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A.6 – TERRAIN FEATURES

A.6.1 INTRODUCTION

Section 6 of the Proposal summarized the effects assessment conducted for terrain features at the Project. Terrain features were selected as a Valued Component (VC) by Casino Mining Corporation (CMC) for the Casino Project (the Project) because of their importance to regional and localized ecological processes. The Proposal defines terrain features as the geological surface features, topography, and layers of mineral and organic materials covering the underlying bedrock geology. The assessment focused on potential effects of the Project to three unique types of terrain features: thaw lakes (lakes found in thermokarst that develop in a depression and accumulate either permafrost melt water or rain water), pingos (mounds of earth-covered ice which grow as a result of periglacial processes), and tors (isolated pillar-like rock outcrops situated on ridges, associated with unglaciated terrain). The Proposal concluded that the potential effects of the Project on existing terrain features are considered to be adverse and irreversible; however, the adverse residual effect is considered Not Significant, since the effects will be on individual terrain features and localized to the Project footprint.

On January 27, 2015, the Executive Committee requested that CMC provide supplementary information to the Casino Project (YESAB Project No. 2014-0002) to enable the Executive Committee to commence Screening. The Executive Committee considered comments from various First Nations, Decision Bodies and regulators on the adequacy of the Project Proposal in the preparation of the Adequacy Review Report (ARR). Casino Mining Corporation is providing this Supplementary Information Report (SIR) to comply with the Executive Committee's ARR; CMC anticipates that the information in the SIR and Proposal, when considered together, is adequate to commence Screening.

The Executive Committee has 11 requests related to information presented in Section 6 Terrain Features of the Project Proposal submitted on January 3, 2014. These requests and the corresponding sections of the SIR where the responses can be found are outlined in Table A.6.1-1.

Table A.6.1-1 Requests for Supplementary Information Related to Terrain Features

Request #	Request for Supplementary Information	Response
R147	A detailed discussion on the short and long-term stability of mine infrastructure and surrounding slopes in the upper Casino Creek watershed due to permafrost degradation. Consideration should be given to the effects of permafrost degradation related to site infrastructure and climate change.	Section A.6.2.1.1
R148	Maps and relevant references showing permafrost distribution within the mine site as well as the Freegold Road, the airstrip and the airstrip access road.	Section A.6.2.1.2
R149	A detailed thermal modeling analysis of the proposed TMF and associated infrastructure on foundation conditions to support engineering design (including determination of embankment height, width of right of way, safety margin, etc.) and to assess the effects of the Project on the ground thermal regime. Include a detailed discussion and analysis about potential impacts to mine infrastructure from altered foundation conditions.	Section A.6.3.1.1
R150	An analysis of how climate change has been incorporated into the thermal erosion analysis to support Project design and the impact assessment.	Section A.6.3.1.2

Request #	Request for Supplementary Information	Response
R151	The depths at which ground temperatures have been measured for each cable installed in 1994.	Section A.6.4.1.1
R152	The ground temperature readings for all thermistor cables (from 1994 to 2013) in the same format (graphs of ground temperature with depth at a given time) which will allow an assessment of the impacts of recent climate warming (from 1994 until now) on permafrost.	Section A.6.4.1.2
R153	A discussion of whether ground temperature monitoring is planned for the proposed alignment of the Freegold Road Extension.	Section A.6.4.1.3
R154	Please clarify the assumption that permafrost might have low ice content based on the comparison between depth of permafrost and depth to groundwater.	Section A.6.4.1.4
R155	Clarification of the legends used in the baseline terrain maps as well as a simpler interpretation (label) of the units, especially those with multiple capital letters and integers. This will help establish the baseline surficial geology (terrain).	Section A.6.5.1.1
R156	Develop and present a site-specific terrain hazard classification scheme for the mine site, the Freegold Road, and the airstrip and airstrip access road, consistent with the YESAB draft guidance document titled Geohazards and Risk: A Proponents Guide to Linear Infrastructure (YESAB, 2014).	Section A.6.6.1.1
R157	Clarification of whether an ice-rich permafrost distribution map has been considered in the terrain hazard classification scheme	Section A.6.6.1.2

Notes:

1. Request # refers to the assigned identification number in the YESAB Adequacy Review Report of January 27, 2015 Prepared by the Executive Committee of the Yukon Environmental and Socio-economic Assessment Board.
2. Response refers to the location of CMC's response to the YESAB request for supplementary information.

A.6.2 PERMAFROST

A.6.2.1.1 R147

R147. A detailed discussion on the short and long-term stability of mine infrastructure and surrounding slopes in the upper Casino Creek watershed due to permafrost degradation. Consideration should be given to the effects of permafrost degradation related to site infrastructure and climate change.

Potential significant adverse residual effects due to permafrost degradation on the short term and long term stability of proposed mine infrastructure and surrounding slopes of the upper Casino Creek valley are not anticipated because of proposed mitigation measures and design standards. For example, prior to construction, the footprints of the mine infrastructure will be stripped of the surficial soils that may otherwise contribute to instability. In general, construction and site preparation techniques on permafrost require frozen, organic and ice-rich colluvium and residual soils to be ripped, blasted and/or excavated to competent, non-frost susceptible bedrock for subgrade preparation. All ice-rich overburden and heavily weathered rock will be removed to prevent potential thaw-settlement resulting from melting permafrost. The exposed bedrock will provide a thaw-stable foundation for mine infrastructure.

In support of future refinement in the Project design and future construction activities, ground temperature data are currently being collected at a number of locations across the site using thermistor strings and data loggers that were installed in vertical drillholes. Continued monitoring in the operations phase will allow for identification of real-time changes in permafrost conditions that may be connected with climate change. The need for additional mitigations for permafrost degradation to ensure the stability of the slopes of the upper Casino Creek valley will be assessed in detailed design taking into account the additional ground temperature data currently being collected.

With the mitigation measures and ground temperature data monitoring program in place, as well as an opportunity to incorporate any new information from ongoing monitoring into the refinement of the Project design, CMC does not anticipate significant adverse residual effects due to permafrost degradation on the short term and long term stability of proposed mine infrastructure and surrounding slopes of the upper Casino Creek valley.

A.6.2.1.2 R148

R48. Maps and relevant references showing permafrost distribution within the mine site as well as the Freegold Road, the airstrip and the airstrip access road.

Permafrost features and processes were rigorously incorporated into the terrain mapping provided in the Proposal. Please refer to the Project terrain and terrain hazards maps in the Surficial Geology, Terrain and Soils Baseline (Appendix 6A of the Proposal), which provides details of the permafrost landforms. Processes that exist in the Project area are based on available information.

Permafrost distribution maps are presented in the Hydrogeology Baseline Assessment (Appendix 7C of the Proposal). The permafrost distribution maps were derived from the terrain maps, which include permafrost processes as an attribute of the existing terrain. The main addition to the permafrost areas shown on the terrain maps was to assume permafrost is present in bedrock slopes and summits that are upslope from colluvial slopes where permafrost was identified (either through terrain mapping or site investigation). In addition, permafrost was assumed to be present in areas where cryoplanation terraces (erosional steps in bedrock), sorted stone polygons and solifluction lobes were identified. The observed depths of permafrost in the various terrain units are discussed in the original mapping reports.

A.6.3 THERMAL EROSION MODELING

A.6.3.1.1 R149

R149. A detailed thermal modeling analysis of the proposed TMF and associated infrastructure on foundation conditions to support engineering design (including determination of embankment height, width of right of way, safety margin, etc.) and to assess the effects of the Project on the ground thermal regime. Include a detailed discussion and analysis about potential impacts to mine infrastructure from altered foundation conditions.

Casino Mining Corporation would like to take this opportunity to clarify that the Report on the Feasibility Design of the Tailings Management Facility (provided herein as Appendix A.4D) states that "Thermal modelling <u>may also</u> be required to predict the effect of the proposed TMF on foundation conditions"; it does not state that predicting effects of the proposed TMF on foundation conditions will require thermal analysis as paraphrased in the ARR.

A detailed thermal modelling analysis has not been completed; though thermistors were installed during the 2011 and 2012 site investigations to provide a better understanding of the thermal regime in the bedrock of the proposed foundation of the TMF. In addition, ongoing site investigations will inform the characteristics of the overburden and bedrock and the extent of permafrost within the TMF embankment area.

The current design of the Project includes mitigation to remove frozen, organic and ice-rich colluvium and residual soils to competent or non-frost susceptible bedrock for subgrade preparation within all infrastructure foundations.

If foundation conditions are suspected to be susceptible to the effects of thermal erosion, after the removal of permafrost to non-frost susceptible bedrock, additional site investigation and detailed thermal analysis will be completed and additional mitigations measures will be applied if required.

A.6.3.1.2 R150

R150. An analysis of how climate change has been incorporated into the thermal erosion analysis to support Project design and the impact assessment.

This supplementary information builds on CMC's response to R149. A detailed thermal analysis has not been completed, though these assessments can input factors that are attributes of climate change.

A.6.4 GROUND THERMAL CONDITION AND PERMAFROST TEMPERATURE MONITORING

A.6.4.1.1 R151

R151. The depths at which ground temperatures have been measured for each cable installed in 1994.

Sensor depths of the thermistor strings installed in 1994 are provided on page A1-55 of the 2012 Baseline Hydrogeology Report (Appendix 7C of the Proposal). Thermistor sensors were numbered sequentially, increasing in number (i.e., VW1, VW2, etc.) downhole. Numbered sensors were installed at the same depths in each drillhole and were installed at depths of 2 m, 3 m, 5 m, 6 m, 8 m, 11 m, 15 m, 27 m, 52 m, and 76 m.

A.6.4.1.2 R152

R152. The ground temperature readings for all thermistor cables (from 1994 to 2013) in the same format (graphs of ground temperature with depth at a given time) which will allow an assessment of the impacts of recent climate warming (from 1994 until now) on permafrost.

Six thermistor strings were installed in drillholes from June to August 1994. Data at each of these locations was manually downloaded once or twice per month until December 1994 or January 1995. All six 1994 thermistor strings have been reportedly damaged or lost and none are currently functioning. The available ground temperature readings for thermistor cables installed in 1994 are provided in Figures C.2.1 through C.2.6 of the 2012 Baseline Hydrogeology Report (in Appendix C2 of Appendix 7C of the Proposal). Temperatures below zero were recorded in the deposit area at 94-321, 94-331, and 94-334, and downstream of the proposed TMF embankment at 94-349. Recorded temperatures were above zero at sensors 94-344 and 94-345 located in Casino Creek valley.

A.6.4.1.3 R153

R153. A discussion of whether ground temperature monitoring is planned for the proposed alignment of the Freegold Road Extension.

A geotechnical site investigation is being planned for the Freegold Road Extension and may include the installation of thermistors to monitor ground temperature. The plan includes installation of thermistors in the swamp areas on the valley floors where the permafrost table is expected to be close to ground surface and the potential is greater for massive ground ice. The thermistor data for these areas will be used to analyze the permafrost conditions and design the insulating embankment upon which the road is to be constructed. The plan also includes installation of thermistors at several bridge sites to determine the permafrost conditions and to investigate the possibility of frost jacking of piles.

A.6.4.1.4 R154

R154. Please clarify the assumption that permafrost might have low ice content based on the comparison between depth of permafrost and depth to groundwater.

Natural Resources Canada's request for "clarification on the assumption that permafrost might have low ice content based on the comparison between depth of permafrost and depth to groundwater" at CAS-034 (YOR 2014-0002-245-1), refers to the following statement in the 2012 Baseline Hydrogeology Report (Appendix 7C of the Proposal): "Since the depth to groundwater within CAS-034 is greater than 99.5 mbgs (Figure 3.2), permafrost at CAS-034 is inferred to be dry or to have low ice content." The sentence was intended to highlight that even though the inferred depth of permafrost (ground at temperature <0ºC) at CAS-034 is 104 mbgs and is among the deepest permafrost depths measured at the site, the permafrost is mostly (if not all) associated with the unsaturated zone; however, it would not be unreasonable for the approximate 100 m thick soil and rock column above the water table to contain ice lenses or wedges due to freezing of infiltrating water within the unsaturated zone, particularly if the near-surface overburden is fine grained.

Natural Resources Canada further commented that "Inferring low ice content can have implications for the disposal procedure of the overburden (containment and sediment control)" (YOR-2014-0002-245-1). The disposal procedure of the overburden will be determined based on actual conditions observed in the field rather than inferred conditions. Care will be taken to follow appropriate procedures for the given material that is encountered.

A.6.5 SURFICIAL GEOLOGY AND TERRAIN MAPPING METHODS AND MAPS

A.6.5.1.1 R155

R155. Clarification of the legends used in the baseline terrain maps as well as a simpler interpretation (label) of the units, especially those with multiple capital letters and integers. This will help establish the baseline surficial geology (terrain).

The terrain unit integers found in labels on Maps 11 to 17 are an adaptation to Howes and Kenk (1997). The integers are deciles that are applied to composite symbols to represent the proportion of each geological component within the terrain unit as outlined in Chapter 6, Terrain Symbols, p.63–64 (Howes and Kenk 1997). The decile method of composite symbolization is an alternative to delimiter symbols ("•" ; "/" ; "//") found on Maps 1 to 10; both methods of symbolization provide the relative proportions of each component. In the example symbol highlighted by the reviewer, the integers represent 70% sxDv, 20% zxsxCv, and 10% R, as interpreted within the terrain unit polygon. Decile composite symbols were used by AECOM in the vicinity of the Casino Mine Site and Airstrip; whereas delimiter symbolization was used by Knight Piésold for the Freegold Road. Please refer to the map legend provided as Figure 1 of the Terrain Hazards Assessment for Proposed Mine Site (Appendix 6D of the Proposal).

A.6.6 TERRAIN HAZARDS ASSESSMENT

A.6.6.1.1 R156

R156. Develop and present a site-specific terrain hazard classification scheme for the mine site, the Freegold Road, and the airstrip and airstrip access road, consistent with the YESAB draft guidance document titled Geohazards and Risk: A Proponents Guide to Linear Infrastructure (YESAB, 2014).

Casino Mining Corporation acknowledges the Executive Committee's request and is aware of the YESAB draft guidance document titled Geohazards and Risk: A Proponents Guide to Linear Infrastructure. This draft guidance document was made available for review in March 2014 after the submission of the Proposal on January 3, 2014. Furthermore, the document "provides guidance and information only. It is not intended to provide legal advice or direction" (YESAB, 2014).

Nonetheless, the site-specific terrain hazard classification scheme that was presented in the Proposal generally conforms to the requirements of the draft guidance, including the adoption of a framework that considers:

- Review of existing guidelines and best practices related to infrastructure;
- Work scale;
- Spatial and temporal data;
- Approaches for geohazards and mapping;
- Risk analysis;
- Consequence assessment;
- Approaches for risk analysis;
- Risk evaluation;
- Risk management, and
- Mitigation.

The information presented in the Proposal also conforms to the information requirements identified within the draft guidance, which includes:

- Project initiation and scoping;
- Objectives;
- Study area and work scale;
- Background information;
- Analysis of baseline data;
- Field investigation;
- Geohazard Assessment;
- Risk assessment;
- The risk assessment: how geohazards affect the proposed development;
- The risk assessment: how geohazards affect construction and engineering;
- Reporting, and
- Map requirements.

The terrain hazard scheme presented in the Proposal generally conforms to the YESAB (2014) guidance and does not warrant updating.

A.6.6.1.2 R157

R157. Clarification of whether an ice-rich permafrost distribution map has been considered in the terrain hazard classification scheme

The ice-rich permafrost distribution map has been considered in the terrain hazard classification scheme. Ice-rich soils within the mine site, the Freegold Road, and the airstrip and airstrip access road were identified and carried through to the terrain hazard classification. Ice-rich permafrost in the terrain maps provided in the Proposal (Appendix 6B and 6D) are those areas denoted with the permafrost process subclass symbol ‘i’.