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20 – EFFECTS OF THE ENVIRONMENT ON THE PROJECT

20.1 OVERVIEW

The YESAA requires that every environmental and socio-economic assessment include a characterization of the potential effects of the environment on the project, including the predicted effects of climate change. The YESAB Guidance to Proponents requires the prediction of potential effects of extreme environmental conditions such as terrain hazards, landslides, flood events, slope stability, and earthquakes on the project to be included as part of the Proposal (YESAB 2005). In addition, the proponent is required to identify and describe the predicted effects of climate change on the project including changes in hydrology patterns, climatic patterns and permafrost regimes for project components and activities that are potentially affected by such changes (YESAB 2005).

This section of the Proposal characterizes the likely extreme environmental conditions and long-term climate change scenarios that have the potential to affect the Casino Project and the predicted effects of those conditions and likely scenarios on the Project's components and activities. The potential effects to the Project take into consideration the probability of occurrence as well as the potential consequences to the Project from occurrence of the event. In addition, potential sensitivities of the Project's components or activities, including the timing of operations and critical site conditions are discussed.

20.2 APPROACH

Environmental conditions with the potential to adversely affect the Project components and activities were identified through the professional experience of CMC, its engineers and environmental consultants. In addition, consultations conducted with First Nations, the public, and Yukon Government helped to inform the scope of the assessment. The range of environmental events that have a potential to affect the Project components and activities during the construction, operations, decommissioning and closure, and post-closure phases include:

- Seismic Activity;
- Terrain Instability (landslides, avalanches, and permafrost disturbance);
- Extreme Weather Events;
- Wildfires; and
- Climate change.

The overall risk of an environmental event on the Project is a combination of both the likelihood of the potential event to occur and the consequences of the potential effect.

Existing information was used to determine a probability of occurrence for an environmental event, if available. Conversely, where existing information was not available, professional judgement was used to characterize the likelihood of occurrence.

A rigorous approach requires consideration of "worst-case" scenarios, which are presented below. It is important to note that the project design standards are conservative with the intention of eliminating the possibility a these scenarios arising as described in this section.

Table 20.2-1 lists the categories of likelihood for a potential extreme environmental event to occur over the life of the Project.

Table 20.2-1 Categories of Likelihood for Potential Extreme Environmental Events

Likelihood Categories	Life of Project Likelihood	Description of Effect Likelihood
Negligible	<1%	Doubt it could happen
Low	5 to 25%	Unlikely to happen
Moderate	25% to 50%	It could happen
High	75 to 99%	Has or probably will happen
Extreme	<99%	Happens regularly

Notes:
1. Life of the Project is defined as construction through to post closure phases.

Potential effects of the environmental event on the Project components and activities were described in terms of a range of potential effects which represents the likely predicted scenario and the unlikely worst case scenario. Even though the unlikely worst case scenario was presented, the likelihood of it occurring is considered to be negligible.

The severity of the potential effect on the Project was rated by selecting the category which best describes the likely consequences. The selection was informed by best available information including design-based mitigation measures, proposed management plans, proposed monitoring plans and response measures, as well as professional judgement. Four general categories of severity were used to rank the potential effects of the environment on the Project (Table 20.2-2).

Table 20.2-2 Categories of Severity of Potential Effects of the Environment on the Project

Severity of Potential Effect	Description of the Potential Effect on the Project
Negligible	Project components, activities and critical services do not shut down.
Low	Complete shutdown of Project components, activities and critical services for more than 24 hours
Moderate	Complete shutdown of Project components, activities and critical services for more than one week
High	Complete shutdown of Project components, activities and critical services for more than one month
Extreme	Complete shutdown of Project components, activities and critical services indefinitely

Notes:
1. The four categories of severity are selected by CMC based on the ability of the Project to continue operations uninterrupted.

Mitigation measures were proposed by CMC to eliminate, reduce or control adverse potential effects of the environment on the Project. The majority of mitigation measures for potential adverse environmental effects were identified early in the Project planning process and have been integrated into the design of the Project. These types of design-based mitigation measures are informed by industry's code of good practice, standards and environmental policies.

The findings of the Proposal and consultations with government reviewers, First Nations and the public will help to refine the mitigation measures proposed. According to YESAA, mitigation measures include measures for the elimination, reduction, or control of adverse environmental or socio-economic effects (YESAA 2005). These measures may include restitution for adverse effects, including replacement, restoration, compensation, or other appropriate means (YESAB 2005).

20.3 EFFECTS OF THE ENVIRONMENT ON THE PROJECT

20.3.1 Seismic Activity

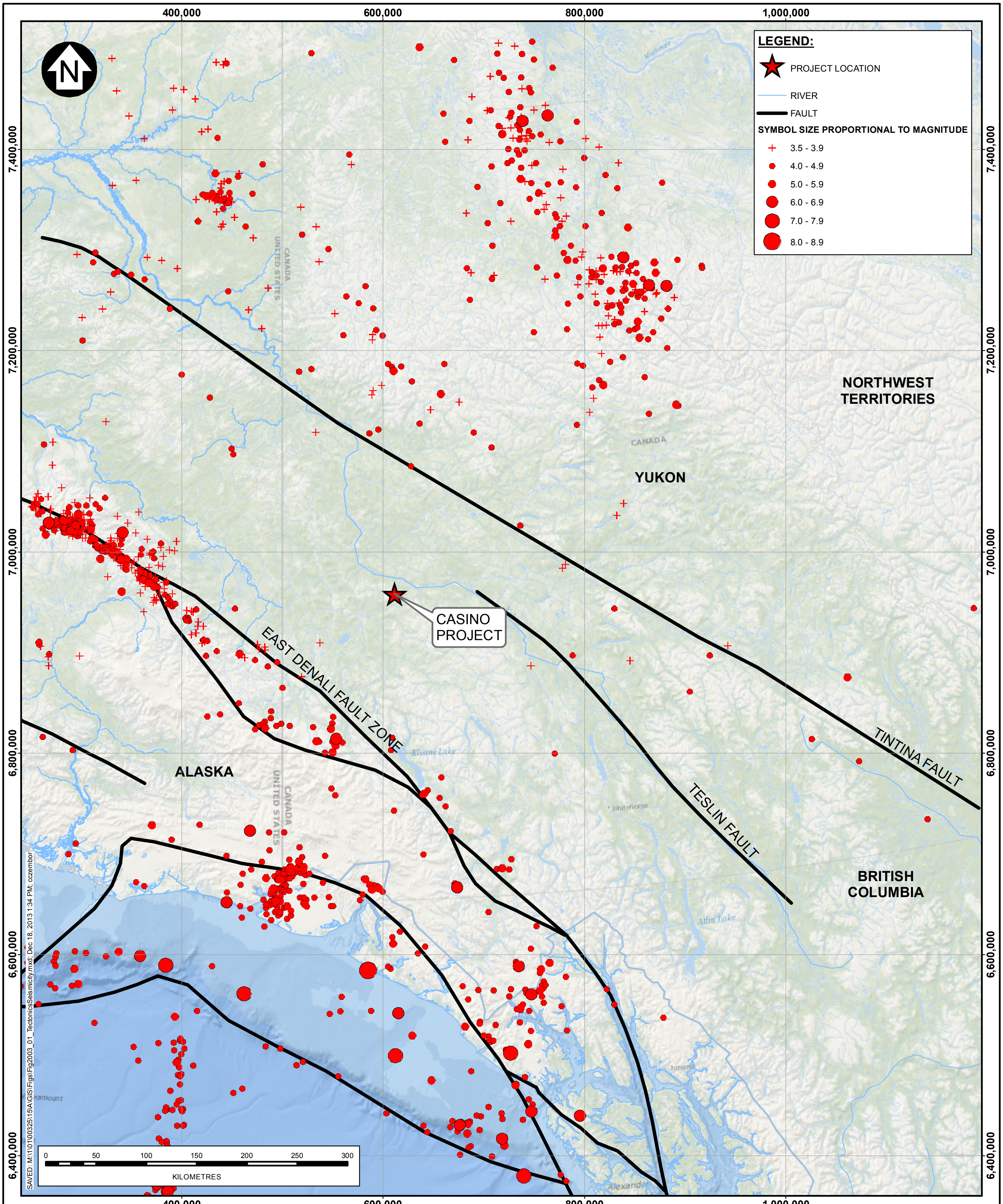
A review of the regional tectonics and historical seismicity was carried out to enable selection of appropriate design earthquake events for key Project components such as the TMF (Knight Piésold Ltd. 2012c). Figure 20.3.1 from Natural Resources Canada shows the regional tectonics and historical seismicity of the Yukon Territory, surrounding regions, and for the location of the Project.

The Project is located in an area of minor seismicity between the Denali and Tintina fault systems. Review of historical earthquake records indicates that the Project is situated in a region that can be generally described as having low seismicity. The seismic hazard for the Casino mine site is predominantly from shallow crustal earthquakes (with magnitudes up to 7.0 on the Richter Scale, or M7.0) that may occur in the region south of the Project. In addition, seismic hazard is also influenced by the potential for larger magnitude earthquakes (of approximately M7.5 to 8.0) occurring farther from the Project site on the East Denali fault zone.

20.3.1.1 Likelihood of Occurrence

The seismic hazard for the Project was defined using probabilistic methods of analysis and design ground motion parameters have been determined for the Project site using information provided by the probabilistic seismic hazard database of Natural Resources Canada (Knight Piésold Ltd. 2012c, NRCan 2012). The results are summarized in Table 20.3.1 in terms of earthquake return period, probability of exceedance (for a 22 year design operating life of the Project) and the corresponding peak ground acceleration (median and mean hazard values).

The Operating Basis Earthquake (OBE) for the Project is a 1 in 500 year return earthquake and was selected from the results of a probabilistic hazard evaluation. The OBE is defined as an earthquake that produces ground motions at the site that can reasonably be expected to occur within the service life of a project; the associated performance requirement is that the project functions with little or no damage, and without interruption of function (FEMA 2005). There are no fixed criteria for selecting the OBE. The hazard level selected for the OBE is often chosen as the earthquake with a 10% probability of exceedance in 50 years (with a corresponding return period of about 500 years). For a return period of 1 in 500 years the corresponding median peak ground acceleration is 0.07g indicating a low to moderate seismic hazard for the Casino mine site.



PREPARED BY:

Knight Piésold
CONSULTING

DESIGNED	GRG
DRAWN	AMD
CHK'D	CAH
APP'D	KJB
REV	0
DATE	16DEC'13

NOTES:
1. BASE MAP: CANVEC.
2. PROJECTION: NAD 1983 UTM ZONE 7N
3. COORDINATE GRID: METRES.
4. HISTORICAL EARTHQUAKE DATA FROM NRCAN, USGS, AND NGDC DATABASES.
5. INCLUDES RECORDED EARTHQUAKES FROM 1600 TO 1973 (MAGNITUDE > 6.0) AND FROM 1973 TO SEPTEMBER 2012 (MAGNITUDE > 3.5).

CASINO COPPER AND GOLD

CASINO PROJECT

REGIONAL TECTONICS AND HISTORICAL SEISMICITY

FIGURE 20.3-1

REF 1

P/A VA101-325/15

Table 20.3-1 Summary of Probabilistic Seismic Hazard Analysis

Return Period (Years)	Probability of Exceedance[1] (%)	Peak Ground Acceleration (PGA)[2]	
		Median PGA[3,4] (*g*)	Estimate Mean PGA[5] (*g*)
100	20	0.04	0.05
500	4	0.07	0.08
1,000	2	0.08	0.10
2,500	1	0.11	0.13
5,000[6]	0.4	0.14	0.17
10,000[6]	0.2	0.18	0.22

Notes:

1. Probability of exceedance calculated for a design life of 22 years q = 1-(-L/T) where: q = probability of exceedance L = design life in years T = return period in years
2. Peak ground accelerations are for soft rock/very dense soil (Vs30 = 360 - 760 m/sec)
3. Median peak ground accelerations for return period up to 2,500 years obtained from the seismic hazard database of Natural Resources Canada
4. Median peak ground accelerations for return periods of 5,000 and 10,000 years obtained for site-specific analysis using EZ-FRISK
5. Mean PGA values estimated as 1.2 x median values
6. Predicted values are derived from EZ-FRISK seismic hazard analysis module

The NRCan database only provides ground motion parameters for an earthquake up to a return period of 2,500 years. Therefore, a probabilistic seismic hazard analysis was conducted for the Project to provide ground motion parameters beyond 2,500 years, specifically for return periods of 5,000 and 10,000 years (Knight Piésold Ltd. 2012a).

The computer program EZ-FRISK was used to develop a seismic hazard model for the Yukon and the surrounding regions (Risk Engineering, Inc. 2008). The seismic hazard analysis module available with EZ-FRISK includes a database provided by Risk Engineering Inc. of faults and areal seismic sources for the pertinent regions of western Canada. Seismic sources defined in the seismic hazard model include the regions of the southern Yukon Territory, southeastern Alaska, and the Denali and Fairweather fault systems. The seismic hazard model was used to determine the relationship between peak ground acceleration and annual frequency of occurrence for the Project site. Predicted values for the Project site are included in Table 20.3.1 for earthquake return periods of 5,000 and 10,000 years. Predicted values for lower return periods were very similar to those provided by the NRCan seismic hazard database.

The OBE for the Project was selected as the 1 in 500 year return period earthquake event. The probability of exceedance for this event is approximately 4% for a 22 year mine life operating period. Based on the categories of likelihood for potential effects on the Project (Table 20.2.1) for the OBE, the overall likelihood of occurrence of a 1 in 500 year return period seismic event during the life of the Project is LOW and is unlikely to happen.

20.3.1.2 Potential Effects

If an earthquake were to occur and affect the Project, the damage potential of the earthquake would depend largely on the proximity of the Project to the epicentre of the earthquake. Damage to Project infrastructure can occur directly through ground shaking and indirectly as a result of induced landslides or other falling objects. All Project components could be affected by seismic activity, though the level of damage depends on the nature of the seismic event. Of particular interest is how the TMF embankments, the Casino pit wall, the heap leach facility and pad, main power plant and the stockpiles are predicted to respond to seismic activity.

Table 20.3.2 outlines a range of potential effects from seismic activity to represent the likely predicted scenario and the unlikely worst case scenario.

Table 20.3-2 Potential Effects on the Project from Seismic Events

Project Component or Activity	Project Phase[1]	Range of Potential Effects[2]	
		Likely Predicted Scenario	**Unlikely Worst Case Scenario**
TMF (main and west) embankments	O, CD, PC	TMF embankments will not fail and both short term (operational) and long term (post-closure) stability is maintained. Any embankment deformations caused by earthquake shaking will be minor and will not have a significant impact on embankment freeboard or result in any loss of embankment integrity. Project components, activities and critical services will not shut down.	Catastrophic failure of the TMF embankments leading to release of water, tailings, and waste rock from the TMF into Casino Creek. Complete shutdown of the Project for an extended period of time.
Temporary ore and topsoil stockpiles	O	The consequences will be negligible and restricted to minor displacement of the surface of the ore and topsoil stockpile slopes (or ravelling). The integrity of the stockpile is maintained and there will be no damage to other mine site infrastructure. Project components, activities and critical services will not shut down.	Complete failure of the stockpiles will occur due to compromised structural integrity from shaking. Failed stockpiles will damage haul roads and other Project facilities such as the Plant site. A complete shutdown of Project components, activities and critical services will occur temporarily for more than one week while Project facilities and critical services are restored.
Heap Leach Facility	O, DC, PC	Heap leach pad deformations will be negligible, if any, and will not impact operations at the HLF. Structural slope stability of the HLF will be maintained. Project components, activities and critical services will not shut down.	Displacement of the heap leach pad slopes and compromised stability of the heap leach pad will occur due to decreased interface shear strength between the various components of the liner system. A complete shutdown of Project components, activities and critical services will occur for more than one week.
Casino Pit	C, O	Small shallow slides and rock falls in the Casino Pit will occur but none on a scale sufficient to disrupt operations or pose a safety concern to personnel. Project components, activities and critical services will not shut down.	A catastrophic failure of the Casino pit wall could be hazardous to personnel and equipment, result in lost production and/or sterilization of resources. A complete shutdown of Project components, activities and critical services will occur for more than one week while Project facilities and critical services are restored.
Ancillary facilities and support buildings at the Casino mine site.	C, O	Buildings and facilities will not fail. Project components, activities and critical services will not shut down.	Structural damage to buildings and facilities will pose a hazard to personnel and critical equipment. A complete shutdown of Project components, activities and critical

Project Component or Activity	Project Phase[1]	Range of Potential Effects[2]	
		Likely Predicted Scenario	Unlikely Worst Case Scenario
			services will occur for more than one week while Project facilities and critical services are restored.

Notes:
Construction (C), Operations (O), Closure and Decommissioning (CD), and Post-Closure (PC)
A range of potential effects are described to represent the most likely predicted scenario and the unlikely worst case scenario.

Based on the consequence categories established in Table 20.2.2 and the potential effects of the likely predicted scenario, the consequence of a seismic event on the Project is considered to be LOW. This rating is due largely to the fact that all critical Project components are designed to perform at earthquake exposure levels meeting or exceeding the 1 in 500 year return period earthquake. For example, the TMF embankments for the Project are designed to perform at earthquake exposure levels meeting the 1 in 10,000 year return period earthquake.

The consequence of seismic activity on the Project as a result of earthquake shaking is anticipated to be minimal and restricted to minor displacement of the surface facilities. The TMF, stockpiles and heap leach facility and pads are expected to function in a normal manner after the OBE. There would be a negligible effect on the integrity of the Project components and little, if any, effect on critical activities and timing of operations. All Project activities and components have been designed to withstand seismic activity and it is very unlikely that a complete shutdown of the Project and critical services will last more than 24 hours.

20.3.1.3 Mitigation Measures

The Project has been designed to ensure that components and activities will perform at earthquake exposure up to the expectations and in compliance with current standards in Canada.

All buildings on site including the accommodations camp, maintenance shops, explosives storage facility and the plant site are designed according to the National Building Code (NBC) of Canada. The NBC incorporates technical requirements to ensure that buildings are protected against earthquakes based on local seismic conditions.

According to the Canadian Dam Association (CDA) guidelines, each dam structure, such as the Project’s TMF embankments, is assigned a “Dam Class” based on the incremental losses that would result from a catastrophic failure of the dam with respect to loss of life, environmental and cultural values, as well as infrastructure and economic losses.

Table 20.3.3 outlines the CDA dam classes and corresponding criteria for incremental losses. The CDA Guidelines require that the Project TMF be designed for a High dam classification. The CDA Dam Class also determines the required Earthquake Design Ground Motion (EDGM) and Inflow Design Flood (IDF) and for the design of the dam structure and water management systems.

Table 20.3-3 CDA Dam Classification

Dam Class	Population at Risk1	Incremental Losses		
		Loss of Life[2]	Environmental and Cultural Values	Infrastructure and Economics
Low	None	Zero	Minimal short-term loss. No long-term loss	Low economic losses; area contains limited infrastructure or services
Significant	Temporary only	Unspecified	No significant loss or deterioration of fish or wildlife habitat. Loss of marginal habitat only. Restoration or compensation in kind highly possible	Losses to recreational facilities; seasonal workplaces, and infrequently used for transportation services.
High	Permanent	10 or fewer	Significant loss or deterioration of important fish or wildlife habitat. Restoration or compensation in kind highly possible.	High economic losses affecting infrastructure, public transportation, and commercial facilities
Very High	Permanent	100 or fewer	Significant loss or deterioration of critical fish or wildlife habitat. Restoration or compensation in kind possible but impractical.	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances.
Extreme	Permanent	More than 100	Major loss of critical fish or wildlife habitat. Restoration or compensation in kind impossible.	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances)

Notes:

1. Definitions for population risk

None – There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure

Temporary – People are only temporarily in the dam breach inundation zone (e.g. seasonal cottage use, passing through on transportation routes, participating in recreational activities

Permanent – The population at risk is ordinarily located in the dam-breach inundation zone (e.g. as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out.

2. Implications for loss of life:

Unspecified – The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during flood season.

Consistent with the current design practice for geotechnical structures such as dams, two levels of design earthquakes have been considered: the OBE for normal operations, and the Maximum Design Earthquake (MDE) for extreme conditions (ICOLD 1995). Values of Peak Ground Acceleration (PGA) and design earthquake magnitude have been determined for both the OBE and MDE for the Project.

For the design of the TMF, the OBE has been taken as the 1 in 500 year return period event. The corresponding median PGA for this event is 0.07g. However, for geotechnical structures it is recommended that the mean average PGA value be used for design (CDA 2007). The mean PGA is likely to be approximately 15 to 20 percent greater than the median value, giving an estimated value of 0.08g. A design earthquake magnitude of 8.0 has been selected for the OBE, based on a review of regional tectonics and historical seismicity.

An appropriate MDE for embankment design has been selected, based on the High dam classification defined for the TMF and the criteria for design earthquakes provided by the Canadian Dam Association's (CDA) "Dam Safety Guidelines" (2007), and presented in Table 20.3.4.

Table 20.3-4 Suggested Design Flood and Earthquake Levels

Dam Class	Annual Exceedance Probability (AEP)	
	Inflow Design Flood (IDF)[1]	Earthquake Design Ground Motion (EDGM)[3]
Low	1/100	1/500
Significant	Between 1/100 and 1/1,000[4]	1/1,000
High	1/3 between 1/1,000 and Probable Maximum Flood[5]	1/2,500[6]
Very High	2/3 between 1/1,000 and Probable Maximum Flood[5]	1/5,000[6]
Extreme	Probable Maximum Flood (PMF)[6]	1/10,000

Notes:

1. As defined in Table 5.2 – Dam Classification
2. Extrapolation of flood statistics beyond 1/1,000 year flood (10-3 AEP) is discouraged
3. AEP levels for EDGM are to be used for mean rather than median estimates for the hazard.
4. Selected on the basis of incremental flood analysis, exposure, and consequence of failure.
5. PMF has no associated AEP. The flood defined as 1/3 between 1/1,000 year and PMF or 2/3 between 1/1,000 year and PMF has no defined AEP.
6. The EDGM value must be justified to demonstrate conformance to societal norms of acceptable risk. Justification can be provided with the help of failure modes analysis focused on the particular modes that can contribute to failure initiated by a seismic event. If the justification cannot be provided, the EDGM should be 1/10,000.

The CDA Guidelines require that a "High" dam classification be designed for a probabilistically derived event (defined as the Earthquake Design Ground Motion) having an annual exceedance probability (AEP) of 1/2,500. Accordingly, the MDE selected for the TMF is the 1 in 2,500 year earthquake. The median PGA is 0.11g for the 1 in 2,500 year earthquake. The corresponding mean average PGA used for design is estimated to be 0.13g. A design earthquake magnitude of 8.0 has been selected for the MDE, based on a review of regional tectonics and historical seismicity. Limited deformation of the TMF embankment is considered to be acceptable under seismic loading from the MDE, provided that the overall stability and integrity of the TMF is maintained and that there is no release of stored tailings or water (ICOLD 1995).

Table 20.3-5 Earthquake Design Basis for Project Components

Design Basis	Heap Leach Facility	Stockpiles	TMF
Operational Basis Earthquake (OBE)	1 in 500 year return period with a maximum firm ground acceleration of 0.08g	1 in 500 year return period with a maximum firm ground acceleration of 0.08g	1 in 500 year return period with a maximum firm ground acceleration of 0.08g
CDA Classification	-	-	High dam classification
Maximum Design Earthquake (MDE)	1 in 500 year earthquake	1 in 500 year earthquake	1 in 2,500 year earthquake
Design Earthquake Magnitude	8.0	8.0	8.0
Median Peak Ground Acceleration (PGA)	0.08g	0.08g	0.11g
Mean Peak Ground Acceleration (PGA)	0.13g	0.13g	0.13 g

The open pit slope angles of the Casino Pit are designed to limit the potential for failures which could lead to hazards to personnel and equipment, lost production, or sterilization of resources (Knight Piésold Ltd. 2012b). There are few, if any, recorded instances in which earthquakes have been shown to produce significant slope instabilities in hard rock conditions, a statement supported by evidence from a number of mines in highly active seismic zones (Read 2009). According to Read, earthquakes are more likely to produce small shallow slides and rockfalls in open pits but none on a scale sufficient to disrupt mining operations. After closure, site drainage will be altered to allow the Casino Pit to be filled with water to create Pit Lake.

A stability assessment has been carried out for the temporary stockpiles proposed for the mine site (Knight Piésold Ltd. 2012d). The design earthquake for the ore and overburden stockpiles have been taken as the 1 in 500 year return period event, consistent with the OBE defined for the TMF. The corresponding mean peak ground acceleration is 0.08g. A design earthquake magnitude of 8.0 has been selected based on a review of regional tectonics, potential seismic source zones in the region and historical seismicity.

The slopes of the topsoil stockpiles have been designed to be low and flat, with gently sloped faces and an overall slope angle of about 14 degrees (4H:1V) to provide stability. The ore stockpiles have been designed with overall slopes of 2H:1V. The temporary stockpiles have been designed to remain stable under both static and seismic loading conditions and have a minimum acceptable factor of safety under static conditions of 1.3 for short-term operating conditions and 1.5 after closure and reclamation. All stockpiles will be removed before or at closure of the Project.

Stability of the HLF during earthquake loading has been assessed by performing a pseudo-static analysis, where a horizontal force (seismic coefficient) is applied to the heap to simulate earthquake loading to determine the critical acceleration required to reduce the factor of safety to 1.0. Deformation is predicted to occur if the critical acceleration is lower than the predicted average maximum ground acceleration along the potential slope surface from the design earthquake. Potential deformations under earthquake loading have been estimated using the semi-empirical simplified methods of Newmark (1965), Makdisi-Seed (1977) and Bray (2007). These methods estimate displacement of the potential sliding mass based on the average maximum ground acceleration and the yield acceleration. The yield acceleration corresponds to the seismic coefficient required to initiate movement of the sliding mass. The yield acceleration was determined by iterative stability analyses. For the final heap leach pad configuration, the estimated yield acceleration is 0.12g. To account for the possible amplification of ground accelerations as seismic waves propagate through the heap leach pad, an amplification factor of 1.5 was assumed, resulting in an estimated average maximum acceleration of 0.12g. Predicted heap leach pad deformations calculated for the design earthquake are negligible, if any, and would not impact operations at the HLF.

The consequences of failure of the HLF during an earthquake event will likely be minimal and restricted to some displacement of the heap leach pad slopes. There would be negligible impact on the integrity of the HLF and little, if any, impact on other mine site facilities. However, for design of the HLF a conservative design earthquake corresponding to the 1 in 500 year return period event has been adopted, consistent with the Operating Basis Earthquake (OBE) defined for the TMF. The corresponding mean peak ground acceleration is 0.08g. A design earthquake magnitude of 8.0 has been selected based on a review of regional tectonics, potential seismic source zones in the region and historical seismicity. The seismic stability assessment of the heap leach pad has included estimation of seismically induced deformations of the pad from the design earthquake.

Table 20.3.6 is a summary of the mitigation measures proposed by CMC for the potential adverse effects of seismic activity on the Project components and activities.

Table 20.3-6 Seismic Events - Mitigation Measures

Project Components/ Activities	Mitigation Measures	
	Design Considerations	**Prevention, Response and Remedial Actions**
TMF Embankments	The TMF has been designed to meet the CDA Guidelines for a “High” consequence dam. An MDE mean PGA value of 0.13 g was used for the design of the TMF embankments based on a 1 in 2,500 year return earthquake event of a design magnitude of 8.0.	Remedial action will be taken for small indications of potential failure modes. Internal erosion and piping will be detected through routine monitoring and inspection by mine site personnel and by qualified geotechnical engineers.
Temporary Ore and Topsoil Stockpiles	The slopes of temporary stockpiles have been designed to be low and flat, with gently sloped faces and an overall slope angle of about 14 degrees (4H:1V). Temporary ore stockpiles have been designed have a 2H:1V slope angle.	Remedial action will be taken for small indications of potential displacement through regular monitoring and inspection by mine site personnel.
Heap Leach Facility	The HLF has been designed to correspond with the 1 in 500 year return period event consistent with the OBE defined for the TMF.	Routine monitoring of the heap leach facility will occur and remedial actions will be taken for small indications of potential displacement.
Casino Pit	The Casino Pit was designed to an acceptable level of risk and incorporate this acceptable level of risk into the stability analyses as a Factor of Safety (FOS) and/or Probability of Failure (POF).	The Casino Pit drainage and dewatering system will maintain pit wall stability via horizontal depressurization holes and drain water and prevent water pressures from building up behind the pit walls during operations.
Ancillary facilities and support buildings at the Casino mine site.	All buildings and structures on site have been designed according to the 2010 National Building Code of Canada	A detailed emergency response plan will be developed and put in place prior to the construction phase of the Project. The emergency response plan will include training and guidance for responding to

Project Components/ Activities	Mitigation Measures	
	Design Considerations	Prevention, Response and Remedial Actions
		earthquakes.

20.3.1.4 Summary Statement

The overall potential effects of seismic activity on the Project is not considered significant because the overall likelihood of occurrence has been determined to be LOW and the consequence of the most likely event has been determined to be LOW. Furthermore, in order to eliminate any reasonable possibility of a negative effect (failure), design considerations for the TMF involved designing the embankments to withstand a 1/10,000 year seismic event.

20.3.2 Terrain Instability

A terrain hazards assessment was carried out for the Casino mine site, Freegold Road Extension, and the Casino Airstrip (Knight Piésold Ltd. 2012f and Appendix 6B). The terrain hazards assessment incorporated terrain mapping, terrain stability mapping and a preliminary assessment of potentially hazardous permafrost-related features. The potential likelihoods for landslides, snow avalanches and permafrost disturbances are described below.

20.3.2.1 Likelihood of Occurrence

Terrain stability mapping was undertaken in 2012 to analyse the terrain stability in relation to the proposed locations of the Project components and activities. Terrain stability refers to the likelihood of a landslide initiating in a terrain polygon following construction activities and timber harvesting and was evaluated based on the slope angle, the slope aspect, the surficial geology, the permafrost conditions and the presence of gullied terrain. Three terrain stability classes were used for the terrain mapping study:

- Stable – Identified as terrain with a ‘negligible’ to ‘low’ likelihood of landslide initiation following road construction
- Potentially Unstable – Expected to contain areas with a ‘moderate’ likelihood of landslide initiation following road construction
- Unstable – Expected to contain areas where there is a ‘high’ likelihood of landslide initiation following road construction.

Terrain stability maps were produced for the Casino mine site, Freegold Road Extension and Casino Airstrip and Airstrip Access Road, to show areas of stable, potentially unstable and unstable terrain (Appendix 6B, 6D). The areas of potentially unstable and unstable terrain are based on the inferred presence of ice-rich soils. Table 20.3.7 summarizes the potential likelihoods of occurrences of terrain instability based on the terrain stability mapping exercise for the Project.

Table 20.3-7 Potential Likelihoods of Occurrences of Terrain Instability

Locations	Stable Terrain (%)	Potentially Unstable Terrain (%)	Unstable Terrain (%)	Occurrence Type	Likelihood
Casino Mine Site	86.5	13	0.5	Landslides and Avalanches	NEGLIGIBLE
				Permafrost Degradation	HIGH
Casino Airstrip and Airstrip Access Road	95	5	0	Landslides and Avalanches	NEGLIGIBLE
				Permafrost Degradation	HIGH
Freegold Road Extension	88	9	3	Landslides and Avalanches	LOW
				Permafrost Degradation	HIGH

Casino Mine Site

The terrain stability mapping indicates that approximately 13% of the Casino mine site is considered to be ‘potentially unstable’ terrain and approximately 0.5% is considered to be ‘unstable’ terrain (Appendix 6D). The terrain stability mapping identified areas of potentially unstable terrain and unstable terrain at the TMF location. Additional areas of potentially unstable terrain were also identified at the temporary stockpile sites and the HLF.

Field studies did not observe any recent debris slides, debris flows or rockfalls within the Casino mine site. A possible solifluction lobe was identified in the footprint area of the proposed location of the Open Pit and discussed in further detail in the terrain hazards assessment report (Appendix 6B).

Snow avalanches and landslides generally occur on terrain with slope angles of approximately 27 to 40 degrees. The predominant slope angle classes within the Casino mine site are gentle slopes (of 4 to 15 degrees) and moderately inclined slopes (of 16 to 26 degrees). Therefore, the likelihood of avalanches and landslides were thought to be negligible.

The Casino mine site is located within a zone of widespread discontinuous permafrost and there is regional evidence of permafrost degradation as well as visually observed evidence (Appendix 6B). Permafrost is ‘most prevalent on north-facing slopes and in valley bottoms where thick fine-grained slope toe complexes (interbedded loess, colluvium and peat) and alluvial sediments have accumulated’ (Bond and Lipovsky 2011). Terrain mapping work at the Casino mine site confirmed that permafrost is present close to ground surface within the majority of summits and ridgelines. Pingos were also identified through field observations in the northeast part of the Casino mine site.

Casino Airstrip and Airstrip Access Road

The terrain stability mapping indicates approximately 5% of the proposed Airstrip and Airstrip Access Road alignment to be ‘potentially unstable’ terrain (Knight Piésold Ltd. 2012f). The existing variable ground conditions along the Casino Airstrip alignment can result in an increased likelihood of differential settlement of the proposed embankment if not mitigated.

The terrain hazards study identified local evidence of permafrost degradation in the area of the proposed Casino Airstrip and Airstrip Access Road. It was believed that the extent of permafrost degradation has been exacerbated, by anthropogenic effects, in particular the construction of access tracks and winter roads.

Freegold Road Extension

The terrain stability mapping indicates approximately 9% of the proposed Freegold Road Extension alignment to be within ‘potentially unstable’ terrain and approximately 3% within ‘unstable’ terrain (Knight Piésold Ltd. 2012f).

Along the Freegold Road Extension, the road sections considered least susceptible to instability are generally those in areas of bedrock exposure. The road sections considered most susceptible to landslides are those in areas of ice-rich, north-facing colluvial slopes, where permafrost degradation can result in slope instability. Gullied terrain is particularly susceptible to landslides because there tends to be concentrations of both surface and sub-surface water.

Snow avalanches generally occur on terrain with slope angles of approximately 27 to 40 degrees. The predominant slope angle classes within the area are gentle slopes (of 6 to 26% or 4° to 15°) and moderate slopes (of 27% to 49%, or 16° to 26°). Overall, a significant proportion of the annual precipitation falls as snow, and the proposed Freegold Road Extension route will pass through some areas of moderately steep terrain that could be susceptible to snow avalanches.

The proposed Freegold Road Extension alignment will traverse extensive areas of permafrost terrain, a significant proportion of which was interpreted in the terrain hazard study to have a shallow (within approximately 1 m of the ground surface) permafrost table and ice-rich soils.

20.3.2.2 Potential Effects

The dominant terrain instability hazard for the Project is permafrost degradation because landslides and snow avalanches are less likely to occur. The baseline rate of permafrost degradation and the extent to which permafrost degradation is anticipated to be affected by anthropogenic processes (including construction activities) is difficult to predict (Appendix 6B). Table 20.3.8 outlines a range of potential effects from terrain instability occurrences to represent the most likely predicted scenario and the most unlikely worst case scenario.

Table 20.3-8 Potential Effects on the Project from Terrain Instability

Project Component or Activity	Project Phase[1]	Range of Potential Effects[2]	
		Predicted Likely Scenario	Unlikely Worst Case Scenario
Casino mine site	C, O, CD	Terrain instability occurrences do not occur or are minor when they occur, detected by monitoring and mitigated. Occurrences do not compromise the short term or long term stability of infrastructure at the Casino mine site. Project components, activities and critical services are not interrupted.	Unstable terrain has the potential to damage Project infrastructure at the Casino mine site, cause adverse environmental effects, and pose a threat to health and safety. The Project would be completely shut down for more than one month.
Casino Airstrip, Airstrip Access Road, and Freegold Road Extension	C, O, CD	Minor slope instability and erosion of embankments which are monitored and mitigated quickly to prevent sediment delivery to watercourses. Project components, activities and critical services are not interrupted.	Differential settlement of air strip embankments, road embankments and bridge foundations. Slope instability and enhanced erosion and sediment delivery to watercourses. Complete shutdown of Project components, activities and critical services for more than one week.

Notes:

Construction (C), Operations (O), Closure and Decommissioning (CD), and Post-Closure (PC)

A range of potential effects are described to represent the most likely predicted scenario and the unlikely worst case scenario

The Casino mine site, Casino airstrip, and Freegold Road Extension are located within a zone of widespread by discontinuous permafrost. Additionally, there is currently regional evidence of permafrost degradation and visually observed evidence with the Casino mine site. Permafrost degradation can occur both during and after construction, resulting in the possibility of differential settlement of infrastructure embankments and foundations, slope instability and enhanced erosion and sediment delivery to watercourses.

20.3.2.3 Mitigation Measures

Given the uncertainty in predicting the extent to which permafrost degradation will occur, CMC has adopted design based mitigation measures for potentially sensitive structures and will establish and monitoring and response measures prior to the construction of the Project (Table 20.3.9). Site selections for potentially sensitive structures including the HLF, TMF embankments and stockpiles were based on engineering assessments that considered geotechnical conditions informed by completing geotechnical investigations and stability analysis for the proposed locations of the embankments and foundations.

Table 20.3-9 Terrain Instability - Mitigation Measures

Project Components/ Activities	Mitigation Measures	
	Design Considerations	**Actions**
Potentially sensitive structures such as embankments and foundations (TMF, HLF, stockpiles, bridges, airstrip, access roads, etc.)	Potential areas of instability were avoided where possible. Where avoidance is not possible, instability will be mitigated through design considerations and actions.	During construction, permafrost zones and potentially unstable foundation materials within the proposed footprint of sensitive structures will be removed to encourage thawing and drainage and to ensure stability before placement of foundations or embankments.
	The design of sensitive structures accommodates for the removal of permafrost zones prior to construction. A safety margin has been built in to the design of sensitive structures to account for potential reduction in stability due to removal of frozen layers.	Sensitive structures will be monitored for their performance throughout life of the Project through regular inspections to identify areas of potential instability. Mitigative measures will be carried out to decrease the likelihood of failure.
	Sensitive structures will be instrumented (as appropriate) to allow for monitoring of temperature, settlement and slope displacement throughout the life of the Project. For example, vibrating wire piezometers can be installed prior to the construction of the starter TMF embankment.	A program can be established to monitor permafrost conditions adjacent to cleared areas within the Project footprint after the construction phase. This program can monitor for downslope movement and soil moisture in sufficient frequency to assess the effects conditions that may affect terrain stability.

20.3.2.4 Summary Statement

The overall potential effects of terrain instability, in particular permafrost degradation, on the Project is not considered significant. Even though the overall likelihood of occurrence has been determined to be HIGH and is likely to occur over the life of the Project, the consequence of the most likely event is considered to be LOW because Project components, activities and critical services are not anticipated to be interrupted for more than 24 hours with the implementation of proposed mitigation measures.

20.3.3 Extreme Weather Events

Extreme weather events are unusual, severe or unseasonal weather at the extremes of the historical distribution. The following provides a brief overview of extreme weather events that may affect the Project and characterizes the likelihood of occurrence and the severity of the potential effects on the Project. An overview of mitigation measures proposed to prevent and minimize potential adverse effects on the Project is provided. This section includes a discussion of:

- Extreme precipitation (including rain and snow); and
- Extreme temperatures.

20.3.3.1 Likelihood of Occurrence

In general, the climate of the Project area is characterized by long, cold, dry winters and short, warm, wet summers, with conditions varying according to altitude and aspect (Knight Piesold 2012). Climatic data was collected on-site at the Project's climate station located in the upper Casino Creek sub-watershed at an elevation of 1,200 m. Climatic data was collected from 1993 to 1994 and from 2008 to present and was used in conjunction with climatic data from regional sites to calculate potential extreme weather conditions.

Annual extreme 24-hour rainfall values were calculated using the Rainfall Frequency Atlas of Canada (Hogg and Carr, 1985) methodology and the return period values were estimated using a Gumbel distribution. The 24-hour rainfall depths range from 29 mm for a 2-year return period, to 56 mm for a 200-year return period. For comparison, the maximum daily rainfall recorded at the Casino mine site from 2009 to 2011 was 31.6 mm, which corresponds to a return period between 2 and 5 years according to the Rainfall Frequency Atlas. The maximum daily rainfall recorded at the Pelly Ranch Regional Climate Station, according to Environment Canada's 1971-2000 climate normal, is 34.8 mm. Scaled to the Casino mine site (according to the regression relationship for monthly precipitation), the calculated extreme 24-hour rainfall value is 57 mm as presented in Table 20.3-10.

The maximum and minimum temperatures recorded at the Project climate station between 2008 and 2011 are 26 C and -40 C, respectively. The extreme maximum and minimum recorded temperatures at Pelly Ranch according to Environment Canada's 1971-2000 climate normals are 35 C and -60 C, respectively. Scaled to the Casino mine site (according to the regression relationship for temperature), the calculated maximum temperature at the Casino mine site is approximately 30 C. The calculated minimum temperature at the Casino mine site is more challenging to calculate due to the weaker correlation in winter temperature but is approximately -50 C.

Table 20.3-10 Weather Extremes

Weather Extremes	Pelly Ranch Weather Station	Project Station (Measured)	Project (Calculated)	Likelihood
24-hour Rainfall	34.8 mm	31.6 mm	57.0 mm	Negligible
Annual Snowfall Depth	180 mm	-	179 mm	Moderate
Temperature - Maximum	35^{o}c	26^{o}c	30^{o}c	Moderate
Temperature - Minimum	-60^{o}c	-40^{o}c	-50^{o}c	Moderate

20.3.3.2 Potential Effects

Extreme weather events have the potential to affect the Project components and activities if not mitigated. For example, extreme precipitation can cause unwanted releases of water from water management components such as the TMF, collection ponds and HLF events pond. Extreme precipitation can also instigate erosion of material from stockpiles and flooding of structures and access and haul roads or increased maximum snow loading on mine site buildings. Prolonged periods of extreme snow fall can decrease visibility and become a major issue that impedes mine and transportation operations. A summary of the potential effects of the extreme weather events on the Project components and activities is presented in Table 20.3-11.

Table 20.3-11 Potential Effects on the Project from Extreme Weather Events

Project Component or Activity	Project Phase[1]	Range of Potential Effects[2]	
		Predicted Likely Scenario	**Unlikely Worst Case Scenario**
Water management structures (including the TMF, collection ponds and HLF events pond)	C, O, CD	Extreme precipitation will increase water levels within the TMF, collection ponds and HLF events ponds but is within maximum capacity. Project components, activities and critical services are not interrupted.	Extreme precipitation will increase water beyond the capacity of the water management structures and will lead to overtopping of mine contact water into the environment prior to meeting discharge requirements for water quality.
TMF, HLF, and stockpiles	C, O	Minor erosion of embankments, from extreme wind gusts or precipitation events will be monitored and mitigated quickly to prevent sediment delivery into watercourses or short and long term instability. Project components, activities and critical services are not interrupted.	Extreme wind gusts and precipitation events can lead to weathering and erosion of materials that will result in run-off of mine contact water from the TMF or instability of embankments and stockpiles.
Access road and haul roads	C, O	Temporarily (short-term) impassable sections of roads due to flooding from extreme precipitation or visibility issues related to extreme snow are mitigated quickly so that Project activities and critical services are not interrupted for more than 24 hrs.	Large sections of roads are impassable due to extreme precipitation or snow for an extended period of time, so that Project activities and critical services are interrupted for more than one week.
Casino airstrip	C, O	Extreme snowfall, low temperatures and wind gusts may cause short term delays and cancelled flights at the Casino airstrip for less than 24 hrs.	Extended extreme snowfall, low temperatures and wind gusts can cause the Casino airstrip to shut down and cancel all flights for Casino staff for more than a week.
Mine operations including HLF ore stacking, open pit development and ore processing	C, O	Short term visibility issues from extreme snowfall may interrupt mine operations. The majority of Project activities and critical services are not interrupted for more than 24 hrs.	Extended visibility issues from extreme snowfall may affect Project activities and critical services for more than a week.
Camp office, maintenance shops, thickened tailings plant, explosives storage magazine, mill	C, O	Localized flooding, and increased snow loading on structures at the Casino mine site will be monitored and mitigated quickly so that Project activities and critical services are not interrupted.	Extreme and extended snow fall and precipitation events could potentially cause generalized flooding at the Casino mine site. Extreme snow fall could cause the collapse of some structures due to snow loading.

Notes:
Construction (C), Operations (O), Closure and Decommissioning (CD), and Post-Closure (PC)
A range of potential effects are described to represent the most likely predicted scenario and the unlikely worst case scenario

20.3.3.3 Mitigation Measures

The Project has incorporated design-based mitigation measures into the design of Project components and activities to prevent and minimize the potential effects of extreme weather events on critical Project components and activities. The calculated extreme weather conditions for the Project (presented in Table 20.3-10) were used as the design values for engineering the Project's key mine site components, water management structures and access components. For example, the capacity of the collection pond for the TMF has been sized to provide sufficient storage for water taking into consideration extreme precipitation events including the Probable Maximum Flood (PMF) event. The PMF, as defined by the Canadian Dam Safety Association, is a flood event which results from the most severe and reasonably possible combination of rainstorm, snow accumulation, melt rate and antecedent moisture conditions (CDSA 1995). The design based mitigation measures listed in Table 20.3-12 are expected to prevent any possible overtopping and accidental release of mine contact water that does not meet water quality objectives during extreme precipitation events.

During the life of the Project, the Emergency Response Plan and other associated environmental management and monitoring plans will define actions and procedures to ensure that human and environmental health and safety is considered in relation to potential effects on the Project from extreme weather events.

Table 20.3-12 Extreme Weather Events - Mitigation Measures

Project Components/ Activities	Mitigation Measures	
	Design Considerations	Actions
Water management structures (including collection ponds, events pond, diversion ditches)	The crest elevations of water management ponds have been designed to provide sufficient storage capacity to safely contain the probable maximum precipitation event. The 1 in 100 year 24-hour storm event is defined as the design storm event for the sizing of surface runoff and diversion ditches. Temporary collection ditches for construction will be sized to convey the runoff from the 1 in 10 year 24-hour storm event. The HLF Fresh Water Supply Pond will be designed with an overflow spillway sized to pass the design storm event commensurate with the dam safety rating.	Throughout the life of the Project, water management objectives will be guided by the Water Management Plan for the Project. During operations, dewatering systems will include ditches, pipes, sumps, pumps and booster pumps. After decommissioning and closure, any mine-contact water that does not meet discharge requirements for water quality will be routed to the Open Pit (anticipated for approximately 10 years).
TMF	A safety assessment of the TMF was conducted to determine the storm storage requirements. The TMF has been designed using a 72-hour 1:1,000 and the Probable Mean Flood (PMF) events. The Inflow Design Flood (IDF) selected for the TMF has a volume of 7.0 million m3 during the construction phase, 9.0 million m3 during operations, and 6.1 million m3 at closure, once the spillway is operational. TMF ditches will be sized to convey the 1 in 10 year peak flow.	During operations, selective handling and placement of materials (including waste rock, tailings, topsoil and overburden) combined with management strategies to avoid or minimize weathering and erosion of materials into run-off will be implemented and monitored.
Stockpiles	The diversion ditching system along the upslope side of the stockpiles have been designed to meet the criteria for a 1 in 100 year 24-hour duration storm event. Where possible soil stockpiles will be oriented to reduce wind erosion and located to reduce wind exposure.	Sediment control fencing will be placed around the down-gradient perimeter sections of the stockpiles to prevent sediment discharge from the stockpiles. All ore and topsoil stockpiles will be removed before or at closure of the mine. The topsoil from the stockpiles will be

Project Components/ Activities	Mitigation Measures	
	Design Considerations	Actions
		used in reclamation activities for the Project.
Access road and haul roads	Any areas in close proximity to flood plains, watercourses and unstable terrain, have been avoided where possible. Road culverts on haul roads and access roads have been designed to account for a 1 in 100 year flood event. Bridges along the Freegold Road have been designed with 2m of freeboard above the 1 in 100 year flow elevation to allow for clearance of debris during a flood event.	The Transportation Management Plan will include snow clearing strategies on haul roads and access roads to ensure continuous operations. Regular road maintenance will include ensuring proper drainage off the road surface, and monitoring for erosion of bridge abutments, approaches, and drainage ditches following heavy rainstorms. In addition, culverts along the Freegold Road Extension and Freegold Road Upgrade will be inspected and cleared to ensure they operate and drain effectively.
Casino airstrip	Any areas in close proximity to flood plains, watercourses and unstable terrain, have been avoided where possible. The airstrip design includes a drainage system to divert subsurface flow and runoff from the airstrip surface.	Special vehicles at the Casino airstrip will clear the snow as fast as possible from the airstrip. Additional mitigation, if required, can include localised slope flatting or air convection embankments to reduce snow accumulation and allow cold air to propagate into the embankment during the winter.
Heap Leach Facility	A number of considerations have been planned for the Heap Leach Facility including In-Heap Storm Storage for the 1 in 25 year storm event, a HLF embankment spillway for conveying the 1 in 200 year storm event, a HLF Events pond designed for the 1 in 100 year storm event with a spillway for the 1 in 200 year storm event and diversion ditches. In addition, in consideration of low visibility months, the Casino mine plan does not propose to carry out ore stacking at the HLF during the worst winter months.	The Emergency Response Plan will define actions and procedures to ensure that human and environmental health and safety is considered during extreme weather events. Staged stacking of the ore at the facility will also take place.
Mine operations including open pit development and ore processing	Information on design mitigation measures adopted for the Project is provided in Section 4.0 of the Proposal.	The Emergency Response Plan will define actions and procedures to ensure that human and environmental health and safety is considered during extreme weather events.
Camp office, maintenance shops, thickened tailings plant, explosives storage magazine, mill	Flood control design based mitigation measures for a 1 in 100 year wet event has been incorporated into the design for all on-site structures including the mill. Snow loading design based mitigation measures have been incorporated into the design of all on-site structures for a 1 in 100 year storm event. As appropriate, building designs will follow Part 4 of the	Sensitive structures and buildings will be monitored for their performance throughout life of the Project, especially during and after extreme weather events, through regular inspections to identify areas of potential failure. Mitigative measures will be carried out to decrease the likelihood of short or long term failure.

Project Components/ Activities	Mitigation Measures	
	Design Considerations	Actions
	Canada Building Code.	

20.3.3.4 Summary Statement

The overall potential effect of extreme weather events on the Project components and activities is not considered to be significant. Given the semi-arid climate of the Project location, the likelihood of occurrence for an extreme weather event during the life of the Project is categorized as negligible to moderate. Even though extreme weather events have a low potential of occurring during the life of the Project, the Project has incorporated design-based measures to mitigate for potential effects and the severity and consequence of potential effects to the Project from extreme weather events are considered to be low. Based on the design considerations employed, it is anticipated that extreme weather events will not cause the Project's critical components and activities to shut down for more than 24 hours.

20.3.4 Wildfires

Wildfires have the potential to cause widespread damage to ecosystems and property if not contained. Wildfire behavior is a function of forest moisture levels, precipitation, wind speed, humidity, and air temperature. The amount of fuel onsite determines the heat and the potential damage that can be caused by a fire. Generally, areas that have a high fire frequency tend to have lower fuel loading and will burn through the understory quickly and with less destructive force. Forests with a lower fire frequency (common in areas where fire suppression is active), have higher fuel loading, and consequently in the event of a wildfire, burn hotter and more destructively.

The following provides a brief overview of wildfire history in the Yukon Territory and characterizes the likelihood of occurrence and the severity of the potential effects on the Project's critical components and activities. An overview of mitigation measures proposed to prevent and minimize potential adverse effects on the Project is provided.

20.3.4.1 Likelihood of Occurrence

Wildfires can originate from lightning strikes, accidents, malfunctions, careless human activity and deliberate criminal acts. As well environmental factors such as dry summer weather, high winds, and lightening will increase the fire risk and risk of accidental fire. According to the Yukon Government, the Yukon has an average of 150 wildfires per year and approximately half of which are caused by people (Government of Yukon 2013). Wildfire statistics for the Yukon Territory between 2000 and 2006 are provided in Table 20.3.13 from statistics available on the Yukon Government Wildland Fire Management Program.

Table 20.3-13 Wildfire Statistics from 2000 to 2006

Year	Lightning Caused	Human Caused	Total Fires	Hectares Burned
2006	53	26	79	95,033
2005	57	26	83	129,472
2004	249	33	282	1,714,875
2003	28	49	77	49,037
2002	30	39	69	36,336
2001	50	18	68	17,334
2000	23	31	54	7,653

Given that half of all wildfires in the Yukon are caused by anthropogenic sources, it is difficult to determine the probability of a wildfire occurring in the Project area. Based on the categories of likelihood and taking into consideration the wildfire data provided by the Yukon Government, the overall likelihood of a wildfire event that has the potential to affect the Project during the life of the Project is moderate and it could happen.

20.3.4.2 Potential Effects

The potential effects of wildfires on the Project include damage to onsite buildings and structures within the Casino mine site, the Casino Airstrip, Yukon River water pipeline and the access road. Primary Project components at risk from wildfire include mine supply traffic along the Freegold Road Upgrade and Freegold Road Extension. Within the Casino mine site, of particular concern is the ability for critical Project components, such as the HLF, to continue to operate safely if the main or supplementary power plants fails to generate power. This potential effect is discussed in detail in Section 21 as part of the assessment of accidents and malfunctions.

Table 20.3-14 lists a range of potential effects to the Project components or activities, from the most likely scenario to the worst case scenario.

Table 20.3-14 Potential Effects on the Project from Wildfires

Project Component or Activity	Project Phase[1]	Range of Potential Effects[2]	
		Predicted Most Likely Scenario	Worst Case Scenario
Freegold Road (Extension and Upgrade)	C, O	Minor damage to bridges and culverts are repaired and Project activities and critical services are not interrupted.	Multiple bridges and culverts along the access road are destroyed by wildfire causing Project activities and critical services to be interrupted for more than one month while repairs are completed.
Casino airstrip	C, O, DC	Minor damage to the Casino airstrip facilities and infrastructure are repaired and Project activities and critical services are not interrupted.	The Casino airstrip infrastructure and facilities are destroyed and regularly scheduled flights in and out of the Casino mine site are disrupted for more than one month while repairs are completed.
On site buildings and structures including the accommodations camp, offices, maintenance shops, plant site, and haul roads	C, O	Minor damage or no damage to buildings and structures at the Casino mine site and activities and critical services are not interrupted.	Buildings and structures at the Casino mine site are destroyed and there is a complete shutdown of Project components, activities and critical services for more than one month.
Explosive facility	C, O	Unintended explosion and fire is within the buffer established and does not affect other buildings at the Casino mine site. The Project activities are not interrupted.	Unintended explosion and fire will destroy other buildings at the Casino mine site. There is a complete shutdown of Project components and activities and critical services for more than one week.
Power plants (Supplementary and Main)	C, O	Minor damage if any to the Main Power Plant or Supplementary Power Plant but not both. Backup generators are available and the Project activities and critical services are not interrupted for more than 24 hrs.	Wide spread power outage at the Casino mine site due to damage to both power plants. Backup generators are insufficient, and Project activities and critical services are interrupted for more than a week until additional generators are brought to the Casino mine site.

Notes:

Construction (C), Operations (O), Closure and Decommissioning (CD), and Post-Closure (PC)

A range of potential effects are described to represent the most likely predicted scenario and the unlikely worst case scenario

20.3.4.3 Mitigation Measures

The Project is located in the Mayo sub-district of the Northern Tutchone fire management district. The closest fire department is located in the Village of Mayo, and is staffed by 15 to 20 volunteers. The Casino mine site will be mainly cleared of vegetation, reducing the risk of a wildfire damaging onsite Project components. Mitigation measures proposed to minimize potential effects to the Project associated with wildfires are listed in Table 20.3-15.

Table 20.3-15 Wildfires - Mitigation Measures

Project Components/ Activities	Mitigation Measures	
	Design Considerations	**Actions**
Freegold Road (Extension and Upgrade)	The Freegold Road Extension will operate as a resource road with controlled and limited access.	Brushing and clearing along the Freegold Road Extension and Freegold Road Upgrade right-of-ways will help minimize the risk of wildfires. CMC will develop a transportation management plan that will include measures to limit the risk of anthropogenic fires as a result of mine generated traffic on the Freegold Road Extension and Upgrade.
Casino airstrip	Firefighting equipment will be located at the Casino airstrip.	Vegetation that could provide fuel for fire will be removed from around the airstrip infrastructure.
On site buildings and structures including the accommodations camp, offices, maintenance shops, plant site, and haul roads	Firefighting equipment will be located throughout the mine site. The process offices, laboratory and shop/warehouse will be fitted with sprinkler systems. Vegetation that could provide fuel for fire will be removed from around mine infrastructure. The HLF will be designed to ensure safe operation and/or shutdown in the event of a site evacuation and/or power failure.	A fire and explosion response process will be developed as part of the Emergency Response Plan for the Project that will include procedures for dealing with wildfire hazards and site evacuations.
Explosive facility	Fire risk is always kept in mind when considering explosives storage and the placement of the explosives magazine at the mine site. Vegetation that could provide fuel for fire will be removed from around mine infrastructure.	Explosives magazines will be located and designed within embankments to prevent damage to other facilities.
Power plants (Supplementary and Main)	Water for firefighting is available at the Casino mine site. Emergency generators are also available on site.	Vegetation that could provide fuel for fire will be removed from around mine infrastructure.

20.3.4.4 Summary Statement

The overall potential effect of wildfires on the Project components and activities is not considered to be significant. The likelihood of occurrence for a wildfire event during the life of the Project is categorized as moderate because approximately half of all recorded wildfires in the Yukon Territory are caused by people. Given the likelihood of occurrence, the Project has incorporated design-based measures to avoid wildfires and minimize the potential severity and consequence to the Project. The overall impact of wildfires to the Project is considered to be low. CMC anticipates that wildfire events will not cause the Project's critical components and activities to shut down for more than 24 hours.

20.3.5 Climate Change

Climate change is defined by the Intergovernmental Panel on Climate Change as "a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties that persists for an extended period, typically decades or longer" (IPCC 2007). Climate change reflects abnormal variations to the expected climate, and is currently most commonly associated with increasing temperatures, although related changes in other parameters such as atmospheric water vapour content; precipitation patterns; snow and ice cover; soil moisture; and runoff, also qualify as abnormal variations to the expected climate.

A preliminary assessment of potential climate change effects was conducted for the Project to verify whether or not the climate scenario used to assess the potential effects on valued components reasonably represents conditions that might be expected over the life of the Project and into post closure. This assessment included a review of relevant literature and examination of historical trends of annual temperature, precipitation, and discharge for the Project. Historical trends were compared to downscaled predictions established from global climate models developed for the Intergovernmental Panel for Climate Change in order to assess a full range of possible climate change scenarios for the Project. The comprehensive findings of this assessment are available in the Climate Change Report (Appendix 20A) and a summary of the key finding is provided below.

Section 8.0 of the Proposal describes air quality as an indicator of both environmental and human health due to the atmosphere's role in transporting air emissions to humans, freshwater, and terrestrial receptors. In the context of climate change, air quality can also be a key indicator of increase greenhouse gasses (GHG) in the atmosphere and its contribution to climate change.

Concerns about the potential effects of GHG related climate change have resulted in national and local policy and regulatory initiatives that apply to developments in the Yukon. At the federal level, legislation and GHG emissions targets are still being developed based on the approach set out in Canada's 2007 Action Plan, the *Turning the Corner Plan*, which was supplemented by the development of a regulatory framework in 2008 (Environment Canada 2008). In addition, a number of provinces and territories have developed their own climate change legislation to reduce local contributions to GHGs. The Government of Yukon's Climate Change Strategy (YGCCS) was published in 2006 (Government of Yukon 2006a).

The Yukon strategy's four goals call for:

- Enhancing public awareness;
- Reducing greenhouse gas emissions;
- Building environmental, social, and economic systems to adapt to changes and take advantage of climate change opportunities; and
- Establishing Yukon as a northern leader in climate change research and innovation.

Environment Yukon has focused on meeting these goals through the development of the Yukon Climate Change Action Plan, which was finalized in 2009 (Government of Yukon 2009a). The Action Plan identifies 33 specific actions that advance the goals set out in the 2006 YGCCS. Currently, though, there are no regulations related to release of GHG emissions within Yukon.

20.3.5.1 Likelihood of Occurrence

Climate change predictions are particularly relevant for development projects in the Yukon because the greatest temperature increases have been noted in northern latitudes (Werner *et al.* 2009). According to the Yukon Government's report "Yukon Water: An Assessment of Climate Change Vulnerabilities" (Goulding 2011), temperature and precipitation generally increased across the Yukon for the period of 1950 to 1998, annual temperatures were generally increasing across the territory, in the order of 2 °C (Lemmen *et al*. 2008), and daily minimum temperatures were found to be increasing faster than daily maximum temperatures (Werner *et al.* 2009). All regions showed slightly increasing winter precipitation, while summer precipitation decreased in the northern

Yukon but increased in the southern Yukon. According to a Pacific Climate Impacts Consortium (PCIC) report "Climate Change in Dawson City, YT: Summary of Past Trends and Future Projections", winter temperatures are projected to increase 2.1°C to 3.5°C by 2050 over baseline climate normal values for 1961 to 1990, and annual precipitation is projected to increase by 10% to 40%, with a 30% to 50% increase expected in the winter and a 10% to 30% increase expected in the summer (Werner *et al*. 2009). Estimates of climate changes predicted for the Dawson Region for 2050 using the PCIC Regional Analysis Tool, based on an ensemble of future emission scenarios, are summarized in Table 20.3-16, and indicate a median temperature increase of 2.6°C and a median annual precipitation increase of 15%.

Table 20.3-16 Climate Change Predictions for the Dawson Region by 2050 and Likelihood of Occurrence

Climate Variable	Season	Projected Change in 2050 relative to 1961-1990			Likelihood of Occurrence
		Ensemble Median	10th Percentile	90th Percentile	
Mean Temperature (°C)	Annual	+2.6	+1.6	+4.4	Moderate
Precipitation (%)	Annual	15%	4%	24%	Moderate
	Summer	12%	2%	28%	
	Winter	17%	3%	37%	
Snowfall (%)	Winter	16%	0%	36%	Moderate
	Spring	6%	-7%	23%	Low

Notes:
1. Source: Pacific Climate Impacts Consortium Regional Analysis Tool, 2013
2. Median and percentile calculations are based on results for emission scenarios used in the IPCC Fourth Assessment Report (AR4)

20.3.5.2 Potential Effect

Equivalent carbon dioxide (CO_{2e}) was estimated for the Project using the US Environmental Protection Agency (US EPA) AP42 emission factors, approved emission limits, manufacturer specifications, NONROAD2008 software, and MOVES 2010a software. CO_{2e} is a measure that describes, for a given mixture and amount of GHG, the amount of CO_2 that would have the same global warming potential, when measured over a specified timescale (generally, 100 years). Project generated CO_{2e} is summarised in Table 20.3-17.

Table 20.3-17 Casino CO_{2e} Emission Estimates

Project Phase	Greenhouse Gas Source	CO_{2e} (kt)
Construction Phase	Mine Fleet (average per year)	140
	Power Generation (average kt per year)	75
	Other Sources (average kt per year)	3.7
	Construction Phase Total (average kt per year)	**216**
	Construction Phase Total Emissions (3 year period)	**648**
Operation Phase	Mine Fleet (average kt per year)	399
	Power Generation (average kt per year)	202
	Other Sources (average kt per year)	3.96
	Operation Phase Total (average kt per year)	**604**
	Operation Phase Total Emissions (22 year period)	**13,297**

Notes:

1. Equipment speeds (other than haul trucks) are based on general mining practices.
2. It was assumes that all vehicles will use diesel fuel and generators will use diesel and LNG.
3. The fuel rates for all vehicles were taken from Caterpillar's Performance Handbook Edition 29.
4. Fuel consumption for vehicles are averages and a load factor of 1 was applied. This assumes that equipment will not be overloaded and will be used on adverse grades and experience some high rolling resistance.
5. Working time was calculated as the productive time, which includes loading, unloading, and transporting.
6. The Main Power Plant will be active for the entire operation phase with 90% efficiency.

Information on Yukon and Canadian CO_{2e} emissions from 1990 to 2011 are presented in Section 8 of this Proposal. Existing levels of annual CO_{2e} emissions from the Yukon in 2011 contributed to approximately 0.05% of the total Canadian emissions. Taking into account the potential CO_{2e} emissions generated by the Project during the construction phase, the Yukon Territory with the Casino Project would only contribute 0.15% of the total annual Canadian emissions (using 2011 rates). In general, the Yukon generates relatively very low CO_{2e} emissions nationally and does not provide a measurable contribution to global emission levels.

According to Nelson and Schuchard (2011), the temperature and precipitation shifts and more frequent and severe extreme weather events associated with climate change will affect the mining sector. Climate models predict a general increase in winter precipitation and rapid warming in the north, which can lead to degradation of permafrost (ICF Marbek 2012). Potential effects to the Project from climate change are outlined in Table 20.3-18.

Table 20.3-18 Potential Effects on the Project from Climate Change

Project Component or Activity	Project Phase[1]	Range of Potential Effects[2]	
		Predicted Most Likely Scenario	Worst Case Scenario
All infrastructure and components	C, O, CD, PC	Minor occurrences of terrain instability will not compromise the short term or long term stability of infrastructure. Project activities and critical services are not interrupted.	Increased heavy rain and increased erosion will affect slope stability of sensitive infrastructure and components. Terrain instability along the transport corridors could temporarily disrupt delivery of process materials to site or of concentrate off site. Project activities and critical services will be temporarily interrupted while repairs are completed.
All infrastructure and components	C, O	Hotter and drier conditions are monitored and responded to appropriately so that wildfires do not threaten facilities and activities. Minor damage is expected to cause only short term interruption to Casino mine site activities and components.	Hotter and drier conditions will cause larger wildfires that could result in damage of infrastructure or medium or long term of disruption of activities.
Water management structures	C, O, CD	Extreme precipitation will increase water levels within the TMF, collection ponds and HLF events pond but water management structures will not overtop.	Flooding from increased rainfall could exceed the capacity of water management structures, resulting in the unintentional release of water into the environment.
Closure and Reclamation Practices	CD, PC	Hotter temperatures will make it more difficult to re-establish native vegetative cover, however increased CO_2 and longer growing seasons could conversely benefit re-vegetation efforts.	Increased erosion resulting from inability of re-vegetated areas to become self-sustaining. PC monitoring will inform adaptive management.

Notes:
Construction (C), Operations (O), Closure and Decommissioning (CD), and Post-Closure (PC)
A range of potential effects are described to represent the most likely predicted scenario and the unlikely worst case scenario

20.3.5.3 Mitigation Measures

Design considerations for the potential effects of climate change on the Project have been incorporated into the design of potentially sensitive components and activities. For example, the designs of the HLF and TMF have incorporated predefined synthetic modelled peak flow assumptions for extreme precipitation events. The design specifications of all key structures have taken into account the potential for climate change and other extreme events and effects of the environment.

Table 20.3-19 outlines the sections of the Proposal that provide design considerations and prevention, response and remedial actions to mitigate for the potential effects of climate change on the Project. Additional measures, outlined in Section 8.0, will be implemented by CMC to minimize potential CO_{2e} emissions from the Project.

Table 20.3-19 Climate Change - Mitigation Measures

Project Components/ Activities	Mitigation Measures	
	Design Considerations	**Prevention, Response and Remedial Actions**
All infrastructure and components	Terrain instability – described in Section 20.3.2	Described in Section 20.3.2
Water Management Structures	Extreme Weather Events – described in Section 20.3.3	Described in Section 20.3.3
All infrastructure and components	Wildfires – described in Section 20.3.4	Described in Section 20.3.4
Closure and Reclamation Practices	A Closure and Reclamation Plan will be developed in the context of future climate, with considerations for future biodiversity, vegetation and other climate change considerations,	Reclamation refinement during mine operations will help select native vegetation that will adapt to the changing climate.

20.3.5.4 Summary Statement

The overall potential effect of climate change on the Project is not considered to be significant. The likelihood of occurrence for climate change during the life of the Project is categorized as moderate, since it is widely recognized that warming of the climate is evident, though the magnitude of the climate change generated effects is uncertain (ICF Marbek 2012). Given the likelihood of occurrence, the Project has taken into consideration potential climate change effects in the design of key and potentially sensitive components and activities to avoid or minimize any potential effects to the Project.

20.4 CONCLUSION

The design considerations for the Project and proposed prevention, response and remedial actions have taken into account the potential for extreme environmental events, including those associated with climate change; therefore, no significant effects to the Project are anticipated due to effects of the environment.

Table 20.4-1 Summary of Potential Effects to the Project from the Environment

Environmental Events	Potential Effect (based on Likelihood and Consequence)
Seismic Activity	Not Significant
Terrain Instability (landslides, avalanches, and permafrost disturbance)	Not Significant
Extreme Weather Events	Not Significant
Wildfires	Not Significant
Climate Change	Not Significant

Notes:
Severity of the potential effect is based on the potential effects described to represent the most likely predicted scenario