Road closures (<1 day)	0.1	1	1	1	1	0.1	1	Very Likely	-	6	5	5	5	HIGH	Avalanche management plan	See Alpine Solutions (2011)	-
	Snow avalanche impact Size 3-4	Multiple fatalities (<10)	0.1	1	0.5	0.01	0.5	0.0025	0.0025	Unlikely	2	-	-	-	2	HIGH	Avalanche management plan	See Alpine Solutions (2011)	-
Treaty Access Road (Km 18-32)	Snow avalanche impact	Road closures (<1 day)	1	10	1	1	1	1	10	Very Likely	-	6	5	5	5	HIGH	Avalanche management plan	See Alpine Solutions (2011)	-
	Snow avalanche impact Size 3-4	Fatality	1	10	0.5	0.01	0.5	0.0025	0.025	Moderate	3	-	-	-	3	HIGH	Avalanche management plan	See Alpine Solutions (2011)	-
	Snow avalanche impact Size 3-4	Multiple fatalities (<10)	1	10	0.5	0.01	0.5	0.0025	0.025	Moderate	2	-	-	-	2	HIGH	Avalanche management plan	See Alpine Solutions (2011)	-
Plant Site Access Road Initial and Ultimate	Snow avalanche impact Size 3	Road closures (<1 day)	1	10	1	1	1	1	10	Very Likely	-	6	5	5	5	HIGH	Avalanche management plan	See Alpine Solutions (2011)	-
	Snow avalanche impact Size 3	Fatality	1	10	0.5	0.01	0.5	0.0025	0.025	Moderate	3	-	-	-	3	HIGH	Avalanche management plan	See Alpine Solutions (2011)	-
Alignments	Snow avalanche impact Size 3	Multiple fatalities (<10)	1	10	0.5	0.01	0.5	0.0025	0.025	Moderate	2	-	-	-	2	HIGH	Avalanche management plan	See Alpine Solutions (2011)	-
	Snow avalanche impact Size 3	Multiple fatalities (<10)	1	10	0.5	0.01	0.5	0.0025	0.025	Moderate	2	-	-	-	2	HIGH	Avalanche management plan	See Alpine Solutions (2011)	-
Upper Treaty Lined PAG Pad	Snow avalanche impact Size 4	Fatality	0.01	0.1	1	0.5	0.5	0.0025	0.025	Moderate	3	-	-	-	3	HIGH	Avalanche management plan	See Alpine Solutions (2011)	-
Upper Treaty Treatment Plant	Snow avalanche impact Size 4	Fatality	0.01	0.1	1	0.5	0.5	0.0025	0.025	Moderate	3	-	-	-	3	HIGH	Avalanche management plan	See Alpine Solutions (2011)	-
Upper Treaty NAG Pad	Snow avalanche impact Size 4	Fatality	0.01	0.1	1	0.5	0.5	0.0025	0.025	Moderate	3	-	-	-	3	HIGH	Avalanche management plan	See Alpine Solutions (2011)	-