TABLE OF CONTENTS

B.4 – PROJECT DESCRIPTION B.4-1

B.4.1 INTRODUCTION B.4-1
B.4.2 OVERSIGHT OF DESIGN, CONSTRUCTION, OPERATION, AND CLOSURE B.4-12
B.4.2.1 Independent Geotechnical Review Panel B.4-12
B.4.2.1.1 R2-1 ..... B.4-12
B.4.2.2 Change Management and Technical Review Procedures B.4-16
B.4.2.2.1 R2-2 ..... B.4-16
B.4.3 ALTERNATIVES B.4-20
B.4.3.1 Tailings Management Facility B.4-20
B.4.3.1.1 R2-3 ..... B.4-20
B.4.3.2 Risk Assessment B.4-21
B.4.3.2.1 R2-4 ..... B.4-21
B.4.3.2.2 R2-5 ..... B.4-38
B.4.4 FEASIBILITY OF THE SULPHIDES REMOVAL PROCESS B.4-38
B.4.4.1 R2-6 ..... B.4-38
B.4.4.2 R2-7 ..... B.4-39
B.4.5 ROADS, SUPPLY ROUTES AND TRANSPORTATION B.4-41
B.4.5.1 Freegold Road Extension and Upgrade B.4-41
B.4.5.1.1 R2-8 ..... B.4-41
B.4.5.1.2 R2-9 ..... B.4-58
B.4.5.1.3 R2-10 ..... B.4-62
B.4.5.1.4 R2-11 ..... B.4-63
B.4.5.1.5 R2-12 ..... B.4-63
B.4.5.1.6 R2-13 ..... B.4-73
B.4.6 WATER MANAGEMENT PLAN B.4-75
B.4.6.1 Conveyance of Water B.4-75
B.4.6.1.1 R2-14 ..... B.4-75
B.4.6.1.2 R2-15 ..... B.4-76
B.4.6.2 Probability of Failure Analysis of Infrastructure Components B.4-79
B.4.6.2.1 R2-16 ..... B.4-79
B.4.7 HEAP LEACH FACILITY B.4-83
B.4.7.1 Liners B.4-83
B.4.7.1.1 R2-17 ..... B.4-83
B.4.7.1.2 R2-18 ..... B.4-83
B.4.7.2 Leak Detection and Recovery B.4-84

B.4.7.2.1 R2-19 ..... B.4-84
B.4.7.2.2 R2-20 ..... B.4-84
B.4.7.3 Leachate Solution and Water Flows B.4-85
B.4.7.3.1 R2-21 ..... B.4-85
B.4.7.3.2 R2-22 ..... B.4-86
B.4.7.4 Ore Stacking Rate B.4-86
B.4.7.4.1 R2-23 ..... B.4-86
B.4.8 TAILINGS MANAGEMENT FACILITY B.4-87
B.4.8.1 Design Methodology and Feasibility B.4-87
B.4.8.1.1 R2-24 ..... B.4-87
B.4.8.1.2 R2-25 ..... B.4-88
B.4.8.1.3 R2-26 ..... B.4-89
B.4.8.1.4 R2-27 ..... B.4-90
B.4.8.1.5 R2-28 ..... B.4-91
B.4.8.1.6 R2-29 ..... B.4-95
B.4.8.2 TMF Dam Failure B.4-96
B.4.8.2.1 R2-30 ..... B.4-96
B.4.8.3 Quantity and Quality of Borrow Source Materials B.4-96
B.4.8.3.1 R2-31 ..... B.4-96
B.4.8.4 Earthquakes B.4-102
B.4.8.4.1 R2-32 ..... B.4-102
B.4.8.4.2 R2-33 ..... B.4-102
B.4.8.4.3 R2-34 ..... B.4-103
B.4.8.4.4 R2-35 ..... B.4-104
B.4.8.5 Flood Modeling B.4-104
B.4.8.5.1 R2-36 ..... B.4-104
B.4.8.6 Spillways B.4-105
B.4.8.6.1 R2-37 ..... B.4-105
B.4.8.6.2 R2-38 ..... B.4-105
B.4.8.6.3 R2-39 ..... B.4-106
B.4.8.7 HLF Failure B.4-106
B.4.8.7.1 R2-40 ..... B.4-106
B.4.8.8 TMF Dam Core and Downstream Filter B.4-107
B.4.8.8.1 R2-41 ..... B.4-107
B.4.8.8.2 R2-42 ..... B.4-107
B.4.8.8.3 R2-43 ..... B.4-108

B.4.8.9 Use of Cyclone Sand in Embankments B.4-109
B.4.8.9.1 R2-44 ..... B.4-109
B.4.8.9.2 R2-45 ..... B.4-110
B.4.8.9.3 R2-46 ..... B.4-110
B.4.8.9.4 R2-47 ..... B.4-110
B.4.8.9.5 R2-48 through R2-56 ..... B.4-114
B.4.8.9.6 R2-57 ..... B.4-115
B.4.8.9.7 R2-58 ..... B.4-117
B.4.8.9.8 R2-59 ..... B.4-118
B.4.8.10 Surface Preparation B.4-118
B.4.8.10.1 R2-60 ..... B.4-118
B.4.8.10.2 R2-61 ..... B.4-119
B.4.8.10.3 R2-62 ..... B.4-121
B.4.8.10.4 R2-63 ..... B.4-122
B.4.8.10.5 R2-64 ..... B.4-122
B.4.8.11 TMF Dam Core Construction B.4-123
B.4.8.11.1 R2-65 ..... B.4-123
B.4.8.12 Starter Dam and Tailings Interface B.4-124
B.4.8.12.1 R2-66 ..... B.4-124
B.4.9 LIQUIFIED NATURAL GAS AND DIESEL B.4-124
B.4.9.1 Description of LNG Facilities B.4-124
B.4.9.1.1 R2-67 ..... B.4-124
B.4.9.2 Description of Diesel Facilities B.4-128
B.4.9.2.1 R2-68 ..... B.4-128
B.4.10 CONCEPTUAL CLOSURE AND RECLAMATION PLAN B.4-129
B.4.10.1 Long-Term Closure and Ongoing Monitoring and Maintenance B.4-129
B.4.10.1.1 R2-69 ..... B.4-129
B.4.10.1.2 R2-70 ..... B.4-134
B.4.10.2 Design and Operation of Wetland Water Treatment System B.4-141
B.4.10.2.1 R2-71 ..... B.4-141
B.4.10.2.2 R2-72 ..... B.4-143
B.4.10.2.3 R2-73 ..... B.4-146
B.4.10.2.4 R2-74 ..... B.4-149
B.4.10.2.5 R2-75 ..... B.4-152
B.4.10.2.6 R2-76 ..... B.4-153
B.4.10.3 Open Pit Stability B.4-154

B.4.10.3.1 R2-77 ..... B.4-154
B.4.10.4 HLF Closure and Cyanide B.4-160
B.4.10.4.1 R2-78 ..... B.4-160
B.4.10.4.2 R2-79 ..... B.4-161
B.4.10.5 HLF and Cover Material B.4-161
B.4.10.5.1 R2-80 ..... B.4-161
B.4.10.6 TMF Winter Seepage Mitigation Pond B.4-162
B.4.10.6.1 R2-81 ..... B.4-162
B.4.10.6.2 R2-82 ..... B.4-164
B.4.10.7 Temporary or Early Closure B.4-168
B.4.10.7.1 R2-83 ..... B.4-168
B.4.10.8 Mine Reclamation and Security B.4-169
B.4.10.8.1 R2-84 ..... B.4-169
B.4.10.8.2 R2-85 ..... B.4-170
B.4.11 WASTE MANAGEMENT B.4-175
B.4.11.1 R2-86 ..... B.4-175
B.4.11.2 R2-87 ..... B.4-177
B.4.11.3 R2-88 ..... B.4-178
B.4.12 CLIMATE CHANGE REPORT B.4-178
B.4.12.1 R2-121 ..... B.4-178
B.4.12.2 R2-122 ..... B.4-179

LIST OF TABLES

Table B.4.1-1 Requests for Supplementary Information Related to Project Description B.4-2
Table B.4.3-1 Likelihood Rating Criteria B.4-24
Table B.4.3-2 Consequence Rating B.4-24
Table B.4.3-3 Risk Matrix B.4-24
Table B.4.3-4 Tailings Management Facility Risk Assessment B.4-33
Table B.4.4-1 Assumptions – Cyclone Sand Production Generated from Hypogene Ore B.4-40
Table B.4.5-1 Required Permits for Construction and Operation of Temporary Construction Camps B.4-43
Table B.4.5-2 Projected Traffic Volumes during the Operations Phase B.4-63
Table B.4.5-3 Projected Traffic Volumes during the Operations Phase inbound and outbound by Vehicle Type B.4-64
Table B.4.5-4 Traffic and Truck Count Statistics from the Whitehorse Corridor (Summer 2011) and Estimated Project-related Truck Traffic B.4-66
Table B.4.6-1 HLF Diversion Ditch Requirements B.4-76
Table B.4.8-1 Summary of Existing Cyclone Sand Tailings Dams B.4-88
Table B.4.8-2 Post-Closure Care and Maintenance Cost Estimate B.4-94
Table B.4.8-3 Mine Site Borrow Material Requirements B.4-97
Table B.4.8-4 Average Minimum Temperatures at Casino Mine Site 2008 - 2014 ..... B.4-116
Table B.4.10-1 Closure Options Analysis B.4-130
Table B.4.10-2 Closure Components to meet Government of Yukon Closure Objectives B.4-136
Table B.4.10-3 Proposed Closure Methodologies and Demonstrated Use in Northern Environments B.4-139
Table B.4.10-4 Campbell and Musselwhite compared to predicted Casino Water Quality Results B.4-142
Table B.4.10-5 Performance Triggers for Wetland Treatment System Development B.4-144
Table B.4.10-6 Available Load from Sub-Aqueous Casino Pit Wall per Year of Sub-Aerial Exposure (Table 8-10 from Lorax, 2013, Proposal Appendix 7D) B.4-155
Table B.4.10-7 Physical Scaling Factors (Table 8-5 from Lorax, 2013, Proposal Appendix 7D) B.4-156
Table B.4.10-8 Examples of Gold Heap Leach Operations where Heap Rinsing has been Successfully Implemented B.4-160
Table B.4.10-9 Feasibility Reclamation and Closure Cost Estimate (Updated) B.4-171
Table B.4.11-1 Landfill Requirements through Construction, Operations and Closure Phases B.4-175

LIST OF FIGURES

Figure B.4.2-1 Inputs, Deliverables and Review of Design Refinements over the Mining Life Cycle B.4-19
Figure B.4.5-1 Carmacks By-Pass Route Showing Temporary Route Through Carmacks B.4-48
Figure B.4.5-2 Freegold Temporary Construction Camp Preliminary Location B.4-60
Figure B.4.5-3 Big Creek Bridge Area B.4-61
Figure B.4.5-4 Yukon Highway Schematic and 2011 Traffic Volumes (Yukon Government, 2011) B.4-65
Figure B.4.5-5 Vehicle Traffic Measured at Alaska Highway km 1435.2 (North Klondike Junction) and added Casino Vehicles (Highway Data from 1990 – 2011) B.4-67
Figure B.4.5-6 Calculated Average and Casino Truck Traffic at Alaska Highway km 1435.2 (North Klondike Junction) B.4-67
Figure B.4.5-7 Vehicle Traffic Measured at Alaska Highway km 1001.5 (Cassiar Jct. South Side) and added Casino Vehicles (Highway Data from 1991 – 2011) B.4-68

Figure B.4.5-8 Calculated Average and Casino Truck Traffic at Alaska Highway km 1001.5 (Cassiar Jct. South Side) B.4-69
Figure B.4.5-9 Vehicle Traffic Measured at Klondike Highway km 280 (Braeburn) and added Casino Vehicles (Highway Data from 1991 – 2011) B.4-70
Figure B.4.5-10 Calculated and Casino Truck Traffic at Klondike Highway km 280 (Braeburn) B.4-70
Figure B.4.5-11 Vehicle Traffic Measured at Klondike Highway km 106.3 (Carcross – South Side) (Highway Data from 1991 – 2011) B.4-72
Figure B.4.5-12 Calculated and Casino Truck Traffic on Klondike Highway km 106.3 (Carcross – South Side) B.4-72
Figure B.4.6-1 Heap Leach Facility Water Management Plan B.4-78
Figure B.4.8-1 Low Permeability Material Borrow Areas B.4-98
Figure B.4.8-2 Filter and Transition Zone Material and General Fill Borrow Areas B.4-99
Figure B.4.8-3 Aggregate Borrow Areas B.4-100
Figure B.4.8-4 Confinement Berm Construction B.4-111
Figure B.4.8-5 Sand Cell Compaction B.4-112
Figure B.4.8-6 Cyclone Sand Deposition Schematic B.4-113
Figure B.4.9-1 Future Process Plant (and LNG facility) location B.4-125
Figure B.4.9-2 Rendering of Proposed Process Plant overlain on Actual Topography B.4-125
Figure B.4.9-3 LNG Storage Separation Distance to Forested Area B.4-127
Figure B.4.10-1 Monthly Flow Rate in Casino Creek at H18 (Realization #1) B.4-150
Figure B.4.10-2 Modelled Copper Concentration at H18 and W4 (Realization #1) B.4-151
Figure B.4.10-3 Modeled Pit Wall Failure Areas B.4-155
Figure B.4.10-4 Rate that HYP wall rock becomes depleted in NP as a function of exposure time (Figure 8-7 from Lorax, 2013, Proposal Appendix 7D) B.4-157
Figure B.4.10-5 Rate that SUP wall rock becomes depleted in NP as a function of exposure time (Figure 8-8 from Lorax, 2013, Proposal Appendix 7D) B.4-157
Figure B.4.10-6 Effect of Pit Wall Failure on pH B.4-158
Figure B.4.10-7 Effect of Pit Wall Failure on Sulphate Concentration B.4-158
Figure B.4.10-8 Effect of Pit Wall Failure on Cadmium Concentration B.4-159
Figure B.4.10-9 Effect of Pit Wall Failure on Copper Concentration B.4-159
Figure B.4.10-10 Effect of Pit Wall Failure on Selenium Concentration B.4-159
Figure B.4.10-11 Typical Dam Cross-Section for the Water Management Pond B.4-165
Figure B.4.10-12 Geotechnical Investigations in the WMP area (1994 – 2011) B.4-167
Figure B.4.10-13 Geotechnical Investigations in the WMP area (2012) B.4-167
Figure B.4.11-1 Proposed Landfill Location B.4-176

APPENDICES

Appendix B.4A Guide to the Management of the Casino Tailings Facility
Appendix B.4B Mine Waste Management Alternatives Assessment
Appendix B.4C Tailings Management Facility Dam Breach Inundation Study
Appendix B.4D Tailings Management Operation, Maintenance and Surveillance Manual
Appendix B.4E 2014 and 2015 Geotechnical Testing of Leach Ore
Appendix B.4F Ore Characterization
Appendix B.4G Review and Updates to the Conceptual Wetland Water Treatment Design

B.4 – PROJECT DESCRIPTION

B.4.1 INTRODUCTION

Section 4 of the Proposal provided an overview of the principal Project, related components and activities and accessory activities that make up Casino Project (the Project). Section 4 detailed the principal project components and activities; related components and activities and accessory activities.

The anticipated schedule of the Project, including Project phases and anticipated duration, was also presented as well as detailed information on Project components and activities for the construction, operation, closure and decommissioning and post-closure phases of the Project.

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). CMC provided a Supplementary Information Report (SIR-A) on March 16, 2015. Subsequently, the Executive Committee issued a second Adequacy Review Report (ARR No.2) on May 15, 2015 following a second round of review. CMC is providing this Supplementary Information Report (SIR-B) to comply with the Executive Committee's Adequacy Review Report ARR No.2.

The Executive Committee has had substantial requests for information on Section 4 (i.e., 146 of 449 requests in ARR No.1 and 90 of 224 requests in ARR No.2) as concerns voiced by reviewers have revolved around the access road, tailings management facility and reclamation and closure, all contained within this Section. The information provided in the Project Description section and subsequent supplementary information reports, is based on conceptual and preliminary designs, limited information from test work or field investigation and is consistent with early stage project development. There are many instances where the level and extent of the information provided goes well beyond what is typically provided for assessment purposes. Project assessment must be made within reasonable limits appropriate to the project's stage of development by experienced, qualified individuals exercising professional and reasonable judgements.

The responses contained herein reflect an attempt by CMC to respond to ARR-2 in the most fulsome manner, with the details and data available at this phase of project development. CMC will continue to provide information as requested throughout the Screening phase of the YESAB assessment to fulfill the needs of YESAB, decision bodies and interested persons participating in the assessment. CMC anticipates that the information in the two SIRs and in the Proposal, when considered together, is adequate to commence Screening and looks forward to commencing the assessment process in a timely manner.

The Executive Committee has 90 requests for supplementary information related to Section 4 Project Description and Section A.4 of the Project Proposal and SIR. These requests, and the sections in which the responses are provided, are outlined below in Table B.4.1-1.

Table B.4.1-1 Requests for Supplementary Information Related to Project Description

Request #	Request for Supplementary Information	Response
R2-1	A framework and associated details for the establishment of the IGRP including its structure, scope and timing. The framework shall include relevant details such as expert reviewers' qualifications, their roles and continued involvement over the mine life. This framework will demonstrate a commitment to those aspects of the Project where external review from the IGRP will be obtained. At a minimum the IGRP will provide oversight for the following: a. alternatives assessment for tailings and waste rock management; b. risk assessment for the chosen method for tailings and waste rock management; c. design of tailings and waste rock management infrastructure; d. change management framework; e. technical review framework; f. hazard classification and rationale for the proposed TMF dam; and g. dam breach/inundation study. The Proponent will provide outcomes from the IGRP's work prior to entering the screening process.	Section B.4.2.1.1
R2-2	Frameworks for a change management procedure and an associated technical review procedure which will define processes for making and approving changes to designs or operating plans, such as may occur when conditions encountered in the field during construction or operations differ from design assumptions. Describe aspects of the project design for which engineering design changes will be overseen by the IGRP. These frameworks will also describe how regulators, First Nations, and other interested parties will be involved in the review processes.	Section B.4.2.2.1
R2-3	A detailed description and assessment of alternatives to or alternative ways of undertaking the Project with respect to tailings and waste rock management. This alternatives assessment should be comprehensive, provide transparent rationale and give consideration to the following: a. Full life-cycle costs and all phases of the proposed TMF dam (i.e. in perpetuity); b. Risks of the proposed TMF dam (i.e. as per risk assessment); c. Potential significant adverse effects of the proposed TMF dam to environmental values (i.e. wildlife, water and aquatic resources) and socio-economic values (i.e. health, social, heritage and economic); d. Identification and comparison of best practices and best-available technologies for tailings management; e. Options for managing water balance to ensure safety and reduce probable risks of structural and/or non-structural TMF dam failure (i.e. as determined by the risk assessment); f. Technically-sound engineering solutions that mitigate potential significant adverse effects based on actual site conditions (e.g. permafrost, climate change, construction challenges); and g. A clear and transparent evaluation of the factors that support the proposed TMF dam.	Section B.4.3.1.1
R2-4	A risk assessment for the TMF dam.	Section B.4.3.2.1
R2-5	Describe the involvement of independent professional engineers in: the ongoing review of monitoring data; the evaluation of site infrastructure performance with respect to design parameters; and any necessary adaptive response measures.	Section B.4.3.2.2

Request #	Request for Supplementary Information	Response
R2-6	Information on the feasibility and limitations of using “on-stream analyzers” on a continuous basis to monitor sulphur removal from the NAG tailings stream.	Section B.4.4.1
R2-7	Discussion on the implications related to the estimate that 25 percent of the processed supergene ore would produce non-PAG rougher tailings.	Section B.4.4.2
R2-8	One of the following: a. Responses to previous Adequacy Review Report requests as they relate to the Freegold Road upgrade and Carmacks by-pass: • R13 and R14 (in relation to the camp for the upgrade), • R18 (including safety, wildlife, and maintenance), • R27 (in relation to traffic in Carmacks and the by-pass), • R297 (in relation to clear span bridges for the upgrade), • R298 (in relation to decommissioning of abandoned structures along the alignment), • R299 (in relation to the Nordenskiold River bridge and pier), • R300 (in relation to available habitat at the Nordenskiold River bridge) • R410 (in relation to a cabin near the project footprint), or b. A modified project proposal that excludes the Freegold Road upgrade and Carmacks by-pass but includes a revised description of activities, transportation plan, and effects assessment.	Section B.4.5.1.1
R2-9	Camp details including: a. Information regarding surface water within the camp footprint and any diversions, b. Supporting information on the appropriateness of a septic system, c. Details for reclamation of camp site, and d. Volumes of vegetation to be cleared and disposal methods.	Section B.4.5.1.2
R2-10	A description and assessment of the two possible scenarios for the Freegold Road extension: a. Road closure and reclamation including methods, objectives, and timelines, b. Continued road use including management, access, and effects.	Section B.4.5.1.3
R2-11	Clarification if project traffic predictions and the project effects assessment include empty vehicles, and if not, updated predictions and corresponding effects assessments.	Section B.4.5.1.4
R2-12	An analysis of potential effects along the Klondike Highway, for all affected sections.	Section B.4.5.1.5
R2-13	An assessment of and mitigations for potential effects due to traffic in Carmacks and Carcross.	Section B.4.5.1.6
R2-14	Additional analysis regarding the appropriate PMP value for the design of the mine facilities. Specifically, utilize the full period of rainfall record as discussed by EcoMetrix (YOR 2014-0002-399-1), discuss the PMP contours presented in TP-47, and utilize other available methods of predicting PMP such as more recent publications regarding PMP estimates for eastern interior Alaska.	Section B.4.6.1.1
R2-15	Typical cross-sections and design drawings of alignments for diversion ditching across the project site with particular focus around the HLF including:	Section

Request #	Request for Supplementary Information	Response
	a. confining embankment; b. access road section; and c. event ponds area.	B.4.6.1.2
R2-16	Details and rationale on the selection of return period design criteria for all the WMP components during all phases of the Project, including long-term closure. Details should include calculation of the failure probabilities.	Section B.4.6.2.1
R2-17	Additional supporting evidence to demonstrate the sufficiency of a 30 cm thick soil liner based on the actual conditions at the mine site (e.g. shear strength, slope stability, stack height, bedrock conditions).	Section B.4.7.1.1
R2-18	An outline of plausible mitigation strategies (e.g. intermediate liners; additional and/or higher standard liners) to ensure performance objectives of the HLF are achieved.	Section B.4.7.1.2
R2-19	Clarification on how one portion of the pad versus another portion will be isolated if a leak is detected. In addition, please provide a full detail design diagram of the components used in the heap leach facility including placement of the LDRS components and how they interact.	Section B.4.7.2.1
R2-20	Details on the maintenance and repair of LDRS sumps.	Section B.4.7.2.2
R2-21	Details on the pipelines, pumps, and related infrastructure connecting the components of the HLF including SART, cyanide, and gold extraction facilities. Include details on pipeline alignments and leak detection measures.	Section B.4.7.3.1
R2-22	Clarify whether CMC intends to seek certification under the International Cyanide Management Code and conduct independent third-party auditing of its conformance with the cyanide management standards of practice. If so, clarify whether results of independent audits would be made available for review by interested stakeholders.	Section B.4.7.3.2
R2-23	Indication when results are expected from the additional test work and how these results will be provided in a timely manner iteratively throughout the screening process.	Section B.4.7.4.1
R2-24	An updated TMF dam hazard classification that is informed by the IGRP-overseen risk assessment and related dam breach/inundation study. Where relevant, also include details regarding the impacts to dam design and mitigation strategies as a result of this additional work.	Section B.4.8.1.1
R2-25	Additional comparison information about natural analogies within similar environments. Include estimates of the hydraulic gradient(s) for the TMF dam, throughout its lifecycle (i.e. in perpetuity), and include a discussion that reflects on the findings of the Bjelkevik (2005) report (i.e. compare the estimated hydraulic gradient of the TMF with the hydraulic gradient of natural analogies that have demonstrated long-term stability).	Section B.4.8.1.2
R2-26	Additional information regarding the factor of safety including: a. The factor of safety under pseudo-static condition, since the minimum factor of safety for slope stability under seismic loading is 1.0 and not less than 1.0 (refer to Table 6-3 of Canadian Dam Safety Guideline, 2007). b. Was the excess pore pressure during the construction period and before the embankment rise considered?	Section B.4.8.1.3

Request #	Request for Supplementary Information	Response
	c. Confirmation that the stability analysis during different stages of construction and impounding meets the minimum factor of safety proposed by CDA such that: the minimum factor of safety of 1.3 “Before the reservoir feeling” and FOS of 1.5 at the “normal reservoir level”.	
R2-27	A conceptual operations, maintenance and surveillance (OM&S) plan to demonstrate how the TMF will be managed in both the operational and closure periods. At a minimum, this plan will meet the current Mining Association of Canada’s (MAC) guidance material for tailings management facilities. The OM&S plan must: a. Comprehensively address how custodial transfer will occur for all liability associated with this project. This aspect of the plan will include criteria for custodial transfer (e.g. to whom; timing; security funding; other obligations) and consider scenarios such as abandonment and end-of-mine life transfer. Provide examples of successful custodial transfer of comparable projects. b. Include supporting information that addresses monitoring and remediation activities that may be required during closure including the extent of remediation required in event of a maximum design earthquake. The plan must also consider response to multiple maximum design earthquakes that may occur considering the TMF is proposed to remain in perpetuity. c. Evaluate the potential effects of climate change on the Project through all phases, in perpetuity.	Section B.4.8.1.4
R2-28	Detail on the care and maintenance costs in perpetuity. This estimate will be supported by the OM&S plan, which will document the ongoing care and maintenance requirements during the closure and post-closure period. This estimate must consider costs for all liability associated with the mine site infrastructure including accidents and malfunctions	Section B.4.8.1.5
R2-29	Demonstrate how the TMF dam will be able to achieve a steady state condition for passive care during the post-closure of this project (i.e. in perpetuity).	Section B.4.8.1.6
R2-30	A dam breach analysis with water/tailings inundation modeling. Include information related to the IGRPs oversight and review of this work. The analysis must be consistent with the Canadian Dam Association’s (2007) dam safety guidelines and include: a. probable maximum flood inundation map showing the maximum extent of flooding relating to a sudden full storage embankment breach extending to when expected flooding is within the natural water channels; b. an assessment of environmental and human impacts associated with a release of tailings; c. an assessment of potential impacts to First Nation Settlement Lands; d. an assessment of impacts to downstream infrastructure; e. mitigation measures in the event of a tailings breach; and, f. for each proposed breach scenario, a cross section of the critical TMF embankment, proposed loading factors, and each scenario’s factor of safety.	Section B.4.8.2.1
R2-31	Detailed information on the sources and quantities for all borrow materials that are required for all mine site infrastructure, the airstrip and airstrip access road, and the Freegold road upgrade and extension, throughout all phases. This information will be based on site investigations and will include: confirmation of the depth and areal extent of the proposed aggregate borrow sources; and, characterization of the physical and chemical variability of materials (i.e. quality and suitability for intended use) required for mine site infrastructure.	Section B.4.8.3.1

Request #	Request for Supplementary Information	Response
R2-32	An explanation on the likelihood and implications of saturation of the TMF dam's foundation, drains, and lower portions.	Section B.4.8.4.1
R2-33	The references used to guide the factor of 1.5 and a discussion about the applicability of the reviewed cases to this project.	Section B.4.8.4.2
R2-34	The measured shear wave velocity for the foundation material.	Section B.4.8.4.3
R2-35	Mean PGA as derived from EZ-FRISK.	Section B.4.8.4.4
R2-36	Information regarding PMP and the IDF including: a. An updated PMP estimate using more robust storm expansion techniques. This modelling must be done by a trained meteorologist with a background in PMP derivation; b. Justification for using the 100 year snowpack combined with the PMP for computing the PMF instead of a more conservative return period; and c. Evidence demonstrating that the IDF represents the worst case in terms of volume of inflow.	Section B.4.8.5.1
R2-37	Following an updated dam hazard classification as requested in section 2.7.1 include a description of how the IDF design will protect the TMF dam from overtopping.	Section B.4.8.6.1
R2-38	Further discussion on the implications of ice build-up in the spillway and how this will be monitored and managed. In addition to ice build-up, describe how the spillway will be monitored and maintained in perpetuity post-closure – this must consider any changing circumstances and/or conditions that may compromise the function of the spillway.	Section B.4.8.6.2
R2-39	Mitigations, with appropriate thresholds for implementation, and monitoring activities for closure spillway related erosion, both in the spillway channel and downstream water bodies.	Section B.4.8.6.3
R2-40	Ensure that the risk assessment requested in section 2.2.2 considers the likelihood and consequence of an HLF failure that results in displacement of water in the TMF.	Section B.4.8.7.1
R2-41	An expansion of CMC's response related to core and filter thickness by providing a review of comparable designs. Also, provide a detailed analysis that describes the deformation response of the core and the downstream filter during different stages of construction.	Section B.4.8.8.1
R2-42	A comprehensive description of the tailings beach design including but not limited to: beach length, width, slope, deposition strategies, construction QA/QC and monitoring/maintenance requirements in perpetuity.	Section B.4.8.8.2
R2-43	Quantification of the reduction of seepage and hydraulic gradient throughout the various phases of the TMF dam based on the chosen design. Provide an estimate of how the seepage and hydraulic gradient may change in perpetuity.	Section B.4.8.8.3
R2-44	The results of laboratory tests conducted to assess whether 12 percent fines sand would be free-draining including under the very high stresses in the proposed dam and frost susceptible of this material. Additionally, if applicable, provide the implications of the 12 percent fines sand not being free-draining or being frost	Section B.4.8.9.1

Request #	Request for Supplementary Information	Response
	susceptible.	
R2-45	Information regarding sand properties including: a. Explanation why the more conservative 30° angle of internal friction for angular sands was not selected for the Casino dam design; b. Explanation why the same value can be assumed to apply to the tailings generated from processing of all of the three ore types; and, c. Implications if the more conservative value of 30° is applied to the tailings generated from processing of all of the three ore types. d. Confirmation whether the maximum anticipated stress for placed cyclone sand is supported by completed testing.	Section B.4.8.9.2
R2-46	Identification the actual source of the discrepancy present in the specific gravity values for the tailings sand products through repeat testing. If repeat testing is not possible, describe the implications of this discrepancy using conservative assumptions.	Section B.4.8.9.3
R2-47	A response to the concerns articulated by EcoMetrix regarding 2 m lifts.	Section B.4.8.9.4
R2-48	Supporting evidence for the absence or presence of faults and fractures within the TMF and embankment areas including their activity. Specifically: a. Confirm whether lidar data has been collected to determine the presence or absence of young faults near the tailings dam; b. Provide the detailed joint surveying along the dam foundation and the abutments and update the seepage analysis report; and, c. Provide a geostatistical model that represents the permeability characteristics of the bedrock below the dam foundation.	Section B.4.8.9.5
R2-49	Additional drill results and associated foundation characterization (e.g. packer testing, trenching), with detailed analysis and discussion, to provide an accurate characterization of the hydraulic conductivity and identification of fault/shear zones within the embankment foundation.	Section B.4.8.9.5
R2-50	A description of how grouting can be successfully performed given the challenges presented by permafrost. Also, update the responses for R89 a – e of the ARR in accordance with the response to R2-49.	Section B.4.8.9.5
R2-51	The rationale behind “the material is assumed to be isotropic” knowing the horizontal permeability is greater than vertical permeability in embankment dams that is constructed in several stages. Also assuming an isotropic permeability for the rock, will not be a valid assumption due to preferential seepage in the rock mass.	Section B.4.8.9.5
R2-52	The justification on why no seepage barrier is proposed for the dam foundation despite the calculated seepage rate.	Section B.4.8.9.5
R2-53	The anticipated seepage problems surrounding the storage area.	Section B.4.8.9.5
R2-54	Details regarding permafrost and permafrost conditions in relation to the TMF, including: a. confirmation that an assessment of the hydraulic properties of the permafrost under the embankment structures studies will be conducted during the detailed design; b. a winter construction execution plan that details measures and procedures for	Section B.4.8.9.5

Request #	Request for Supplementary Information	Response
	embankment placement of fill that ensures the fill soils are not frozen at the time of placement and compaction; c. QA/QC plan for construction during the cold season; d. details on permafrost conditions of the foundation materials before the construction and during the embankment raise; e. a discussion regarding the potential segregation of solids and water fractions, with the formation of discrete ice lenses within the tailings mass and its implication for tailings management; and, f. a discussion regarding the integrity implications of the potential frozen and unfrozen fill co-existing within the structure.	
R2-55	A detailed schedule for the works required to construct the TMF before and during operations. Consideration should be given to key QA/QC requirements and contingency planning for scheduling delays and freezing conditions.	Section B.4.8.9.5
R2-56	QA/QC measures during the lifetime of the embankment to ensure the effectiveness of insulation and the core structure will not be affected by the action of freezing. Please also provide confirmation regarding if permafrost aggradation potential has been considered into the TMF containment structure? If permafrost aggradation has not been considered, provide a discussion regarding the potential of permafrost aggradation into the TMF.	Section B.4.8.9.5
R2-57	Additional detail to understand the implication of shorter than expected construction windows for the TMF dam and specifically: a. Describe the implications of suspensions in fill placement operations if CMC is unable to operate in November and/or March. Also consider the implications of not being able to operate for additional months should they prove too cold. Describe how CMC will manage these implications. b. Clarification if the likelihood of one or more very cold years for the construction window has been evaluated. If so, describe the implications. Describe how CMC will manage these implications.	Section B.4.8.9.6
R2-58	Further detail on the referenced examples provided in response to R94. Demonstrate how these examples are applicable to this project and how they support the proposed construction schedule and methodology. Include details regarding the equipment and infrastructure required to facilitate winter construction.	Section B.4.8.9.7
R2-59	Discuss the implications of potentially incorporating frozen layers within the embankment (e.g. discrete ice lenses within the tailings mass; layers of frozen and unfrozen fill) to the stability and integrity of this infrastructure.	Section B.4.8.9.8
R2-60	Provide comprehensive characterization of the depth, extent and nature of permafrost where the TMF is to be constructed. Based on this characterization, confirm that excavation of all permafrost soils will be practical and how this excavation will successfully be achieved.	Section B.4.8.10.1
R2-61	Details regarding: a. A clear definition of ice-rich soils and rock; b. Characterization of the ice content of the near surface soils and rock to assess the potential volume of ice-rich materials to be excavated and disposed; c. A well-defined and rational methodology and decision making process to identify and characterize permafrost soils and rock that can be used to guide all excavation and stripping work;	Section B.4.8.10.2

Request #	Request for Supplementary Information	Response
	d. A detailed permafrost hazard map (predictive) and associated methodology that identifies type, nature, and magnitude of permafrost related hazards in the study area; e. If the TMF is situated on permafrost soils that are too deep to excavate, consideration of creep deformation of those permafrost soils resulting from placement of the TMF; and, f. Based on the map above, identification of specific risks to the Project (i.e. minesite infrastructure and the Northern Freegold Road) from identified permafrost hazards. The map should include consideration of climate change, as well, over the life of the Project.	
R2-62	Based on the risk identified in response to the questions above, please provide general options and considerations for engineering design to mitigate the identified risks.	Section B.4.8.10.3
R2-63	Provide a comprehensive assessment of how groundwater flow may be affected due to changing thermal conditions (i.e. melting permafrost). Consideration should be given to all stages of the Project, including in perpetuity for post-closure.	Section B.4.8.10.4
R2-64	Provide further justification of the validity of the baseline model calibration and its potential impact on groundwater flows in the Mine Effects models ensuring permafrost is considered in the calibrations.	Section B.4.8.10.5
R2-65	Confirm how the dam core will be insulated during construction and include comprehensive details (e.g. properties and characteristics of insulation; methodology for installing insulation; objectives and adaptive management). Provide relevant examples to support the proposed methodology.	Section B.4.8.11.1
R2-66	An explanation on how the additional transition zones can affect the current analysis.	Section B.4.8.12.1
R2-67	Identification of potential hazards of wildfire to LNG facilities at the Casino Mine site and a quantitative assessment of the related risk to those facilities. Ensure that risks and procedures associated with forest fires are discussed.	Section B.4.9.1.1
R2-68	For the diesel facilities and fueling stations, provide: a. a detailed description for all facilities related to diesel including location, design, construction, operation and closure; b. measures for the safety of project personnel including separation distances from office and living areas; and c. design measures and operating procedures to prevent a cascading accident.	Section B.4.9.2.1
R2-69	Further analysis of closure options including long-term and short-term costs, care and maintenance requirements, and long-term environmental risks. The options analysis should include: a. open pit; b. tailings management facility; c. heap leach facility; d. stockpile areas; and e. water management and treatment.	Section B.4.10.1.1
R2-70	Discussion and, if necessary, an update to the conceptual closure plan to take into account the most recent Government of Yukon Reclamation and Closure Planning for Quartz Mining Projects, Plan Requirements and Closure Costing Guidance (Government of Yukon, 2013). Details should include:	Section B.4.10.1.2

Request #	Request for Supplementary Information	Response
	a. additional closure methodology that demonstrates that the open pit water can passively flow to the TMF without continued intervention; and b. identification of closure methodologies that have been demonstrated effective in northern environments, and that clearly meet the objectives described in Section 5 of the guidance document.	
R2-71	In relation to examples of successful similar treatment systems provided in Appendix A.4H (Cold Climate Passive Treatment Systems Literature Review), a discussion on flow rates relative to those for the proposed project.	Section B.4.10.2.1
R2-72	In relation to plans on field studies to support and refine the effectiveness of the wetland water treatment system, details on: a. what benchmarks (e.g. CCME WQO or SSWQO identified in proposal) will serve as the performance objectives for the overall passive treatment system; b. what performance triggers (i.e. clear indication that the current strategy will not achieve treatment objectives) will be used during the development of the passive treatment system to identify when contingency treatment methods, such as development of bioreactors in the case of the HLF, will need to be investigated.	Section B.4.10.2.2
R2-73	Contingency, alternative, or additional treatment options that could achieve water quality objectives should the passive treatment system not be viable or perform as required. Details should include: a. identification of alternative treatment methodologies that can be employed at the site with best practicable technologies that is supported by comprehensive technical information; b. a conventional water treatment option within the framework of the water treatment plan for temporary and final closure. This should include the circumstances and triggers under which this treatment option would be developed; and c. a full alternatives assessment to demonstrate how alternative treatment technologies (that do not include wetland systems) were considered.	Section B.4.10.2.3
R2-74	In order to evaluate the potential effects related to the worst case scenario of an ineffective passive treatment, prediction of a worst case scenario of downstream water quality assuming no treatment system. Predictions should extend as far downstream as necessary to demonstrate no further exceedances of the CCME surface water quality objectives attributed to the mine (or 90th percentile of background for those constituents that naturally exceed CCME).	Section B.4.10.2.4
R2-75	A discussion and rationale on how the design of the north end of the tailings management facility wetlands will accommodate a range of possible flows from the pit lake. Identify how residence time can be controlled when flows are expected to be so highly variable, and how the proposed control valves could be relied upon in such a remote area.	Section B.4.10.2.5
R2-76	Details and design considerations for the remotely operated solar powered decant valves. Details should include: a. contingency planning related to malfunctions, inappropriate feedback and interaction; and b. examples where such systems are effectively used in similar northern or cold climate conditions.	Section B.4.10.2.6
R2-77	Details regarding potential impacts to pit water quality, and demonstrate water treatment capabilities in the TMF are sufficient, if a pit wall fails and there is a spike in	Section B.4.10.3.1

Request #	Request for Supplementary Information	Response
	metals and/or acidity in pit water.	
R2-78	Examples of successful heap rinsing at comparable sites where materials of a similar nature, mass and northern location have been encountered.	Section B.4.10.4.1
R2-79	A description how the liner in the HLF will be perforated following completion of the rinsing stage. Include a description of how drainage flowing from the HLF through the perforated liner will be captured by the TMF.	Section B.4.10.4.2
R2-80	Details on the design of the HLF cover. Details should include: a. details of construction materials and methods being proposed (e.g. on-site borrow material and/or geosynthetic liner) and supported by on-site characterization; b. consideration of other mine-site facility requirements for low-permeability material; and c. stability and long-term maintenance requirements if incorporating a geosynthetic liner.	Section B.4.10.5.1
R2-81	Feasibility level design details for the water management pond cut-off wall and cut-off trench/barrier. Include a discussion of how the structures are to be constructed. Details should include: a. details on how CMC will ensure that all groundwater seepage is collected in the water management pond as designed and modelled; b. what monitoring will be set up to ensure that the water management pond is performing as predicted, including groundwater and seepage monitoring; and c. contingencies for all project phases, in case the water management pond does not perform as expected, including if groundwater/seepage is found to by-pass the water management pond.	Section B.4.10.6.1
R2-82	Additional details about the water management pond dam should include: a. cross-sections; b. construction materials; c. consequence of failure classification; d. detailed foundation characterization; and e. monitoring and maintenance requirements.	Section B.4.10.6.2
R2-83	Contingency measures or alternatives that may be required in the event of early closure if passive treatment system field trials have not been completed or are shown to be unsuccessful. Details should include: a. identification of alternative treatment methodologies that can be employed at the site with best practicable technologies that is supported by comprehensive technical information; b. a conventional water treatment option within the framework of the water treatment plan for temporary and final closure. This should include the circumstances and triggers under which this treatment option would be developed.	Section B.4.10.7.1
R2-84	Update the CCRP and security estimates based on the Government of Yukon's updated guidance document: Reclamation and Closure Planning for Quartz Mining Projects, Plan Requirements and Closure Costing Guidance (Government of Yukon, 2013).	Section B.4.10.8.1
R2-85	Additional justification and discussion on security estimates based on new information generated by questions throughout this report. Details should include: a. all major mine components;	Section B.4.10.8.2

Request #	Request for Supplementary Information	Response
	b. all reclamation and closure stages; c. consideration of temporary or early closure; d. consideration of accidents and malfunctions, including the implications of structural and non-structural failures of the TMF dam; and e. consideration of effects of the environment.	
R2-86	Location, size, volume, and hydrology of the landfill site	Section B.4.11.1
R2-87	Anticipated volume of landfill space required for different waste streams.	Section B.4.11.2
R2-88	A description of the liner and/or leachate collection system proposed, including details for maintenance, operation, and closure.	Section B.4.11.3
R2-121	Clarification on how the design for the TMF accounts for climate variation in perpetuity, beyond the construction and operation phases of the mine.	Section B.4.12.1
R2-122	After the application of a maximum 25 percent increase in flow to all relevant baseline information, a comprehensive description of resulting changes to the tailings management facility, open pit, water management pond, heap leach facility, and diversion ditches. This should include consideration of project effects, and mitigations.	Section B.4.12.2

B.4.2 OVERSIGHT OF DESIGN, CONSTRUCTION, OPERATION, AND CLOSURE

B.4.2.1 Independent Geotechnical Review Panel

B.4.2.1.1 R2-1

R2-1. A framework and associated details for the establishment of the IGRP including its structure, scope and timing. The framework shall include relevant details such as expert reviewers' qualifications, their roles and continued involvement over the mine life. This framework will demonstrate a commitment to those aspects of the Project where external review from the IGRP will be obtained. At a minimum the IGRP will provide oversight for the following:
a. alternatives assessment for tailings and waste rock management;
b. risk assessment for the chosen method for tailings and waste rock management;
c. design of tailings and waste rock management infrastructure;
d. change management framework;
e. technical review framework;
f. hazard classification and rationale for the proposed TMF dam; and
g. dam breach/inundation study.
The Proponent will provide outcomes from the IGRP's work prior to entering the screening process.

Casino Mining Corporation has voluntarily established an Independent Engineering Review Panel (IERP) for the Casino Project to review and consider the Project's Tailings Management Facility (TMF) and Heap Leach Facility (HLF) with a focus on their structural stability and integrity. In the SIR-A, the IERP was called the "Independent Geotechnical Review Panel", however, as the fundamental criteria of waste and water management at the Casino

Project is to achieve a management strategy that is considered most geochemically conservative, CMC has changed the name to the IERP.

While CMC has voluntarily created the IERP for the Casino Project, independent tailings dam review boards have become mandatory for *operating* mines in British Columbia (BC Ministry of Energy and Mines, 2015), and guidance for independent audits or assessments are outlined by the Mining Association of Canada (MAC) in their Guide to the Management of Tailings Facilities (MAC, 2011), also intended for operating facilities. The MAC guidelines have been incorporated into CMC's preliminary Guide to the Management of the Casino Tailings Facility (Appendix B.4A), which includes guidelines for independent review of site selection and design, and construction of a tailings facility.

Scope

The role of the IERP is to provide independent expert advice and oversight on the design, construction, operations, and planned closure of the TMF and HLF. The responsibilities of the IERP include:

- Review of existing design concepts and alternatives previously considered to confirm that the proposed facilities incorporate the most appropriate site specific technologies for responsible development.
- Periodic reviews of the design, construction, operations and closure planning of the TMF and HLF in accordance with "international good practice". This can be considered to include guidelines or regulations specific to the Yukon as well as standards set by the International Commission of Large Dams (ICOLD), the Canadian Dam Association (CDA), as well as the Mining Association of Canada (MAC) for the TMF, and guidelines from the State of Nevada for the HLF (Nevada has the most heap leaching operations in the world).
- Provision of advice and guidance to CMC and its design consultants and construction contractors in relation to geotechnical, geochemistry, hydrogeological, hydrological and environment matters for the TMF and HLF.
- Provision of independent and updated opinions to CMC as to whether the TMF and HLF are being designed, constructed, operated, and planned for closure in accordance with current international good practice.
- Provision of input on design, construction, and operational activities that may have long-term stability or other critical performance implications.
- Provision of technical support to CMC for design and implementation of corrective measures or other activities, if required.

Composition

CMC has invited four experts to serve on the panel. Three are internationally recognized geotechnical experts each with over 40 years of experience in the design, construction, operation and closure of cyclone sands tailings dams. All three are presently serving or have recently served on independent tailings dam review boards. The fourth member is an internationally recognized expert in the field of geochemistry. A geochemical expert is included as the design of the TMF has a strong geochemical focus as well as a geotechnical one and the two aspects cannot necessarily be considered in isolation. Contracts have been signed with all members to participate on the panel, and the members' qualifications are described below. Due to the extended duration of the project, the experts presently on the panel may be replaced by other independent experts as the project progresses.

Peter Lighthall, M.Sc., P.Eng., FEIC

- Peter Lighthall is an independent geotechnical consultant with over 40 years of experience, specializing in tailings dams and tailings impoundments, mine waste and mine water management. He has a broad understanding of geotechnical aspects of mining projects, having participated in scoping studies, due diligence assessments, pre-feasibility and feasibility studies, detailed engineering, project development, operation and closure planning. Peter has worked throughout the world, including South and North America, Eastern and Western Europe, Russia and former Soviet Union states, China, the Middle East and Australia, as well as extensively within Canada and USA. He is experienced in tailings dam design in high earthquake risk areas. He has worked in development and implementation of leading edge technologies for tailings management, including thickened and paste tailings and filtered dry stack tailings. He has been active in recent years on review and/or technical advisory roles on numerous major mine developments.
- Mr.Lighthall has been involved in the design, construction, operation and review of several large cyclone sand tailings dams, most recently consulting on Pelambres Copper Mine Mauro cyclone sand dam in Chile, permitted to a height of 190m. He also has extensive northern experience in Yukon Territory, Alaska and Far East Russia. He served as technical advisor to Yukon Energy, Mines & Resources for the Minto Copper Mine.

James Obermeyer, M.Sc., PE

- Principal and Senior Vice President with MWH based in Denver, Colorado. His technical focus has been on engineering, design, construction, operation, and closure of tailing dams and on design and construction of water supply dams.
- Mr. Obermeyer has worked in the United States and internationally on over 500 dam projects. He serves as MWH Energy and Industry's Global Practice Leader for Tailing Dams and Water Storage Dams. In this role he provides technical review and quality assurance / quality control for all tailing dam planning, design and construction projects for MWH's global mining sector. Mr. Obermeyer also serves on Boards of Consultants for dams and other geotechnical projects for mining companies, other engineering companies and governmental entities responsible for dam design.
- Mr. Obermeyer has managed numerous tailing dam projects involving the full life cycle of the mine including site selection, scoping level studies, pre-feasibility studies, feasibility studies, detailed design, construction management, commissioning and start-up, operations, closure planning and implementation, and post-closure. Many of these projects have been located in seismically active areas, requiring special considerations to address seismic stability and liquefaction issues. He has extensive experience with tailing dams that are built using deposition of both cycloned and whole tailing materials.

- Mr. Obermeyer is the Engineer of Record for the Quebrada Enlozada Tailing Storage Facility (TSF) at the Cerro Verde Mine, near Arequipa Peru. This sand dam is constructed with compacted cyclone sands and will have an ultimate height of 260 meters at the centerline. Mr. Obermeyer participated personally for four and a half months during start-up of the TSF at this 120,000 tonne per day facility and has continued his involvement managing MWH's ongoing Quality Assurance and Operations Support to Cerro Verde during subsequent operation of the facility. A 170 meter tall starter dam for a second TSF at the Cerro Verde Mine is currently under construction. Commissioning of this facility, which will have an ultimate height of 310 meters at the centerline and will receive tailing at 240,000 tonnes per day, is scheduled for late 2015. Mr. Obermeyer is the Principal-in-Charge for this project.

Luis Valenzuela, M.Sc.

- Experience in large industrial, mining and infrastructure projects, mainly in Chile and Brazil but also in other Latin American countries.
- Experience includes feasibility studies, engineering design and construction supervision and operational experience through his participation in the Brazilian companies HIDROSERVICE and THEMAG Engenharia and as a co-founder and partner of GEOTECNICA Consultores in Chile in 1981, now known as ARCADIS Chile and part of the international engineering company ARCADIS. This experience includes tailings and water management facilities including large cyclone sands dams.
- Mr.Valenzuela is an active participant in international and Chilean learned societies including member and past president of Institution of Civil Engineers of Chile (IICH), Vice President for Central and South America chapter of International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), active member of the Chilean Chapter of International Commission on Large Dams ICOLD.
- Extensive experience includes participation, individually or as part of a review board in many mining and infrastructure projects including Antamina (Teck, Rio Tinto); Quellaveco (AngloAmerican), La Colosa (AngloAshantiGold), Caserones mine (Lumina Copper, a Mitsui company), El Mauro (Los Pelambres mine, Antofagasta Minerals), Laguna Seca (Escondida mine, BHP Billiton).
- At present, acting as the Engineer of Record for the three tailings dams at Las Tortolas, Chile (AngloAmerican).

Stephen Day, M.Sc., P.Geo,

- Mr.Day is the SRK Corporate Consultant in Geochemistry and North America Practice Leader. He has 25 years of experience in development of waste management plans to address acid rock drainage and leaching of mine wastes in general. He has particular expertise in the selection of appropriate prediction methods for mine planning and modeling of leachate chemistry.
- Mr.Day's project experience includes numerous new mine developments, operating mines and mine closures in western, northern and central Canada, arctic and temperate regions of the USA, southeast Asia and South America. For these projects, he has been involved in waste characterization, selection of control and prevention technologies, and predictions of drainage chemistry for input into water quality impact assessments and selection of water treatment approaches. His clients have included mining companies, utilities, professional associations, Canadian provincial and federal government departments, including the Yukon Government and US state departments.

Structure and Timing

1. The first step for the IERP is to have an initial meeting at the Project Site and conduct a review of the existing design. This is proposed to occur following the Adequacy determination by YESAB, so as to provide the IERP with the same information as provided to Federal, Territorial and First Nations reviewers. This timing is intended to enable feedback from the IERP in preparation of basic design, required by regulatory agencies for Quartz Mining License and Water Use License applications.
2. The IERP will meet and report on their findings at three stages during the development of the detailed design. Meetings will be scheduled when the design is approximately 30%, 60% and 90% complete.
3. The IERP will meet at appropriate intervals (3 - 4 times) during the construction phase.
4. The IERP will meet at regular intervals (approximately every 5 years) during operations and report on their findings.
5. The IERP will meet during the closure phase at intervals to be determined in the latter stages of mine operations.
6. The IERP will review any significant changes to the design and operation of the TMF, as required, throughout all phases of the project.

The purpose of the IERP is to inform, guide, and provide independent oversight to CMC on the design, construction, operation and planned closure of the TMF and HLF. The results of the IERP reviews will be incorporated into the tailings management framework, including the Operations, Maintenance and Surveillance Manual, and Audit and Assessment Frameworks for the Casino TMF, as described by MAC, on a regular basis. CMC will make all reports from the panel available to assessors, regulators and governments, as appropriate, when the reports are available.

B.4.2.2 Change Management and Technical Review Procedures

B.4.2.2.1 R2-2

R2-2. Frameworks for a change management procedure and an associated technical review procedure which will define processes for making and approving changes to designs or operating plans, such as may occur when conditions encountered in the field during construction or operations differ from design assumptions. Describe aspects of the project design for which engineering design changes will be overseen by the IGRP. These frameworks will also describe how regulators, First Nations, and other interested parties will be involved in the review processes.

The design, construction, operation, and ultimately, the closure and reclamation of key facilities at the Casino Project (e.g., TMF and HLF) is complex. It may be necessary to modify the design and operating practices at each stage because of new information or advances in technology, changes in regulation, climate change, or a variety of other reasons. Proposed modifications to the TMF and HLF will be identified and designed by the Engineer of Record (EOR). Significant changes will be reviewed by the Independent Engineering Review Panel (IERP). The modifications will then be submitted to the appropriate regulatory body for review and approval. These steps complement the regular independent reviews by the IERP and the regulators and ensure that the final designs are consistent with the conclusions of the Project screening throughout the detailed design, construction and operation of the Project.

Some examples of factors or influences that may result in changes during the design and initial construction phases include, but are not limited to:

- Changes in standards and regulations;
- Changes in operating/production requirements over time;
- Changes or advances in technology;
- Changes in ore and waste characteristics;
- Climate change;
- Unforeseen conditions (geotechnical, other);
- Personnel changes;
- Changes requested by the construction contractor;
- Availability of materials for construction; or
- Changes in the environment at or near the site.

The general framework that governs changes to engineering design is outlined in Figure B.4.2-1, providing an overview of the inputs and possible change management outcomes during the conceptual design, engineering design, construction, operations and closure phases of the Project. Independent oversight by the EOR, the IERP, and the regulators plays an important role in all phases of project development.

Change management framework

When a change occurs or is expected to occur it is necessary to evaluate the effect of the change on the current design and operation of the TMF and when necessary make revisions to the design and operating practice to accommodate the changed condition. The EOR has design responsibility for the life of the facility (Figure B.4.2-1) unless and until that responsibility is assumed by another Engineering entity. To implement a design change the EOR issues revised design criteria, revised design specifications, revised drawings, or other design document as appropriate, duly signed off by the individual with responsibility for the design within the EOR organization, for action to be taken by CMC. CMC has the responsibility to document that the design change has been effected in accordance with the EOR's direction. The EOR must take appropriate measures to verify to its own satisfaction that the necessary change has been implemented.

Subsequent changes during operations and through the on-going construction must maintain the change control management exercised during design and initial construction. All changes requested by operations or by the construction contractor must be referred to the EOR for evaluation and disposition. No change in design or operating practice (that impact on the design or quality control) is allowed without specific direction from the EOR and signed-off by the appropriate authority within the EOR organization. Both the EOR and CMC will maintain complete records of the original design documentation and all subsequent approved design or operating procedure changes that take place over the life of the facility.

Under all conditions, CMC will comply will all requirements for inspection and review of the TMF as required by the most up-to-date guidelines issued by the Territorial and Federal regulators, and the Canadian Dam Association. Further conceptual details of management of the TMF are provided in the Casino Project Guide to the Management of the Casino Tailings Facility (Appendix B.4A).

Internal and Independent Audit Process

CMC will conduct on-going internal audits of the operations, performance, QA/QC program, and change control management for project facilities. Periodically, an independent audit of the operation will be conducted which will

include, among others, a review of the internal audit program. Analysis of the information provided by the independent audits may provide valuable insights into opportunities to enhance the operation of the facilities. The audit results will be made available to the EOR, the IERP, and the Territorial, Federal and First Nations governments.

At some interval after commencement of initial operations (possibly every 5 years), the facilities will undergo an assessment by CMC, the EOR, and the IERP. This assessment will review the current design basis and operating practice, performance to-date, current state of best available technologies and practices, advances in technology relevant to the facility design & operation, changes in the community and environment, and effects or anticipated effects of climate change. The assessment will result in a report that recommends specific actions that need to be actioned for sustained operation of the TMF.

Regulatory Oversight

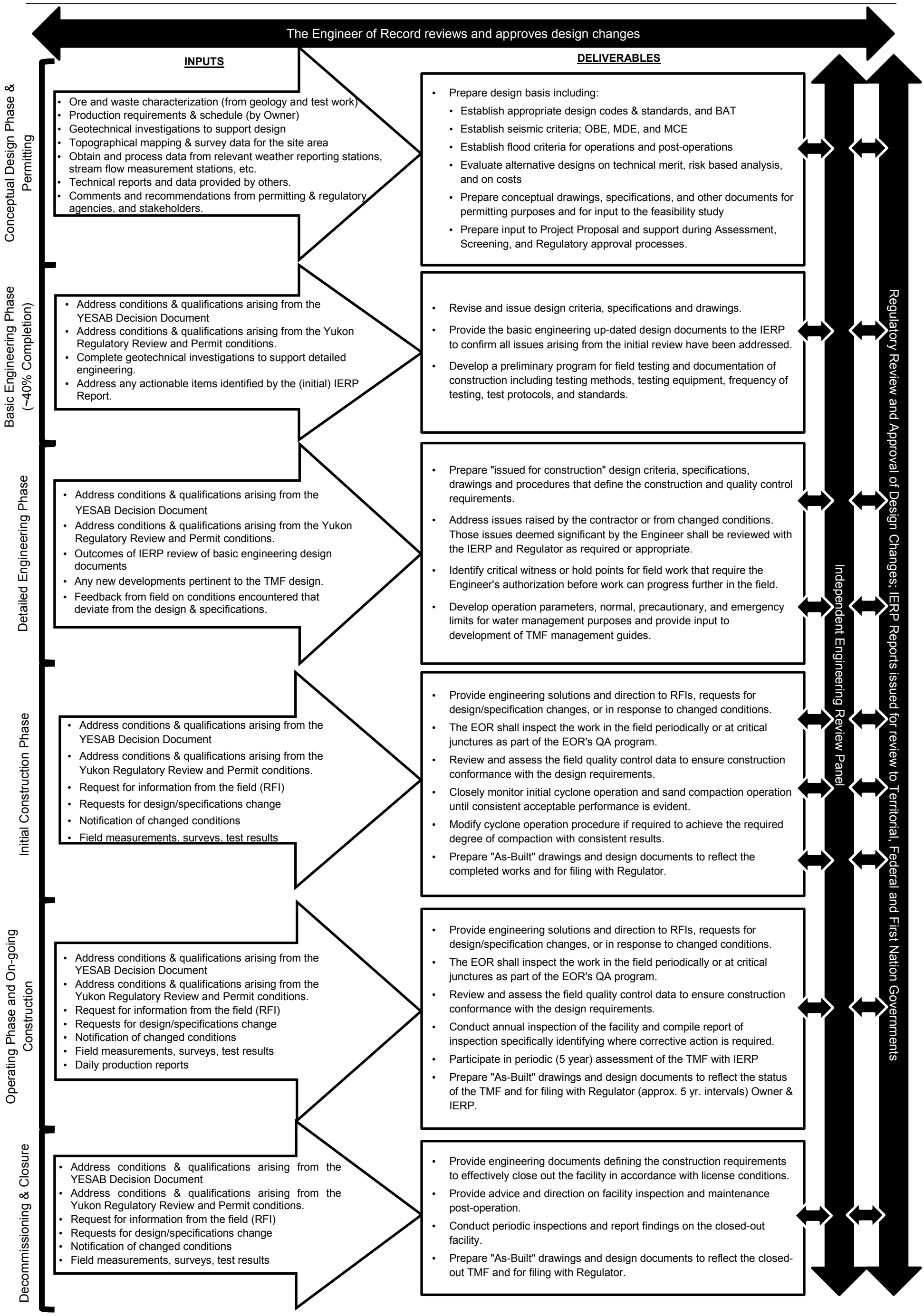
CMC will comply with all requirements of Territorial and Federal regulations, including conditions within permits and licences issued to the Project. CMC will provide Regulators documentation on changes made by the EOR, as required by licences and permits, and as requested. The results of the 5 year assessment will be filed with Regulators and any significant changes to the design and operation of the facility will be subject to review and approval (Figure B.4.2-1).

IERP Oversight

A full description of the role of the IERP is provided in the response to R2-1. Significant changes to the design or operating procedures must be conveyed to the IERP and any outcomes from the IERP must be addressed and documented. The results of the independent audit and the 5 year assessment will be made available to the IERP for review and feedback, as will any other documentation the IERP requires to complete its review.

First Nations

CMC will have continuous dialogue with affected First Nations and any significant changes to the design or operating procedures will be communicated on a timely basis. Should multiple options be available to modify the Project as a result of updated information, CMC will present the options and the comparative analysis to affected First Nations for their review and feedback. The results of the 5 year assessment will also be made available to the affected First Nations.



QA = Quality Assurance; EOR = Engineer of Record; RFI = Request for Information from the Field; BAT = Best Available Technologies; OBE = Operating Basis Earthquake; MDE = Maximum Design Earthquake; MCE = Maximum Credible Earthquake

Figure B.4.2-1 Inputs, Deliverables and Review of Design Refinements over the Mining Life Cycle

B.4.3 ALTERNATIVES

B.4.3.1 Tailings Management Facility

B.4.3.1.1 R2-3

R2-3. A detailed description and assessment of alternatives to or alternative ways of undertaking the Project with respect to tailings and waste rock management. This alternatives assessment should be comprehensive, provide transparent rationale and give consideration to the following:
a. Full life-cycle costs and all phases of the proposed TMF dam (i.e. in perpetuity);
b. Risks of the proposed TMF dam (i.e. as per risk assessment);
c. Potential significant adverse effects of the proposed TMF dam to environmental values (i.e. wildlife, water and aquatic resources) and socio-economic values (i.e. health, social, heritage and economic);
d. Identification and comparison of best practices and best-available technologies for tailings management;
e. Options for managing water balance to ensure safety and reduce probable risks of structural and/or non-structural TMF dam failure (i.e. as determined by the risk assessment);
f. Technically-sound engineering solutions that mitigate potential significant adverse effects based on actual site conditions (e.g. permafrost, climate change, construction challenges); and
g. A clear and transparent evaluation of the factors that support the proposed TMF dam.

CMC has completed an alternatives assessment to evaluate several options for mine waste (tailings and waste rock) management, including slurried tailings, thickened tailings, dry stack tailings, surface waste rock disposal and co-disposal of waste rock and tailings, provided in Appendix B.4B. The initial evaluation indicated that conventional slurry tailings disposed of subaqueously is the preferred option, and subsequently multiple TMF locations were evaluated, considering economic, environmental, technical and socio-economic parameters. The assessment was conducted in accordance with Environment Canada's guidance on alternatives assessment (Environment Canada, 2011) and gives consideration to the following:

a. Full life-cycle costs: The alternatives assessment contained in Appendix B.4B identified the most appropriate option for mine waste management at the Casino Project based on a number of technical, environmental, socio-economic, and economic factors. While the economic parameters were considered in the analysis, they were not given greater weight than the others. The economic portion of the analysis focused on capital and operating costs only, but cost was not the most important factor in the selection. Other factors, such as technical feasibility and site disturbance, were key in the determination of the most appropriate option for mine waste management at the Casino Project.

b. Risks of proposed TMF: The risks associated with the proposed TMF are described in the alternatives assessment contained in Appendix B.4B.

c. Potential significant adverse effects of the proposed TMF to environmental and socio-economic values: The potential significant adverse effects relating to the TMF are described in the alternatives assessment contained in Appendix B.4B.

d. Identification and comparison of best practices and best-available technologies for tailings management: Alternative disposal methods are compared in the alternatives assessment contained in Appendix B.4B.

e. Options for managing water balance: The TMF water balance was assessed for a range of climatic conditions (Appendix A.7A). The water balance is expected to be in deficit during operations and in surplus in closure, even during extremely dry conditions.

   During operations, when no spillway is in place, the TMF water balance is managed by the amount of water pumped from the Yukon River. Should conditions be significantly different than expected, CMC has the option to stop, reduce, or increase the amount of water pumped from the Yukon River.

   During closure, water balance surplus is managed through the spillway. The spillway is sized for a probable maximum flood, and can manage a great surplus. In the unlikely scenario that the facility will be in a deficit during closure, pumping of water from the open pit lake or even the Yukon River are other options available to CMC to keep the waste flooded.

f. Engineering that mitigates potential significant adverse effects based on actual site conditions: All aspects of engineering design are aimed at mitigating potential adverse effects based on site-specific conditions. Further site investigations completed to meet the requirements of regulatory bodies for application for the QML and YWL will drive many of the detailed design and construction decisions. On-going QA/QC measures and the change management framework will ensure the TMF is built in accordance with terms and conditions of licenses. These on-going controls are discussed throughout this SIR-B, and include:

   - General risks and mitigation strategies are discussed in the response to R2-4;
   - TMF design and construction considerations are discussed in responses to R2-57 through R2-66; and
   - QA/QC and change management procedures are discussed in R2-2.

g. Evaluation of the factors supporting the proposed TMF: The detailed evaluation that supports the proposed TMF is included in the Mine Waste Management Alternatives Assessment in Appendix B.4B.

B.4.3.2 Risk Assessment

B.4.3.2.1 R2-4

R2-4. A risk assessment for the TMF dam.

Section 21 of the Project Proposal provided a determination of the significance of any environmental or socio-economic effects resulting from accidents or malfunctions. This included a qualitative risk assessment associated with *credible* hazard scenarios. Potential hazards related to the tailings management facility (TMF) included a TMF embankment failure or overtopping; tailings distribution pipelines failure and a reclaim water line rupture (Section 21.3.4.1). Below, CMC has provided the results of a more comprehensive risk assessment specific to the TMF. In addition, CMC proposes to conduct a Failure Modes and Effects Analysis (FMEA) assessment at discrete stages in the project development as follows, as shown on Figure B.4.2-1:

- A FMEA will be completed during the early regulatory review phase informed by advanced engineering, final geotechnical investigations, review of key design basis by the Independent Engineering Review Panel (IERP), input from the YESAB Decision Document, input from the regulator, territorial, federal and First Nations governments, and Communities of Interest (COI). The intent is that this FMEA together with other project documents will support the Quartz Mining License (QML) application leading to a provisional QML with attendant conditions and qualifications that are to be addressed to obtain an operating license.

- The FMEA will be re-evaluated during later stages of detail design when the final design basis has been vetted by the IERP and comments and recommendations of the first FMEA participants have been addressed.
- The final FMEA, prior to start of operations, will be conducted during the later stages of construction and will reflect any design changes or developments in the field since the previous FMEA and will be informed by the actual foundation conditions encountered at the site. The conditions and qualifications attached to the provisional QML will have been addressed at this juncture and the FMEA will reflect any design or procedural changes arising from the provisional QML conditions.
- During operations and in post-closure the TMF facility will undergo an assessment every five (5) years which will include a review of the effects of climate change and an updated risk assessment.

Tailings Management Facility Design

All waste rock, tailings and water from the mine and process operations will be stored in the Casino Project TMF, located southeast of the Open Pit within the Casino Creek headwater valley. The TMF is designed to retain tailings and potentially reactive waste rock and overburden materials. The TMF will be developed starting in the construction phase in Year -4 and will be utilized throughout the mine life and will be a permanent landform in the post-closure phase.

The TMF will be comprised of:

- Two earth-rockfill-cyclone sand zoned embankments constructed by a centerline raise construction method, with the downstream shells constructed from dozer compacted cyclone sand and other suitable borrow materials;
- Cyclone plant to generate clean sand from the bulk NAG (Non-Potentially Acid Generating) tailings for embankment construction and tailings distribution pipelines (bulk NAG tailings, PAG tailings, cyclone sand, cyclone overflow);
- Supernatant (surface water) pond;
- Mill and cyclone plant reclaim water systems;
- Waste storage area in the upstream portion of the TMF impoundment for potentially reactive waste rock and overburden;
- Tailings storage area in the downstream portion of the TMF impoundment for storage of PAG tailings and the portion of NAG tailings not used for embankment construction;
- A NAG tailings beach above water, separating the supernatant pond from the embankments;
- Water management system (seepage collection ditches and pond, and seepage recycle system);
- A closure spillway and downstream channel near the right abutment of the West Saddle Embankment terminating at an erosion protected plunge pool into Casino Creek; spillway will pass a 24-hr probable maximum flood event; and
- Wetland treatment for the removal of contaminants at closure.

The TMF Main and West Saddle Embankments have been designed in accordance with the 2007 CDA Dam Safety Guidelines, and based on site-specific geotechnical, hydrogeological, hydrometeorological, and seismic information (Appendix A.4D). Considering the incremental consequences of failure including loss of life,

environmental and cultural values and economic loss, the Casino TMF was classified as “High” according to the 2007 CDA Dam Safety Guidelines, and the feasibility level design was completed in accordance with those design criteria.

Components of the Casino TMF have been over-designed to an “Extreme” level for earthquake events and a 24 hour PMF storm event, despite a “High” rating. Dam classification is used to determine design criteria for earthquakes and flood events. Although classified as “High”, conservatively, the Casino TMF design incorporates an evaluation of embankment design to a seismic loading of the 1 in 10,000 year earthquake. The CDA guidelines recommend the 1 in 10,000 year earthquake event for the design of dams classified as “Extreme”. The predicted embankment deformations resulting from the 1 in 10,000 year earthquake are less than 0.5 m, and there is no significant impact on the embankment freeboard (minimum 2 m) and no loss of embankment integrity. Static and post-earthquake stability is also satisfactory. Therefore, the TMF meets the CDA Dam Safety Guideline seismic design criteria corresponding to an “Extreme” dam class.

Additionally, the TMF design for flood events requires *storage* for that flood event during operations, and *conveyance* of the flood event within the spillway during closure. The definition of the flood event varies depending on the dam classification. The updated 2014 guidelines define return periods as follows:

Dam Class	Annual Exceedance Probability (AEP) - Inflow Design Floods	
	Construction, Operation and Transition Phases	Closure - Passive Care
Low	1/100	1/1,000
Significant	Between 1/100 and 1/1,000	1/3 between 1/1,000 and Probable Maximum Flood
High	1/3 between 1/1,000 and Probable Maximum Flood	2/3 between 1/1,000 and Probable Maximum Flood
Very High	2/3 between 1/1,000 and Probable Maximum Flood	Probable Maximum Flood (PMF)
Extreme	Probable Maximum Flood (PMF)	Probable Maximum Flood (PMF)

However, the guidelines do not specify flood *duration*. The Casino TMF has been designed for an inflow design flood (IDF) of 1/3 between the 1/1,000 and Probable Maximum Flood (PMF) for a 72 hour storm duration during operations (equivalent to a 9 Mm^3 flood volume) and the PMF for a 24 hour storm during closure (or peak flow). These events are again equivalent to a dam classification of “Extreme” for 24 hour storm events, or 6.1 Mm^3 flood volume during operations and peak flow during closure.

Therefore, while classified as “High”, the Casino TMF meets the main criteria for a dam classification of “Extreme” according to the updated CDA Dam Guidelines (CDA, 2014).

Further details of the TMF design can be found in Appendix A.4D.

A guide to the management of the Casino Tailings Facility and an Operating, Maintenance & Surveillance Manual (OM&S) are currently under development by CMC. These guides are based on the latest issues of MAC guidelines for management of tailings facilities and OM&S manuals. For example, MAC is currently undergoing a review of the tailings management guides. CMC will follow the guidelines of MAC to compose its tailings management system in accordance with the most up-to-date MAC guidelines. When fully developed, these manuals will be submitted to the decision bodies in support of the Quartz Mining License and Yukon Water Use License applications. Early drafts of these manuals are included in Appendix B.4A and Appendix B.4D for information purposes only at this time to indicate the comprehensive scope and content of the guides under development. The completed manuals will provide management and operations personnel an effective tool for the training of operating personnel and contractors. They will also provide a means to manage, control and document operations and to develop an awareness and ability to recognize and respond to conditions that deviate from

design or approved operating procedures. The manuals will also be provided to the IERP for review and input, to ensure they reflect current industry practice.

Risk Assessment Methodology

Risk is typically defined as the product of the likelihood and the consequence of an event. The risk assessment presented here is on the Project Proposal basis. Likelihood is assigned based on the level of design information available for the Project, review of historic or current mining accidents and malfunctions, and professional judgement (Table B.4.3-1). Consequence is assigned based on the spatial and temporal context of the Project (Table B.4.5-1).

Table B.4.3-1 Likelihood Rating Criteria

Unlikely	Event is not expected to occur during the life of the Project
Rare	Low probability of occurrence during the life of the Project
Possible	Event may occur during the life of the Project
Likely	Event is expected to happen at least once during the life of the Project

Table B.4.3-2 Consequence Rating

Very Low	Effects occur near the source, are contained, and are immediately reversible
Low	Effects extend beyond event site but are confined, and persist over the short-term but are reversible through mitigation
Moderate	Effects extend beyond event site, have medium-term recovery but are reversible through mitigation, with no residual impacts
High	Effect is widespread, requires long-term recovery with mitigation, leaves a residual impact

Confidence in the likelihood and consequence ratings is also provided. Low confidence in the ratings would be a result of insufficient information regarding details of the Project component or activity, or incomplete knowledge of the site-specific setting (or a combination of the two); high confidence would be assigned where information is available on design and failure modes for similar components or activities.

Risk grades range from Non-actionable (negligible risk; no additional mitigation or re-design required) to High (serious risk; re-design or operational changes required), as shown in Table B.4.3-3. Hazard scenarios ranked as 'Non-actionable' risk to 'Moderate' risk are considered Not Significant; those rated as 'High' are considered to constitute a potentially significant impact. Risk grades are used to assist management and decision making in determining where focus will be needed at the design detail stage or during operations to minimize the risk of failure of a component or activity.

Table B.4.3-3 Risk Matrix

Likelihood	**Consequence**			
	Very Low	**Low**	**Moderate**	**High**
Likely	Low	Moderate	High	High
Possible	Low	Low	Moderate	High
Rare	Non-actionable	Low	Low	Moderate
Unlikely	Non-actionable	Non-actionable	Low	Low

Risk Identification

Potential accidents and malfunctions and hazards assessed for the TMF are described in Table B.4.3-4, but fit into the following main categories:

- Failure of retaining embankments (coffer dam during construction or tailings embankment during operations and closure);
- Failure of associated infrastructure (e.g., HLF, waste storage area, distribution pipelines); and
- Failure of the water management and treatment system.

In addition to the mitigations and management measures described in Table B.4.3-4, CMC will have a rigorous program of internal monitoring and management subject to extensive auditing and quality assurance and quality control procedures. These include:

- Robust QA/QC program during construction, verified by the engineer of record.
- Comprehensive sampling, testing, and documentation regime to demonstrate effectiveness of material quality control and placement.
- Managing operations to meet or exceed MAC guidelines, including the incorporation of Towards Sustainable Mining initiatives and compliance with the various protocols and frameworks, including the Tailings Management Protocol and the:
    - Guide to the Management of Tailings Facilities;
    - Operation, Maintenance and Surveillance Manual; and
    - Audit and Assessment of Tailings Facilities Management Manual.
- Compliance with the International Cyanide Code and the inherent auditing required for compliance with the Code.
- On-going monitoring of site infrastructure and receiving environment to ensure compliance with model predictions.
- Scheduled Dam Safety Reviews in accordance with CDA Guidelines.
- Annual review of major facilities operations by Chief Operating Officer.
- Annual audit of operation.
- IERP review of design and operations.
- External (independent) audit of operations every 3 years.
- Assessment of the facilities including consideration of climate change every 5 years.
- Review and approval of issued-for-construction reports by the Yukon Government.
- Submission of as-constructed design drawings and reports to the Yukon Government and the Yukon Water Board.
- Regular Inspections by Yukon Government regulators.

Regardless of these mitigations, the assessment of potential accidents and malfunctions are discussed further below.

1. Embankment Failure

The likelihood of a TMF embankment failure is difficult to predict. Azam and Qi (2010) note that the failure rate over the last 100 years, based on a world inventory of 18,401 mine sites, is estimated as 1.2%; however, Haile and Brouwer (2012) note that "it is incorrect to imply that any particular proposed or actual dam structure is more or less likely to fail based solely on the extrapolation of general dam failure statistics", and that the assessment of the integrity and stability of any dam is more correctly based on site-specific conditions and facility details.

Azam and Qi (2010) attempted to statistically analyze available data on tailings dam failures; failure modes were attributed to unusual weather events, seepage, poor management (inappropriate dam construction procedures, improper maintenance of drainage structures, and inadequate long-term monitoring programs), slope instability, structural defect, and overtopping. Overtopping can be attributed to inadequate spillway design, spillway debris blockage, or settlement of the dam crest, while seepage occurs around pipes and spillways, through animal burrows and through cracks in the dam or dam foundations (ICOLD, 2013). Improved engineering practices, construction technology, and more stringent safety criteria have significantly reduced dam failures since the 1990s (Azam and Qi 2010). The decrease over the several decades in the failure rate of dams has been attributed to, among other things, improvements in investigation techniques and dissemination of knowledge on risks (ICOLD, 2013).

In lieu of TMF embankment failure likelihoods, the probability of occurrence of the design earthquakes and floods can be considered. The 1 in 10,000 year earthquake is an earthquake having a 0.01% probability of occurrence being exceeded in any year. The 1 in 1000 year flood is a flood having a 0.1% probability of occurrence being exceeded in any year. The Probable Maximum Flood is the largest possible flood based on an analysis of the maximum possible precipitation in a given area. By definition a PMF event is so improbable that a probability of occurrence is *not assigned*.

Assessment of embankment failure evaluated in Table B.4.3-4 includes the following, discussed further below:

- Failure of coffer dam or temporary construction measures;
- Failure due to a seismic event;
- Failure due to piping;
- Slope-stability foundation failure; and
- Failure due to overtopping.

The embankments will be constructed as water-retaining zoned structures with a low permeability core zone and appropriate filter and transition zones to prevent downstream migration of fines. The core zone will include a seepage cut-off key into competent rock in the foundation. Foundation preparation for the TMF embankments will involve the stripping of topsoil and vegetation and excavation of underlying frozen soils to competent, stable bedrock or non-frost susceptible overburden foundation. The removed material will be replaced with core, filter or shell zone material. The Main Embankment will be constructed in several stages over the operating life of the mine using the centreline method of construction. Development of sufficient tailings beach area is required between the supernatant pond and the embankment to provide a stable upstream construction surface for the centreline embankment raises.

The centerline raise construction method is a widely used construction technique that "affords superior seismic and static stability as compared to upstream construction methods and results in an inherently stable structure that does not rely on the strength of the deposited tailings solids. There are relatively few instances of catastrophic failure for tailings dams constructed using the centerline and downstream methods" (Haile and Brouwer, 2012). The results of the stability analyses conducted for the Project indicate that the design satisfies the requirements for factors of safety for short term (initial construction phase) and long term operations and post-closure stability (1.3 and 1.5, respectively) (Appendix A.4D). The seismic analysis for the TMF embankment indicates that any embankment deformations during OBE or MDE earthquake loading would be minor, and would not have any significant impact on embankment freeboard or result in any loss of embankment integrity (Appendix A.4D).

Based on these design measures using the site specific geotechnical, hydrogeological, hydrometeorological, and seismic information, the likelihood of failure has been rated as **Rare**.

To evaluate the consequences of a hypothetical dam breach, a dam breach inundation study was conducted (Appendix B.4C). However, the study does not evaluate the likelihood of occurrence as discussed above. The modelled dam failures are hypothetical and should not occur if the TMF is designed, constructed and operated following standard engineering practices. However, it is prudent to understand the potential consequences of failure, and the results of this study can be used to aid in the development of emergency planning. The CDA guidelines (2007) suggest that causes of earth dam failures include overtopping and seepage, piping and internal erosion, embankment instability and slides. Overtopping is a common mechanism for failure during a flood induced breach. As the TMF has the capacity to contain the IDF under normal operating conditions, the initial pond level was raised from operational limits for the study, in order to cause the dam to overtop during the 24-hour PMF.

The dam breach inundation study was structured to estimate the potential inundation limits that would result from a hypothetical dam breach at its maximum height, resulting in the largest potential consequences. Impacts to aquatic and terrestrial ecosystems, as well as to socio-economic indicators are also provided in Appendix B.4C.

In the event of a TMF embankment failure the consequences would be **High** if tailings and supernatant water were released into the environment, depending on the magnitude of the release.

2. Failure of associated infrastructure

Assessment of associated infrastructure evaluated in Table B.4.3-4 includes:

i) failure of the HLF embankment and release of leach solution into the TMF; and

ii) failure of distribution facilities.

Water can only be impounded in the HLF prior to closure, as the Events Pond will be removed and the liner of the confining embankment will be perforated after the rinsing stage, and the HLF will drain freely into the TMF.

i) Failure of the HLF embankment and release of leach solution into the TMF

The heap leach pad and events pond will be located upstream and within the same catchment area as the TMF thereby minimizing potential environmental impact (Appendix A.4C). The heap leach pad embankment constructed at the toe of the proposed pad will provide stability to the heap leach pad and provide in-heap storage for solution. The heap leach pad is designed to be operated predominantly as a 'dry' pad with minimal solution storage occurring in the in-heap storage during normal operating conditions. The embankment will be constructed with an upstream slope of 3H:1V and downstream slope

of 2H:1V to ensure embankment stability. Storage of leachate during operations is not expected to occur during the course of normal operations; however, during significant rainfall events or during a process shut-down, in-heap storage will be used. The heap leach pad liner system is designed to be operated as a dry operation, with pregnant leachate solution being pumped out as soon as it collects in the sump; this will reduce the hydraulic head on the liner system. Solution storage in the ore-pore volume behind the confining embankment is possible up to elevation 1096 m (approximately two days irrigation volume) before discharging over the confining embankment spillway to the Events Pond.

The Events Pond will be situated immediately down gradient of the HLF embankment and pond flows will be conveyed via the HLF spillway. The Events Pond is designed to meet the following design criteria:

- Storage capacity to contain the excess heap leach pad leachate and surface runoff from the 1 in 100 year 24-hour storm event without discharge to the TMF; and
- Spillway designed to discharge the 1 in 200 year 24-hour storm event with a minimum embankment crest freeboard of 0.3 metres.

Solution stored in the events pond will be pumped back to the heap leach pad using the events pond pump station, designed to empty the 1 in 10 year storm runoff volume over ten days, and the 1 in 100 year volume over 12.5 days (Appendix A.4C). During storm events greater than the 1 in 200 year 24-hour, water volumes exceeding the events pond storage capacity will be conveyed to the TMF pond via the events pond spillway.

The heap leach pad and events pond feasibility design were based on site geotechnical investigations, hydrogeological conditions, and a probabilistic seismic hazard assessment. Construction of the embankment will involve stripping the topsoil and excavating the underlying frozen colluvial and residual soils down to competent, stable bedrock (Appendix A.4C). Failure modes for the embankments will be similar to those for the TMF embankments (unusual weather events, seepage, poor management, slope instability, structural defect, and overtopping).

Based on the design measures using the site-specific geotechnical, hydrogeological, and seismic information, the likelihood of heap leach embankment failure has been rated as **Unlikely**. In the event of a HLF embankment failure the consequences would be **Very Low**, since the Events Pond immediately downstream of the heap leach pad embankment is designed for sufficient storage capacity to contain the excess leachate and surface runoff from the 1 in 100 year 24-hour storm event without discharge to the environment.

The likelihood of an events pond embankment failure is rated as **Unlikely**, based on the design and construction methods. The consequences for an Events Pond embankment failure are rated as **Very Low** since water volumes exceeding the events pond storage capacity will be conveyed to the TMF pond via the events pond spillway and not be discharged to the environment.

Failure of the Events Pond embankment simultaneously or as a result of a heap leach pad embankment failure could result in release of barren and pregnant solution; however, this would be contained within the TMF and not be discharged into the environment. The Project Emergency Response Plan (Appendix 22B) will outline the containment and cleanup measures to be implemented in the event of any heap leach pad or Events Pond embankment failure, methods for the disposal of contaminants and debris, and post-incident evaluations. Special handling methods for cyanide may be required; this will be outlined in the Emergency Response Plan.

ii) Failure of distribution facilities

Three tailings streams will discharge into the TMF: PAG tailings, bulk NAG tailings and the cyclone overflow (the fine fraction of bulk NAG tailings). The TMF design includes separate tailings lines from the main plant site for the PAG tailings and NAG tailings. Thickened NAG tailings from the processing plant will have a solids concentration of 55% solids by weight; this will be directed to the cyclone feed tank where it will be diluted with pond reclaim water to an optimum solids concentration of 36%, and will then flow by gravity to the cyclones.

The cyclone feed tank will be comprised of four compartments: the NAG tailings and dilution water report to the first compartment before flowing over a baffle to a rubber lined 38" carbon steel pipe to the cyclone cluster. In the event that bypass of the cyclones is required, the 38" carbon steel pipe can be isolated with a knife gate valve. The slurry level would then increase in the overflow compartment before reaching an overflow weir; from the overflow weir the slurry flows to a bypass compartment piped through the cyclone plant and cyclone overflow distribution system, where it will be deposited on the upstream side of the tailing dam. The fourth compartment of the cyclone feed tank takes all tank overflows and spillage in emergency situations and feeds into a 42" emergency spillage line, which takes the spillage to the nearest location of the tailings pond .

The cyclone underflow (sand fraction) will be discharged from the sand plant as slurry at 65 – 74% solids (by weight) to construction cells along the upstream and downstream shells of the TMF embankment. The cyclone overflow material (fine fraction) will be discharged directly to the TMF impoundment as slurry at approximately 25% solids by weight. The cyclones will be in operation for approximately nine months equivalent of each year, since cyclone operations may become more problematic as the temperature decreases during the winter months. The bulk NAG tailings will be deposited during the winter months and any other time the cyclone plant is not in operation. The bulk NAG tailings and cyclone overflow will be discharged to the TMF from valved off-takes located along the Main Embankment and from the West Saddle Embankment. The PAG tailings will be deposited within the TMF near the Waste Storage Area; the PAG tailings line will be laid heading east from the main plant, running between the low grade ore stockpiles. Upon mine closure the tailings and reclaim delivery systems, cyclone plant and all pipelines, structures and equipment not required beyond mine closure will be dismantled and removed from site.

The hazard scenario assessed for the tailings distribution lines is rupture, either due to freezing temperatures or to damage from heavy equipment, resulting in a release of tailings within the impoundment facility during the construction and operation phases. Three scenarios are discussed:

- PAG tailings line rupture between the main plant and TMF;
- NAG Bulk tailings line rupture between the main plant and the cyclone plant; and
- NAG Tailings underflow and overflow into the TMF.

Risks and mitigation plans accounted for in the cyclone and transport system include (Appendix A.4D):

- Slack flow and associated high tailings slurry velocities, up to 11 m/s, creates very high wear in the piping: risk of high pipeline wear in sloped sections (slack flow) was resolved through the use of ceramic orifices to dissipate energy and reduce slack flow section lengths, and ceramic lined pipes on remaining slack flow pipe section;
- Risk of blockage of the cyclone underflow pipeline was mitigated through proper design and flush water availability along the whole pipe;

- Risk of freezing of pipeline addressed through design using heat tracing and insulation; during operations the slurry pipelines will be drained for shutdowns longer than two hours;
- Risk of valve malfunctions due to freezing will be mitigated through insulation and heat tracing; and
- Risk of pipeline failure addressed through drainage construction to ensure that spills are directed into the TMF through a 42" emergency spillage pipe.

The higher elevation of the main plant site relative to the TMF will enable gravity discharge for the tailings streams, therefore any PAG tailings released from a tailings line rupture between the main plant site and TMF would eventually report by gravity flow to the TMF, if not contained and cleaned up immediately. Similarly, release of material from a NAG tailings rupture between the main plant site and TMF embankments would flow by gravity to the TMF. Rupture of the cyclone sand piping system would result in release of cyclone underflow from the NAG tailings on the downstream side of the embankment; the underflow is approximately 74% solids by weight and is anticipated to be captured within the sand deposition cells. Any significant pipeline failure on the downstream side of the dam would be addressed by bypassing the cyclone plant and routing the bulk tailings directly into the TMF. Rupture of the tailings fines from the cyclone overflow discharge lines would result in deposit of NAG tailings onto the beach of the TMF and contained within the impoundment.

Based on the design measures the likelihood of a tailings line rupture is rated as **Rare** and the consequence is rated as **Very Low**.

Failure of the PAG tailings pipeline between the main plant and the TMF would result in release of material into the terrestrial environment. An uncontrolled release of the PAG tailings may travel downhill and in any case will remain within the confines of the TMF catchment area. Localized impacts uphill of the TMF will be mitigated by cleaning up any spill that occurs during operations.

Failure of the NAG tailings distribution system would result in release of tailings onto the downstream side of the embankment to be captured within cells and/or by the seepage return system or onto the tailings beach within the TMF. Deposit of the cyclone underflow tailings on the downstream embankment could result in unplanned release of seepage water from the cyclone sand; this water would report to the surface ditch system, which discharges into the water management pond located downstream of the embankment. Tailings seepage water could have elevated concentrations of total suspended solids and some metals. Seepage and runoff collected in the water management pond will be pumped back into the TMF.

3. Failure of the water management and treatment system

Assessment of the various components that would impact downstream water quality evaluated in Table B.4.3-4 include the following:

i) PAG tailings mistakenly identified as NAG and used in construction;

ii) Unexpected metal leaching from the NAG and overburden material;

iii) TMF seepage collection failure;

iv) Unpredicted seepage volumes; and

v) Failure of wetland treatment system.

These failures are discussed further below.

i) PAG tailings mistakenly identified as NAG and used in construction

To ensure the accurate characterization of tailings and waste rock materials, and identify the metal leaching and acid generating potential of that material, a broader monitoring and control process is used to monitor and manage the quality of the NAG tailings reporting to the cyclone station. Measures include:

- Mine production planning and scheduling documents that characterize the ore to be fed to the coarse ore stockpile ahead of the processing facility
- Sampling of the drill cuttings prior to blasting of a bench so that the ore can be tested in advance of processing for sulphide sulfur and carbonate to determine the initial neutralization potential ratio (NPR);
- On-stream analyzers, supported by check assays, installed at strategic points in the processing plant to collect data from the various plant input and output streams to inform operations personnel on plant performance, allowing them to manage the facilities efficiently and effectively;
- The tailings stream at the cyclone plant is assayed multiple times per day to confirm the material is NAG and suitable for dam construction; and
- Tests to confirm the tailings coarse fraction meets the specified size distribution criteria.

ii) *Unexpected metal leaching from the NAG and overburden material*

Thresholds for acceptable construction material (e.g., NAG tailings) will be set sufficiently low to be conservative, and allow for some variance. Through testing of several different composites from the Casino ore body, the ability of the flotation process to reduce the sulfur content to achieve a NP/AP > 2.0 was proven. The NP/AP criterial of 2.0 is also very conservative and a NP/AP = 1.5 is likely more appropriate for the low-sulphur desulphurized tailings as shown by the low sulphide oxidation rates in the tailings kinetic tests and liberation of carbonate minerals in the finely ground tailings. Testwork on individual ore types defines the specific sulphide sulphur requirements to maintain a conservative NP/AP > 2.0, which was provided in Table A.4.5-2. Operational monitoring will be conducted to confirm the non-PAG characteristic of hypogene tailings used for the construction of the embankment or the final tailings cover that will be placed on the upper surface of the TMF.

iii) *TMF seepage collection failure & iv) unpredicted seepage volumes*

As discussed in the TMF failure section, the core zone will include a seepage cut-off key into competent rock in the foundation. Additionally, the Water Management Pond will be located downstream of the TMF main embankment, in the Casino Creek valley to collect embankment seepage and runoff. Seepage and runoff collected in the water management pond will be pumped back into the TMF. Monitoring wells will be constructed downstream of the collection system to ensure the water management pond is working as predicted. A wetland treatment system may also be constructed in the area downslope of the water management pond, if required (see the response to R2-73).

v) *Failure of wetland treatment system*

Failure of the wetland treatment system may occur due to failure of the wetland itself (e.g., not performing as predicted) or through failure of the infrastructure on which the wetland is built (e.g., TMF embankment). The phased design and optimization program for the wetland treatment system is intended to be an adaptive and responsive program, allowing for the systems to be effectively developed to treat water for the ranges of contaminant loads, flows, and climate at the Casino site, for successful treatment in

perpetuity. As with any water treatment system, an assessment of the uncertainty associated with the performance of the proposed passive treatment systems will be conducted as part of the design and testing process. Uncertainties will be evaluated and integrated into the phased research program in order to identify their scope and develop contingencies to address them. The phased approach being undertaken in the design and optimization of the passive treatment systems has been developed specifically to address uncertainties associated with such systems, allowing for optimizations, design revisions, and contingency options to be integrated through the process. While some uncertainty remains with the currently proposed systems, all foreseeable uncertainty will be addressed through the execution of appropriately planned laboratory, bench- and field-scale experiments and subsequent monitoring of the installed systems. Additionally, the conservative nature of the water quality model predictions and the treatment systems proposed will result in discharge water quality that will be protective of the receiving environment.

Table B.4.3-4 Tailings Management Facility Risk Assessment

Potential Issue of Concern	Potential Effect(s)	Project Phase	Design Measures	Risk Assessment			Rationale	Mitigation / Management	Risk Level	Significance
				Likelihood	Consequence	Confidence				
Failure of coffer dam or temporary construction measures	Discharge of non-contact water and natural materials	Construction	• Designed to manage runoff from the 10-year, 24-hr rainfall event for the construction period. • Backup equipment and procedures to relieve problem by controlled (pumped) discharge. •	Possible	Very Low	Moderate	• Limited exposure due to short construction period. • Any water released is non-contact. • Backup capability comparatively simple to provide.	• Awareness of snowpack condition ahead of freshet enables ability to take proactive measures. • Monitoring of freeboard. • Can raise coffer dam or pump out water if required.	Low	Not significant
Erosion from construction areas during runoff events.	High suspended solids and sediment loading to the downstream environment	Construction	• Use appropriate erosion control measures as required by project construction specification.	Possible	Low	High	• Best management practices will be incorporated into the construction procedures. Sediment control measures will be inspected and maintained to ensure they are effective. • Silt, sediment and erosion control plan will be implemented.	• Additional measures may be incorporated into the plan if the planned measures are shown to be insufficient.	Low	Not Significant
Severe weather impact on construction	Failure to meet design specification and quality control standards	Construction & operations	• Provide detailed design and specification requirements including quality control measures for construction with specific measures for cold weather conditions.	Unlikely	Moderate	High	• Practices and procedures for cold weather construction are known and understood by construction contractors, engineers, and EPCM contractors. All qualified contractors have relevant experience dealing with these issues. • Weather susceptible construction activities scheduled outside of colder season.	• EOR provides detail specifications and QC requirements. Construction contractor provide work plan to demonstrate compliance & his QC program. EPCM & EOR provide QA of QC program. • Contractor required to re-perform unacceptable work.	Low	Not significant
Failure of tailings embankment and release of tailings from a Seismic event	Discharge of deleterious substances to environment arising from a seismic event	Construction, operations, closure, and post-closure	• The embankment has been over-designed in consideration of seismic loading for the 1 in 10,000 year earthquake, which is comparable to a hazard rating of “Extreme” and more robust than the recommended CDA Guidelines for a "High" classification of a 1 in 2,500 year earthquake.	Rare	High	High	• Embankment raises constructed by a centerline raise construction method as per design results in a stable structure that does not rely on the strength of the deposited tailings solids; selected because of its superior seismic and static stability as compared to upstream construction methods. • Experience at other comparable operations in similar cold climates demonstrates that cyclone sand operation produce construction material with consistent properties and that required levels of compaction can be reliably obtained.	• Emergency Response Plan. • Scheduled Dam Safety Reviews in accordance with CDA Guidelines. • IERP review of design and operations. • Regulatory inspection	Low	Not significant
Seismic event continued.	Leading to failure of the tailings dam and loss of water and solids to the downstream environment.	Construction, operations, closure, and post-closure	• Per the above.	Unlikely	High	High	• Appropriate design standards. Surveillance, maintenance and monitoring. • Good operating practice (beach widths and freeboard) to accommodate potential deformations. • Using good operating practice allows	• Per the above.	Low	Not Significant

Potential Issue of Concern	Potential Effect(s)	Project Phase	Design Measures	Risk Assessment			Rationale	Mitigation / Management	Risk Level	Significance
				Likelihood	Consequence	Confidence				
							quality construction to continue even in adverse weather conditions. • Operator and Contractor training. .			
Failure of tailings embankment and release of tailings due to a precipitation event	Discharge of deleterious substances to environment arising from flood event	Construction, operations, closure, and post-closure	• The embankment has been designed in consideration of an appropriate IDF per CDA guidelines for each stage in the life of the facility.	Unlikely	High	High	• The IDF criteria is per CDA guidelines and the design provides a minimum of 2 m freeboard over the requirement to store or route the flood event.	• Emergency Response Plan. • Scheduled Dam Safety Reviews in accordance with CDA Guidelines. • IERP review of design and operations.	Low	Not significant
High runoff event leading to dam overtopping.	Failure of the tailings dam and loss of water and solids to the downstream environment.	Operations	• Design includes 2 m freeboard over and above storage required for design flood events occurring at maximum operating level.	Unlikely	High	High	• Designed to a high standard with abundant flood storage. • Regular inspection and maintenance.	• Emergency Response Plan. • Scheduled Dam Safety Reviews in accordance with CDA Guidelines. • IERP review of design and operations.	Low	Not significant
Piping failure of the dam	Failure of the tailings dam and loss of water and solids to the downstream environment.	Construction, operations, closure, and post-closure	• Design includes substantial core and filter zones.	Unlikely	High	High	• Conservative embankment filters design. • Surveillance, maintenance and monitoring. • Good operating practice (beach widths).	• Maintain a stockpile of material for a downstream filter.	Low	Not significant
Slope stability - Foundation failure	Leading to failure of the tailings dam and loss of water and solids to the downstream environment.	Construction, operations, closure, and post-closure	• Extensive geotechnical investigations to support design. • Evaluation of “as excavated” foundation conditions by geotechnical engineer to confirm consistent with design requirements. • Design review by IERP.	Unlikely	High	High	• Appropriate design standards. • Surveillance, maintenance and monitoring. • Good operating practice (beach widths). • Operator training. • Excavation of poor (ice-rich) foundation materials.	• Emergency Response Plan. • Scheduled Dam Safety Reviews in accordance with CDA Guidelines. • IERP review of design and operations. • Frequent inspection by EOR geotechnical engineer during initial and on-going construction.	Low	Not Significant
Failure of tailings embankment and release of tailings due to overtopping	Discharge of deleterious substances to environment arising from failure to operate the facility within design parameters	Operations	• The embankment has been designed with substantial freeboard. • Detailed procedural and control measures will be co-developed by Owner and the EOR prior to putting facility into operation.	Unlikely	Moderate	High	• Robust design features. • Comprehensive monitoring and control systems included. • Comprehensive operating procedures, QA/QC control measures, and reporting requirements in accordance with MAC guidelines. • Operations subject to internal audits, external audits, and inspections by EOR and Regulatory annually. • Emphasis on training of operating personnel and contracted forces, documentation of all training.	• Annual review by COO of CMC. • Annual audit of operation. • External (independent) audit of operations every 3 years. • Assessment of the facility including consideration of climate change at 5 year intervals. • Operation managed to meet/exceed MAC guidelines. • IERP review of operations. • Emergency Response Plan • Scheduled Dam Safety Reviews	Low	Not significant

Potential Issue of Concern	Potential Effect(s)	Project Phase	Design Measures	Risk Assessment			Rationale	Mitigation / Management	Risk Level	Significance
				Likelihood	Consequence	Confidence				
								in accordance with CDA Guidelines.		
Failure of tailings embankment by overtopping and release of tailings	Discharge of deleterious substances to environment arising from a flood event after operations have ceased and while spillway is being constructed.	Post-closure	• The embankment has been designed in consideration of an appropriate IDF per CDA guidelines for this stage and there are no inflows from operations. Duration of spillway construction will not span more than one spring freshet. • The reclaim water system will remain operational with a modification to the discharge line to allow water to be pumped from the TMF to the pit if required during spillway construction. • No discharge to the receiving environment during transition phase.	Unlikely	High	High	• Embankment raises constructed by a centerline raise construction method as per design result in a stable structure that does not rely on the strength of the deposited tailings solids; selected because of its superior seismic and static stability as compared to upstream construction methods.	• As per the above.	Low	Not significant
Blockage of the spillway (debris, beaver, snow, ice).	Overtopping of the dam leading to failure and loss of tailings.	Post-closure	• Design includes barriers to be installed upstream of spillway to preclude blockage of spillway.	Unlikely	Low	High	• During post-closure period PMF can be contained and routed through the spillway. • Regular surveillance, inspection and maintenance.	• Annual inspections by Owner/EOR and Regulator and per MAC guidelines. • Monitoring of site per closure plan.	Low	Not significant
Failure of tailings embankment and release of tailings	Discharge of deleterious substances to environment arising from flood event	Post-closure	• The embankment has been designed to route a PMF event via the spillway per CDA guidelines.	Unlikely	High	High	• The IDF criteria is per CDA guidelines and the design provides a minimum of 2 m freeboard over the requirement to store or rout the flood event.	• Emergency Response Plan • Scheduled Dam Safety Reviews in accordance with CDA Guidelines. • Annual inspections by Owner/EOR and Regulator and per MAC guidelines. • TMF is assessed every five years including consideration of climate change. • IERP review of design and operations.	Low	Not significant
Failure of HLF embankment and release of leach solution into TMF	Discharge of deleterious substances to the TMF	Operations	• The embankment has been designed to retain a 1 in 100 year flood event. Without discharge to the TMF. • Events pond spillway designed for a 1 in 200 year event. • Appropriate factors of safety for short & long term, 1 in 500 seismic event considered in design.	Unlikely	Low	High	• Robust design features consistent with good practice. • TMF provides secondary containment; no direct discharge to receiving environment. • Maximum volume reporting to the TMF in event of a failure is about 246,000 m3 and is insignificant compared to the TMF storage capacity during operations of 9 Mm3. • Leach solution reporting to the TMF under	• Emergency Response Plan. • Design and operated in accordance with the International Cyanide Code.	Low	Not significant

Potential Issue of Concern	Potential Effect(s)	Project Phase	Design Measures	Risk Assessment			Rationale	Mitigation / Management	Risk Level	Significance
				Likelihood	Consequence	Confidence				
							failure conditions will be rapidly diluted and consumed by water and solids within the TMF. Cyanide is toxic relatively low concentrations but degradable. Any impact will be limited and short.			
PAG tailings mistaken as NAG during construction	ARD and metal leaching in seepage reporting to environment.	Construction, operations	• Monitoring and control measures to characterize ore starting at mine daily production level planning, sampling of drill hole cuttings, in-process monitoring and analysis, sampling and testing at the tailings cyclone facility. • Design provides flexible operation and ability to quickly direct off-specification material directly into the impoundment.	Unlikely	Moderate	High	• Strong geochemistry data base, conservative segregation criteria, operational ARD management plan. On-going testing and monitoring. Seepage collection ditches will capture runoff. • Experience at other operations demonstrates that material control can be consistently maintained.	• Collect and treat affected water. • Comprehensive sampling, testing, and documentation regime to be implemented to demonstrate effectiveness of material quality control and placement.	Low	Not Significant
Unexpected metal leaching from the NAG and overburden.	Leached metals reporting to the environment.	Operations, post-closure	• Surface drainage from TMF is captured by the seepage control system and returned to the TMF. • Sub – surface flow is monitored for water quality by monitoring wells downstream of the seepage collection facility.	Unlikely	Moderate	High	• Significant metal leaching and test work done to date. On-going testing and monitoring including on-site lysimeters. • Seepage collection ditches will capture runoff.	• Collect and treat affected water, provide low permeability cover. • Pump back through monitoring wells as required.	Low	Not Significant
Tailings distribution pipelines failure (bulk NAG tailings, PAG tailings, cyclone sand, cyclone overflow)	Discharge of deleterious substances to environment	Operations	• Bulk NAG, cyclone overflow and PAG tailings will be disposed of in the downstream end of the impoundment. • Discharge will be from valved off-takes located along the main headers of Embankment and from the West Saddle Embankment. • Slurry pipelines will be drained for shutdowns longer than 2 hours to prevent freezing.	Rare	Very Low	High	• PAG tailings will flow by gravity into the TMF; NAG tailings used in embankment construction or discharged to TMF could result in high TSS concentrations and sedimentation in Casino Creek downstream. • Water management pond may intercept NAG tailings.	• Emergency Response Plan. • Spill Contingency Plan. • Bulk NAG tailings will bypass cyclone station and discharge into the impoundment in the event of issues with underflow transport or deposition.	Non-actionable	Not significant
TMF seepage collection failure	Discharge of deleterious substances to environment	Operations, post-closure	• Seepage water losses from the TMF are collected in seepage collection systems constructed downstream of the embankments. The seepage is collected and pumped back into the TMF. • 20m wide low permeability core located in the Main Embankment is surrounded by filter and transition zones constructed from crushed and screened rock; the filter and transition zones function in the	Possible	Low	High	• The NAG tailings provide a low permeability zone downstream of the PAG tailings and the coarse waste rock in the waste storage area. • The NAG beach above water will function as a seepage control measure by keeping the pond at a distance from the dam crest. • Monitoring wells are installed downstream of the collection system; if there is indication of contaminated water flow this early detection will allow remedial action to be taken.	• Emergency Response Plan. • Spill Contingency Plan. • Pump back through monitoring wells as required.	Low	Not significant

Potential Issue of Concern	Potential Effect(s)	Project Phase	Design Measures	Risk Assessment			Rationale	Mitigation / Management	Risk Level	Significance
				Likelihood	Consequence	Confidence				
			prevention of piping and migration of fines, and act as drains. • The seepage collection system remains in operations until the wetlands treatment results in water quality that meets the discharge requirements.							
Greater than predicted seepage volumes	Unacceptable water quality in the receiver.	Operations, post-closure	• Per the above.	Possible	Low	High	• Seepage collection system in place. • Additional groundwater modelling being undertaken. • Additional tailings characterization being undertaken. • Monitoring programs.	• Groundwater recovery systems. • In situ groundwater treatment.	Low	Not Significant
Drought and/or dusting	Cannot maintain tailings water cover resulting in acid generation from the reactive tailings and waste rock affecting downstream water quality.	Post-closure		Unlikely	Low	High	• Waste rock is covered by layer of tailings. Tailings have some buffering capacity so the drought would have to be multi-year. In the long term sediments and organics will cover the tailings further limiting oxygen infiltration.	• Divert water or flows onto the tailings. • Improve the cover.	Low	Not Significant
Failure of Waste Storage Area	Minimal effect as storage is fully contained within TMF	Construction, operations, post-closure	• Contained within TMF pond.	Unlikely	Very Low	High	• Small height difference between tailings and waste rock during construction to increase stability.	• Fully contained within TMF.	Low	Not significant
Rupture of reclaim water line	Discharge of deleterious substances to environment (erosion causing sedimentation)	Operations	• Contained within the TMF pond.	Possible	Very Low	High	• Water discharged from a ruptured pipeline would report to the TMF.	• Sediment and Erosion Control Plan. • Emergency Response Plan. • Spill Contingency Plan.	Low	Not significant
Failure of wetlands treatment systems	Discharge of deleterious substances to the environment	Post-closure	• The wetlands treatment facility is established during operations and fully developed before closure.	Possible	Low	Moderate	• Limited experience with comparable facilities in this climate regime. On-going study and test work to develop design and operating parameters.	• Water treatment technologies can be applied until passive wetland treatment is demonstrated to be effective and reliable.	Low	Not significant

B.4.3.2.2 R2-5

R2-5. Describe the involvement of independent professional engineers in: the ongoing review of monitoring data; the evaluation of site infrastructure performance with respect to design parameters; and any necessary adaptive response measures.

Engineer of Record

As described in Section B.4.2.2.1, and shown in Figure B.4.2-1, the Engineer of Record (EOR) is integral to all aspects of design, construction, operation and closure of all major facilities at the Casino Project. Ongoing site investigations, process data, monitoring data, technical reports, comments and requirements from regulators and First Nation governments, outcomes from IERP reviews, feedback from field conditions, etc. are all accounted for in inputs to the advancement of detailed engineering design and ongoing quality assurance/quality control processes conducted by the EOR.

Internal and Independent Audit Process

CMC will conduct internal audits of the operations, performance, QA/QC program, and change control management for project facilities. Periodically, an independent audit of the operation will be conducted which will include, among others, a review of the internal audit program. Analysis of the information provided by the independent audits may provide valuable insights into opportunities to enhance the operation of the facilities. The independent audit results will be made available to the EOR.

Additionally, periodically (approximately every 5 years) the facilities will undergo an assessment by CMC, the EOR, and the IERP. This assessment will review the current design basis and operating practice, performance to-date, current state of best available technologies and practices, advances in technology relevant to the facility design & operation, changes in the community and environment, and effects or anticipated effects of climate change. The assessment will result in a report that recommends specific actions that need to be actioned for sustained operation of the TMF. The results of the independent audit and the 5 year assessment will be made available to the IERP for review and feedback, as will any other documentation the IERP requires to complete its review. Significant changes to the design or operating procedures must be conveyed to the IERP and any outcomes from the IERP must be addressed and documented.

Regulatory Oversight

CMC will comply with all requirements of permits and licences issued to the Project. CMC will provide Regulators documentation on approved (by EOR) changes, as required by licences and permits, and as requested. The results of the 5 year assessment will be filed with Regulators and any significant changes to the design and operation of the facility will be subject to approval.

B.4.4 FEASIBILITY OF THE SULPHIDES REMOVAL PROCESS

B.4.4.1 R2-6

R2-6. Information on the feasibility and limitations of using “on-stream analyzers” on a continuous basis to monitor sulphur removal from the NAG tailings stream.

On-stream analyzers are used to support the de-pyritization process through which sulphide is removed from the rougher tailings stream. On-stream analyzers are installed at strategic points in the processing plant to collect

data from the various plant input and output streams to inform operations personnel on plant performance, allowing them to manage the facilities efficiently and effectively. On-stream analyzers provide information for many purposes, including measuring metallurgical balance. The on-stream analyzer on the tailing stream monitor the tailings composition going out to the TMF.

On-stream analyzers are conventional, well-proven technology commonly used in modern concentrators such as Los Pelambres (Chile – 160,000 tpd), Collahuasi (Chile – 150,000 tpd), Penasquito (Mexico - 100,000 tpd), Thompson Creek (Idaho – 28,000 tpd), and many others. On-stream analyzers are part of a broader monitoring and control process used to monitor and manage the quality of the NAG tailings reporting to the cyclone station. Other measures include:

- Mine production planning and scheduling documents that characterize the ore to be fed to the coarse ore stockpile ahead of the processing facility;
- Sampling of the drill cuttings prior to blasting of a bench so that the ore can be tested in advance of processing for total sulfur and total carbon and the neutralization potential ratio (NPR) can be determined to ensure the material meets specification for use in dam construction;
- The tailings stream at the cyclone plant is assayed multiple times per day to confirm the material is NAG and suitable for dam construction; and
- Tests to confirm the tailings coarse fraction meets the specified size distribution criteria.

The use on-stream analyzers as part of a complete monitoring and control process is standard conventional practice at similar processing facilities around the world. CMC's detailed process to ensure effective sulphide removal will be developed during the design phase of the project and will be detailed in the Mill Development and Operations Plan, the Tailings Management Plan and the Heap Leach and Process Facilities Plan required for mine construction and operation under the Quartz Mining Act, following the issuance of a Water Use Licence (Yukon Government, 2013).

B.4.4.2 R2-7

R2-7. Discussion on the implications related to the estimate that 25 percent of the processed supergene ore would produce non-PAG rougher tailings.

The amount of supergene (oxide and sulphide) tailings used to produce cyclone sand for the construction of the tailings impoundment embankment has no significant implications the construction of the TMF.

The estimated amount of cyclone sand required for embankment construction is 134 Mm^3, or 221 Mt at 1.65 t/m^3 (Table 5.5 of TMF Design Report Appendix A.4D). The amount of cyclone sand that can be generated from the hypogene ore is projected to be 217 Mt, representing 98% of the total required material. This is just 4 Mt short of the total requirements for dam construction. Some limited amount of NAG tailings may need to be produced from the supergene ore. Any remaining shortfall would be supplemented with NAG rockfill borrow material. The project proposal states that based on analysis of the composition of the supergene ore, and test work conducted to date, approximately 25% of this material, after sulphide removal, would meet the criteria for NAG material for dam construction purposes. However, as per the above, only 5% of the 316 Mt of supergene ore would be needed to produce the additional 4 Mt of sand required for dam construction. The basis for these assumptions is summarized in Table B.4.4-1.

Table B.4.4-1 Assumptions – Cyclone Sand Production Generated from Hypogene Ore

Total hypogene ore milled	649Mt
Recovery rate of cyclone sand from NAG tailings	50%
Cyclone sand production limited to 9 months a year by inclement weather	75%
Cyclone sand plant operational availability	90%
Amount of ore not reporting as concentrate	99%
Total estimated cyclone sand generated from hypogene ore	217Mt

In addition, there are a number of assumptions in the design basis that are appropriately conservative for the project's stage of development in relation to the production of coarse sands. There is additional potential to exceed the design basis assumptions for annual sands production. Should any of the criteria noted below exceed the estimates, the cyclone sand for construction could be met solely through the processing of hypogene ore.

The design basis assumes coarse sands for dam construction is produced for the equivalent of nine months of the year (75%). The equivalent of three months of production is assumed to be lost with the tailings diverted to the impoundment due to inclement weather (i.e. cold weather). Experience at other operations has demonstrated that coarse tailings can be placed and compacted to specification at temperatures down to -40°C (Martin, 2011). The estimated number of days that the Casino site might be expected to see the daily minimum temperature to fall to a more conservative threshold for operations of -30°C is about 40-50 days per year (86%). Should coarse sands production be suspended for only 50 days per year, as opposed to the projected three months, the estimated cyclone sand produced from hypogene ore increases to 250 Mt, well in excess of the design requirements.

The cyclone plant utilization assumed in the design basis is 90 % while experience at other operations has shown that utilization greater than 92% is achievable. Should this prove to be the case at Casino, the estimated coarse sand production from hypogene ore is 222 Mt, meeting the design requirement for 221 Mt.

Finally, the design basis limits the percentage of fines in the cyclone underflow product to 12%. With additional testing and experience in operations there is the potential to raise the allowable fines content to about 15%, thereby increasing the mass of sands available for dam construction.

The amount of supergene ore tailings appropriate for dam construction is not a significant factor to the total material required to build the dam embankment. The amount of cyclone sand generated from hypogene ore should provide 98% of the material (217 Mt) for the construction of the embankment. The remaining 4 Mt of material will be obtained through a combination of appropriate supergene tailings, borrow material, and/or exceeding projected operating parameters.

B.4.5 ROADS, SUPPLY ROUTES AND TRANSPORTATION

B.4.5.1 Freegold Road Extension and Upgrade

B.4.5.1.1 R2-8

R2-8. One of the following:
a. Responses to previous Adequacy Review Report requests as they relate to the Freegold Road upgrade and Carmacks by-pass:

- **R13 and R14 (in relation to the camp for the upgrade),**
- **R18 (including safety, wildlife, and maintenance),**
- **R27 (in relation to traffic in Carmacks and the by-pass)**
- **R297 (in relation to clear span bridges for the upgrade)**
- **R298 (in relation to decommissioning of abandoned structures along the alignment)**
- **R299 (in relation to the Nordenskiold River bridge and pier)**
- **R300 (in relation to available habitat at the Nordenskiold River bridge)**
- **R410 (in relation to a cabin near the project footprint),**

or,
b. A modified project proposal that excludes the Freegold Road upgrade and Carmacks by-pass but includes a revised description of activities, transportation plan, and effects assessment.

Responses to requests R13, R14, R18, R27, R297, R298, R299, R300 and R410 as they relate to the Freegold Road upgrade and Carmacks by-pass are provided below.

R13. Detailed description of the temporary construction camp including:
a. layout of infrastructure such as camp facilities, generators, sewage disposal system, fuel storage, and generators;
b. proximity to surface water;
c. human-wildlife conflict prevention; and
d. fuel storage requirements and capacity of diesel generators.

It is expected that the construction of the Carmacks by-pass, Nordenskiold Bridge and Freegold Road upgrade will be completed by the Yukon Government, Department of Highways and Public Works (HPW). Contractors working on HPW projects have the option of making arrangements with private individuals for the establishment of temporary work camps, or making use of commercial operations or businesses. Alternatively contactors can establish work camps at sites identified by HPW as suitable camp locations.

A conceptual-level description of the temporary construction camp follows:

a. *Camp infrastructure*: Typical work camps can consist of a kitchen and wash-up trailer and possibly 8 - 12 ATCO type trailers to be used for living quarters, laundry and offices. Larger work camps of 40 to 50 people may require upwards of 15 to 20 ATCO trailers. Alternatively, workers and project staff may use self-contained RV units or travel trailers, that are supplemented by ATCO trailers that serve as office,

laundry, wash-up and eating facilities. Dependent upon how the upgrade of the Freegold Road and the by-pass work is undertaken, and the location of the work, there will likely be the need for multiple camp locations for the duration of the work. Typically HPW work camps are located in existing or abandoned gravel pits; these are well-drained, level sites that offer sufficient room for camp set-up, possible storage of equipment and if necessary, allow for the easy installation of wells and septic leach fields. Specific camp locations have yet to be determined

b. *Proximity to surface water:* Installation of a well or water purification system for camp water must follow the Guidelines for Drinking Water Systems from YG Environmental Health Services. The contractor may choose to have a septic pump-out system, or install a septic leach field. A sewage disposal system will be installed and used in accordance with the Yukon Sewage Disposal Systems Regulation and a permit will be obtained from YG Environmental Health Services.

c. *Human-wildlife conflict prevention:* Camps will be laid out and operated following the "Guidelines for Industrial Activity in Bear Country", Yukon Environment. Bear deterrents such as air horns and whistles will be kept on-site. Feeding of wildlife is prohibited. The camp will be kept clean and free of any domestic waste that may attract wildlife. Camp related waste will be disposed of at an approved dump site or incinerated on a regular basis. The camp will be entirely decommissioned after the project is complete.

d. *Fuel storage:* The temporary work camp locations may also include a service, maintenance and an equipment and fuel storage area. Routine maintenance and servicing will be carried out within a designated area on an impermeable liner that is either manufactured or made of natural material. If a liner is created using existing soils it will have a permeability of <1x10-6 cm/s. At the end of the project any soil on the liner will be treated as potentially contaminated and dealt with in accordance with the Yukon Contaminated Site Regulations. Used oil and lubricants may be stored, but will be disposed at the end of the project in accordance with the applicable regulations.

   For fuel storage, contractors typically use double-walled tanks. If double walled tanks are not used, a dyke will be constructed around each stationary fuel container or group of stationary fuel containers where any one container has a capacity exceeding 4,000 litres. The dyke will have a capacity 10% greater than that of the largest storage container within it. Any contaminated (rain/snow) water generated within the dyke will be captured/pumped out on a regular basis and stored in capped containers of an appropriate size. Contents of these containers will then be disposed of on a regular basis, at an approved facility and in accordance with relevant regulations. All refuelling of equipment will occur over drip pans or drip trays; any contaminated or waste water within these trays will be disposed of as stated above, on a regular basis. Fuelling within 30 m of a waterway will only occur with the express permission of the project engineer. HPW Oil and Fuel Best Management Practices will be followed.

   HPW also requires all contractors to submit an Environmental Management Plan (EMP) for its operations and undertaking of all Project related activities. This plan includes details on the storage, handling, and disposal of materials used in the course site activities, site management, waste management, sediment and erosion control, and emergency response protocols. This plan will include a Spill Prevention & Contingency Plan with Oil & Fuel Best Management Practices.

Any temporary construction camps will comply with, and acquire permits for, as necessary, all Yukon and Federal Acts and regulations as they apply to the construction and operation of camp facilities, including those summarized in Table B.4.5-1 (repeat of Table A.4.6-1).

Table B.4.5-1 Required Permits for Construction and Operation of Temporary Construction Camps

Legislation		Permit/License	Requirement	Government Agency
Building Standards Act		Building Permit	Occupancy permit for construction of buildings outside of a municipality	Community Services, Building Safety
***Environment Act* Consolidated Permit**	*Environment Act, Air Emissions Regulation*	Air Emissions Permit	Release of air pollutants	Yukon Environment, Environmental Programs
	Environment Act, Special Waste Regulation	Special Waste Permit	Handling, disposal, generation or storage of special (hazardous) wastes	
	Environment Act, Storage Tank Regulation	Storage Tanks Systems Permit	Storage and handling of petroleum products	Community Services, Protective Services, Fire Marshal's Office
		Application for Operation, Closure, Abandonment or Renovations to Storage Tanks	Use of storage tanks containing petroleum and allied petroleum products	
Public Health and Safety Act		Permit to Install a Sewage Disposal System	Installation and operation of construction phase septic tanks and sewage holding tanks	Yukon Health and Social Services
Waters Act		Notice to Use Water Without a License or Type "B" water license if more than 300 cubic metres per day is required	Water use	Yukon Water Board

R14. Detailed description of activities required for construction of camp including:
a. site preparation such as clearing, grubbing, and disposal of materials;
b. construction material volumes and sources (e.g. granular material requirements); and
c. anticipated timing and duration of the proposed activities.

As indicated in response R13, contractors for the Freegold Upgrade work could establish temporary work camps on private land or at a site identified by HPW or make alternative arrangements with private individuals or commercial businesses. Typical camp locations for HPW projects are in gravel pits near the project site, or on flat and level crown land either in the right of way (RoW) of the Freegold Road or adjacent to the RoW. These sites are often disturbed (e.g. limited vegetation) and offer well-drained level locations for camp set-up and the establishment of wells/septic facilities if required. For camp establishment, the following guidelines as well as the response to R13 above, will apply:

a. *Site Preparation:* Site preparation will be kept to a minimum as the facilities are temporary and designed to be easily transported, erected and dismantled. Camp preparation will consist of clearing trees and brush from the area but little or no grubbing is expected to be necessary. Cleared material will be disposed of by burning.

b. *Construction Material:* Wherever possible the fill material will be native unprocessed material from a local borrow pit. Camp sites are graded to promote the natural drainage of water and prevent inundation of the camp site during periods of high runoff (e.g. during freshet). Drainage channels may be constructed to direct water into natural drainages. Imported granular fill will be used in areas of traffic to provide a suitable driving surface for construction vehicles and heavy equipment.

c. Timing and Duration: If camps are required, and dependent upon the work schedule for the Freegold Road upgrade and the Carmacks by-pass, camp construction will be one of the earliest construction activities. Some adjustments may be required to accommodate weather conditions; mobilizing equipment and facilities in winter months provides a solid ground on which to transport goods but performing earthworks at this time of year would not be practical. Establishment of a camp such as this should take no longer than a couple of weeks under ideal conditions; it may be more of a progressive exercise depending on the weather conditions.

Following the completion of access construction activities, the camp will be decommissioned, and all structures, equipment, and facilities will be removed.

R18. A detailed Road Management Plan for the entire Freegold Road. Specific details for the Freegold Road extension should include:
a. description of what other users will have access to the Freegold Road extension; and
b. description of the legal instruments and measures that will be implemented to control access to the Freegold Road extension.

A detailed Road Use Plan will be the outcome of further discussions with Little Salmon Carmacks First Nation, Selkirk First Nation and Yukon Government. CMC expects this to be a regulatory requirement pursuant to the *Territorial Lands (Yukon) Act* and the Quartz Mining License. The Road Use Plan has been updated and is attached in Appendix A.22E. A detailed description of other users of the road will be determined in further discussions with First Nations and Yukon Government and be reflected in the final Plan and cannot be determined at this time.

The Highways Act currently regulates and governs the Freegold Road from km 0 to km 83 (Big Creek) and will continue to do so once the upgrades are complete; this section of the road is considered a public road and open to the general public for use.

a. The principle regarding user access to the Freegold Road is that local use as it exists now will continue.

i. Industrial activities are subject to licensing which includes review by YESAB for projects beyond the scope of this review;

ii. Traditional Use is protected under land claims agreements and is expected to continue.

iii. CMC does not propose access to the Freegold Road by new users and as such, is beyond the scope of the Project.

b. The legal instruments are identified in Section 2 of the Road Use Plan. Further details are provided below:

Yukon Government

Territorial lands in the Yukon are administered by the Ministry of Energy, Mines and Resources pursuant to the Territorial Lands (Yukon) Act, SY 2003, c. 17. Section 6 states:

"Subject to this Act, the Commissioner in Executive Council may authorize the sale, lease, or other disposition of territorial lands and may make regulations authorizing the Minister to sell, lease, or otherwise dispose of territorial lands subject to such limitations and conditions as the Commissioner in Executive Council may prescribe."

Yukon Government is working towards developing a new regulation pursuant to the *Territorial Lands (Yukon) Act*. The intent is to manage the construction, operation and maintenance and finally decommissioning and reclamation of access road over the life of the project.

The new regulation is expected to address 6 key issues that are missing in the current regulations:

- Ability to tie the life of the permit to the life of the main project;
- Provide for appropriate security consistent with other policy direction (i.e. mine site reclamation policy);
- Ensure that resource roads do not become public;
- Ensure decommissioning plans are developed;
- Provide compliance and enforcement tools for road management; and
- Ability to manage and restrict access.

It is also expected to include an ability to authorize multiple permit holders and facilitate agreements for multi-use as may be allowed under a management plan.

Yukon Government Highways and Public Works released a document titled *Resource Access Road Framework* (2013). The Framework outlines the "goals and principles that guide decisions around the development and management of resource access roads". Resource Access Roads are defined as "all routes needed by industry to access their properties and move their product to market." The Proposed Freegold Road Extension will be a Mine Haul Road, defined as:

"A new road built to a haul/industrial standard that meets vehicle and employee safety standards and is used to transport minerals from a developed mine or for re-supply and movement of people and goods to and from the mine site. In most cases, mine haul roads connect to a publicly maintained existing road network" (Yukon Government, 2013).

First Nations Governments

Little Salmon Carmacks First Nation (LSCFN) and Selkirk First Nation (SFN) were established in 1997 through Settlement Legislation in Canada and the Yukon that gives effect to their final agreements. LSCFN and SFN are responsible for their settlement lands and resource management on these lands. Under their Self-Government Agreements, LSCFN and SFN have the legislative powers to manage, administer and control the right or benefits of persons enrolled under their final agreements. SFN has established a Constitution for the purpose of protection of its settlement lands and resources, and governing the rights of its citizens on these lands. LSCFN has not established legislation for the management and administration of settlement lands

The statutory authority to enter into an Access Agreement for SFN and LSCFN comes from the *Yukon First Nations Self-Government Act (Self-Government Act).* This is a federal statute that establishes as legal entities those First Nations that are listed in the Act (because they have settled land claims). Both First Nations are listed in the Self-Government Act and have the powers granted under that Act which include law-making authority in relation to their respective Settlement Lands.

Specifically in relation to settlement land, each of the SFN and LSCFN have the authority under s. 11(1) and s. 1 of Part III of the Self-Government Act to enact laws in relation to, among other things, the "use, management, administration, control and protection of settlement land". There are similar provisions in the Final Agreement for each of the SFN and the LSCFN.

Co-Management Structure

As noted above, First Nations governments have the statutory authority to enact laws and enter into agreements with respect to settlement lands and impose conditions, including a requirement for a management plan.

Yukon Government has the statutory authority to impose license terms and conditions for the access road on Crown lands including a requirement for a management plan. The intent is for the Yukon Government to exercise this authority with due regard to First Nations rights and interests with respect to their Traditional Territories, and responsibilities for co-management or management of renewable resources under the land claims agreements.

The Freegold Road Upgrade includes one option that would see some sections of the road impact LSCFN Settlement Land outside of the right-of-way designated in the LSCFN Final Land Claim Agreement. If this option is confirmed in final design, and accepted by LSCFN, then they would become a Decision Body for the project under the YESAA and the ability to exercise their statutory authority.

The Freegold Road Extension includes a proposal that would see one section cross SFN Settlement Land. Casino Mining Corporation has submitted an application to SFN for an access agreement to cross these settlement lands.

While the proposal provides for each government to exercise their statutory authority without being fettered, the objective is to work towards consensus acceptable to all governments and provide for operational requirements for the mine. Essentially co-management between the governments is required between SFN Government, LSCFN Government and Yukon Government.

Yukon Government Department of Energy, Mines and Resources released a Resource Access Road Regulation Discussion Paper in 2014 (Yukon Government, 2014). The discussion paper outlines the scope of new regulatory authorities proposed by the Yukon Government that would apply to the proposed Freegold Road Extension.

The legal instrument currently in place to manage the Freegold Road Extension is through a long-term surface lease and land use permit pursuant to the *Territorial Lands (Yukon) Act*, and agreement with Selkirk First Nation pursuant to Selkirk's internal land use approval process. In the absence of new legislation as proposed by Yukon Government, CMC would seek to license the construction and operation of the road through these existing legal instruments - a long-term lease and land use permit as identified in the proposed Land Use Plan. The long term management of the road would be done through a lease or license. Once a road is built through a land use permit, the lease/license would be the guiding legal instrument and can include authority for maintenance needs or minor realignments.

There are active discussions between CMC and Little Salmon Carmacks First Nation to determine an appropriate approach to authorizing use of that First Nation's settlement lands for the purposes of upgrading the existing Freegold Road.

R27. A traffic management plan for routing traffic through Carmacks prior to the completion of the Carmacks by-pass. Details should include:

a. route through Carmacks;
b timing of transportation activities (e.g. daily, weekly and monthly restrictions);
c. safety of residents with particular focus given to routes with no pedestrian sidewalks;
d. communication with residents within community; and
e. congestion aversion.

As more fully described in the Freegold Road Report (Appendix 4B), the Carmacks by-pass road and bridge over the Nordenskiold River will be completed as preconstruction activities to provide a suitable access route for construction traffic and deliveries of fuel, supplies, and equipment, to avoid traveling through the Village of Carmacks at the earliest possible time.

The by-pass construction would likely be one of the first construction activities completed, and could be completed over the course of one construction season. Therefore, the effects of subsequent construction traffic through Camacks will be negligible, and will be limited to the single construction season when the by-pass is not yet available for use.

a. *Route through Carmacks:* During the construction of the by-pass, the proposed access route for vehicles requiring access to the Freegold Road is outlined in Figure B.4.5-1 and consists of a turn onto Freegold Road from Highway 2, then a left turn onto River Road, which turns into the Freegold Road. The route was chosen as it is the current route for traffic traveling through Carmacks to access the Freegold Road and it minimizes traffic near the school and recreation centre.

b. *Timing of transportation activities:* The timing of the traffic will be during the day only, to minimize disturbance to residents, however, will be 7 days per week, to maximize the construction of the road during the snow-free season. The bypass is expected to be complete by the fall of the year in which the construction began.

c. *Safety of residents:* The additional traffic and its related effects on the town of Carmacks during the by-pass construction is expected to be negligible due to the small number of additional vehicles (4), the chosen route minimizes traffic near the school and recreational centre, vehicles will only travel during the day and road use will be communicated to residents by CMC and the Yukon Government Department of Highways and Public Works (HPW). Vehicles will also comply with all standards and guidelines established in the Traffic Management and Road Use Plans and with local speed limits.

d. *Communication with residents:* As the route will be constructed by the HPW, communication will be closely connected between HPW, the Village of Carmacks, CMC and the construction contractor.

e. *Congestion aversion:* As outlined in Table A.4.4-1, annual average daily traffic is estimated to be 3 “heavy” vehicles and 1 “light” vehicle, for a total of 4 extra vehicles per day. The effect of this traffic on the town of Carmacks is expected to be negligible, and vehicles will comply with all standards and guidelines established in the Traffic Management and Road Use Plans and with local speed limits. The route was selected to minimize traffic near the school and recreational centre.

Figure B.4.5-1 Carmacks By-Pass Route Showing Temporary Route Through Carmacks

R297. Clarification of whether clear-span bridges are proposed for all fish-bearing watercourses. If culverts will be installed on some fish-bearing creeks, please provide rationale, mitigations, and incorporate habitat losses into the habitat compensation plan.

There are 20 crossings along the Freegold Road upgrade that have been identified as being fish bearing (Appendix 10B - Freegold Road Baseline Aquatic Report). Of those, 4 bridge designs have been provided in the Freegold Road Report (Appendix 4B). Two options are proposed for crossing fish bearing streams: short span bridges, and CSP flush passable culverts.

Selection Criteria and Rationale

Short-span bridges are the preferred alternative; however, selection of the appropriate crossing option will be based on site conditions, environmental and fisheries requirements, geotechnical considerations, constructability, schedule and cost. For example, it is expected that culverts will be selected where the proposed road geometry such as high fills or sharp curves would require a longer bridge. Detailed stream crossing evaluations and site specific designs will be completed during the detailed design phase of the Project.

Culvert Installation and Impact Mitigation

The installation of culverts will follow the general best management practices and standard project considerations as outlined by the Province of British Columbia (BC) and Fisheries and Oceans Canada (DFO) for instream works (BC & DFO, 2015a), which include:

- Consultation with a Qualified Professional (QP) or team of professionals;
- Continued monitoring of the project, including an environmental monitor;
- Consider regional timing windows for fish or species at risk and nesting birds, avoid in-channel works in the presence of species at risk and incorporate weather considerations to minimize impacts from sedimentation;
- Prevent the release of silt, sediment or other contaminants;
- Isolate the work area appropriately;
- Complete and fish and amphibian salvage before the start of works;
- Implement erosion and sediment control measures throughout the project;
- Minimize impacts to vegetated areas;
- Restore the site appropriately; and
- Operate temporary diversion systems (e.g., conduits, coffer dams, ditches), in consideration of the best management practices for those systems.

Additionally, removal of culverts will be conducted in accordance with the BC and DFO Standards and Practices for Instream Works – Culverts (BC & DFO, 2015b), including:

- Adequate rip rap or wing walls to protect the road embankment and stream channel from erosion;
- Prevent eroding inlets and outlets through rip rap amoring;
- Materials placed within the average high water mark must be free of silt, overburden or debris; and

- Use proper erosion and sediment control measures to protect exposed areas of the stream channel and culvert.

Details on how site assessments by Qualified Professionals are conducted, and how subsequent recommendations are implemented to comply with the requirements of the *Fisheries Act* are provided in the response to R2-141.

Environmental performance during construction is monitored as part of the project inspection regime. Ongoing monitoring is done as per any permit condition requiring it. The level of monitoring changes and is driven by the permit/licence. All large multiplates >2m and bridges are inspected every two years as part of the HPW bridge/culvert management program.

Habitat Compensation Considerations

Any fish-bearing crossings requiring culverts will be designed to ensure fish passage and habitat losses will be assessed and offset accordingly, in accordance with the *Fisheries Act*.

R298. Details on existing crossing structures no longer used for portions of the Freegold Road upgrade once the road is re-aligned.

The Freegold Road upgrade includes 9 minor stream crossings which will require upgrade or relocation (Appendix 4B - Freegold Road Report). For those crossings that will no longer be required as part of the Freegold Road, CMC will remove the crossing structures and restore the sites.

The removal of the culverts will follow the general best management practices and standard project considerations as outlined by the Province of British Columbia (BC) and Fisheries and Oceans Canada (DFO) for Instream Works (BC & DFO, 2015a), and may include the following:

- Consultation with a Qualified Professional (QP) or team of professionals;
- Continued monitoring of the project, including an environmental monitor;
- Consider regional timing windows for fish or species at risk and nesting birds, avoid in-channel works in the presence of species at risk and incorporate weather considerations to minimize impacts from sedimentation;
- Prevent the release of silt, sediment or other contaminants;
- Isolate the work area appropriately;
- Complete and fish and amphibian salvage before the start of works;
- Implement erosion and sediment control measures throughout the project;
- Minimize impacts to vegetated areas;
- Restore the site appropriately; and
- Operate temporary diversion systems (e.g., conduits, coffer dams, ditches), in consideration of the best management practices for those systems.

Additionally, removal of culverts will be conducted in accordance with the BC and DFO Standards and Practices for Instream Works – Culverts (BC & DFO, 2015b), including:

- Leaving cribbing structures in place if stable and if integrated into the stream banks, unless the cribbing structure constricts the watercourse;
- Isolation of the work area, if required, from flowing water in a manner that does not cut off flow to downstream portions of the stream;
- Removal of structures to a suitable upland disposal site away from the riparian area to ensure materials don't re-enter the watercourse;
- Restoration of the banks to original conditions, where possible;
- Maintain effective erosion and sediment control measures until complete re-vegetation of disturbed areas is achieved.

All required permits will be obtained from DFO, as required to complete the decommissioning of structures along the Freegold Road. Details on how site assessments by Qualified Professionals are conducted, and how subsequent recommendations are implemented to comply with the requirements of the Fisheries Act are provided in the response to R2-141.

R299. Details on when and how the Nordenskiold River bridge pier will be constructed.

Timing

The Carmacks by-pass road and bridge over the Nordenskiold River will be completed as preconstruction activities to provide a suitable access route for construction traffic and deliveries of fuel, supplies, and equipment, to avoid traveling through the Village of Carmacks at the earliest possible time. The by-pass construction would likely be one of the first construction activities completed, and could be completed over the course of one construction season.

Design

As detailed in the Freegold Road Report (Appendix 4B), a detailed site survey of the Nordenskiold River crossing was completed in June 2013. A hydro-technical analysis of the crossing was carried out to establish the bridge height and required hydraulic opening. A bridge concept was then developed based on the site conditions, road geometry, geotechnical conditions, and environmental considerations. The proposed Nordenskiold Bridge is a single lane bridge, with steel girders and precast concrete deck panels. Pullouts are provided at each approach to allow for the safe passing of vehicles. The bridge will have two spans with a pier located in the river channel. Two metres of freeboard above the 1 in 100 year flow elevation is provided to allow clearance of debris during a flood event. Rip Rap is required at the bridge abutments to provide scour protection. Bridge foundations are assumed to be steel pipe piles and precast concrete pile caps with the steel girders secured to the pile caps. The preliminary design drawings for the Nordenskiold River bridge were provided in Appendix F of the Freegold Road Report (Appendix 4B), and are re-provided below, however, are contingent on approval of the final design HPW.

WESTERN COPPER AND GOLD CORPORATION

CASINO MINE ACCESS

DRAWING LIST			
DRAWING NUMBER	DESCRIPTION	REV.	DATE
20092374-23-3-101	GENERAL ARRANGEMENT	0	2013/09/12
20092374-23-3-102	SITE PLAN	0	2013/09/12

REFERENCE DRAWING LIST			
DRAWING NUMBER	DESCRIPTION	REV.	DATE
20092374-02-3-110	GENERAL NOTES - SHEET 1	0	2011/08/12
20092374-02-3-111	GENERAL NOTES - SHEET 2	0	2011/08/12

NORDENSKIOLD RIVER BRIDGE
NORDENSKIOLD RIVER

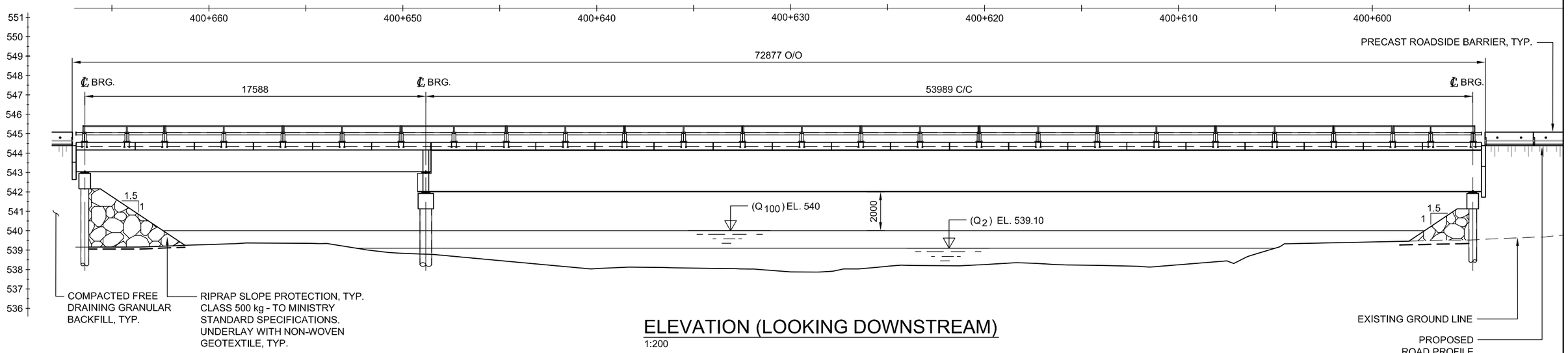
AE Project Number: 20092374-23

Associated Engineering

GLOBAL PERSPECTIVE.
LOCAL FOCUS.

DRAWING NUMBER	REV. NO.	SHEET
20092374-23-3-100	0	- / -

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



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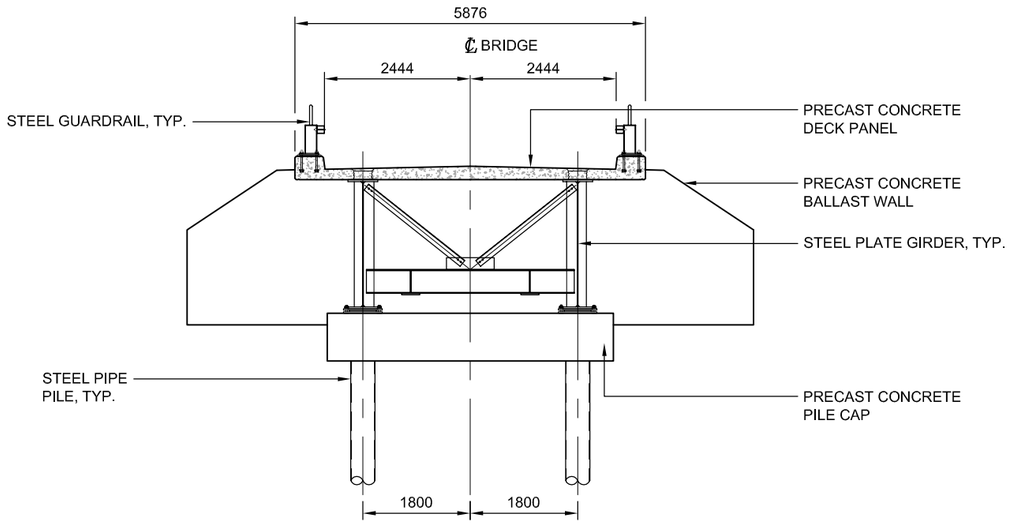

TYPICAL ABUTMENT ELEVATION
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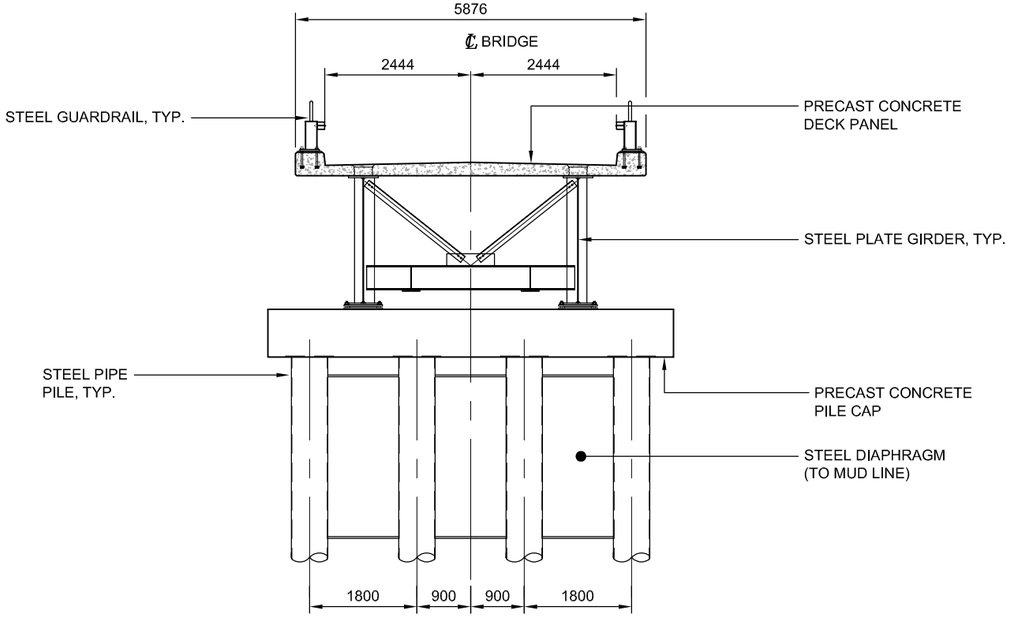

TYPICAL PIER ELEVATION
1:100

NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

western COPPER AND GOLD

PRELIMINARY NOT FOR CONSTRUCTION

DRAFT

Associated Engineering

PROJECT No.	20092374-23		
SCALE	AS SHOWN		
DRAWN	MATTHEW BOWEN		2013/09/12
DESIGNED	MATTHEW BOWEN		2013/09/12
CHECKED	RAY KORPELA		
APPROVED			
DATE		INITIAL	

WESTERN COPPER AND GOLD CORPORATION

GENERAL ARRANGEMENT

NORDENSKIOLD RIVER BRIDGE

NORDENSKIOLD RIVER

DRAWING NUMBER	REV. NO.	SHEET
20092374-23-3-101	0	

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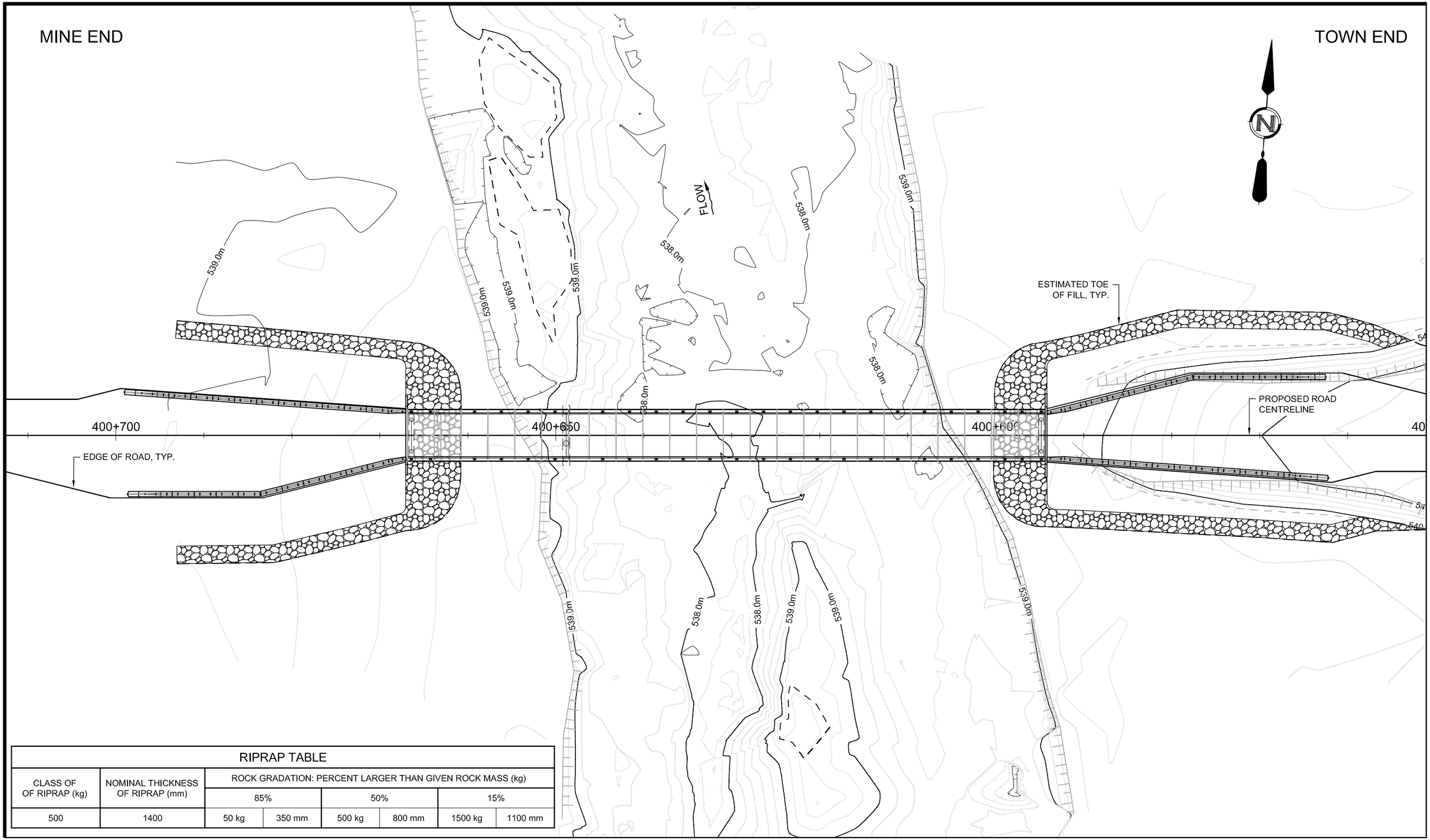
DATE: 13/09/2013 10:19:54 AM, Matthew Bowen

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



RIPRAP TABLE							
CLASS OF OF RIPRAP (kg)	NOMINAL THICKNESS OF RIPRAP (mm)	ROCK GRADATION: PERCENT LARGER THAN GIVEN ROCK MASS (kg)					
		85%		50%		15%	
500	1400	50 kg	350 mm	500 kg	800 mm	1500 kg	1100 mm

NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

western COPPER AND GOLD

PRELIMINARY NOT FOR CONSTRUCTION

DRAFT

Associated Engineering

PROJECT No.	20092374-02		
SCALE	1:400		
DRAWN	MATTHEW BOWEN		2031/09/12
DESIGNED	MATTHEW BOWEN		2013/09/12
CHECKED	RAY KORPELA		
APPROVED			
DATE		INITIAL	

WESTERN COPPER AND GOLD CORPORATION

SITE PLAN

NORDENSKIOLD RIVER BRIDGE

NORDENSKIOLD RIVER

DRAWING NUMBER	REV. NO.	SHEET
20092374-23-3-102	0	

R300. The quality and type of fish habitat (e.g. highly suitable spawning and/or rearing habitat, confirmed spawning habitat, and migratory channel) potentially affected by the Nordenskiold River bridge. Discussion should include identification of potential effects of the bridge and the pier, focusing on potential long-term morphological changes to the river in contrast to natural morphological changes.

The pier is expected to cause very localized and minor changes in morphology, with no adverse effects on fish habitat or fisheries productivity. The pier's only anticipated effect is a deep, yet small pool formed and maintained on the east and downstream side of the pier, which may be attractive to fish species seeking deep water refuge.

Quality and Type of Fish Habitat

No fish sampling was conducted at any site in the Nordenskiold River watershed (Appendix 10B); however, both sites 1 and 1N are considered fish bearing (Figure B.10.2-2). It is known that the Nordenskiold River hosts eleven species of fish (Chinook salmon, chum salmon, lake trout (*Salvelinus namaycush*), Arctic grayling, round whitefish, lake whitefish (*Coregonus clupeaformis*), longnose sucker, burbot, northern pike, Arctic lamprey and slimy sculpin), all of which are common to the Yukon River Basin (Nordenskiold Steering Committee, 2010). Both Chinook salmon and chum salmon utilize the river for spawning and rearing habitat and the river provides suitable conditions for overwintering habitat. No barriers to fish movement where identified as part of this study, however frequent log jams within the Nordenskiold River may restrict salmon movement (Nordenskiold Steering Committee, 2010).

In situ water quality data were collected at sites 1 and 1N (Appendix 10B). The mean temperature as measured on August 9, 2013, for both sites was 15.9°C, which is warm for the Yukon River Basin but not uncommon in large watercourses. The pH, conductivity, and DO for the two crossings averaged, 7.2, 175µS/cm, and 8.6 mg/L, respectively.

It is expected that the proposed bridge site may support spawning and rearing habitat for any of the documented fish species in the river, including Chinook and Chum salmon. As depths are generally less than 1 m, it is unlikely that any overwintering habitat will be lost. As the total footprint of the bridge pier is small (6 m^2) relative to the estimated area of the river mainstem (estimated 1.43 km^2), it is anticipated that any potential impacts on fisheries productivity will be minor.

Morphology

As described in Appendix 10B (p.18-19), the proposed Nordenskiold River crossing has a wetted width of 53 m, an average depth of 1 m and a cobble dominated substrate. In-stream cover was low (<20%) and the channel gradient was low (2%) typical of large watercourses within the study area. A geomorphological impact assessment of the proposed Nordenskiold bridge pier was conducted using the following reference materials:

1. Historical photos of the Nordenskiold crossing;
2. Fluvial Geomorphology Hazard Assessment for Proposed Access Roads (Appendix 6E);
3. On-site field photos from 2013;
4. Google Earth imagery; and
5. Proposed bridge/pier design from *Casino Project Access Overview for Submission to YESAB* (Appendix 4B).

The proposed Nordenskiold River bridge crossing is immediately downstream of a tortuous meander that was cut-off (naturally) sometime between 1994 and 2008. A large, side- to mid-channel gravel bar formed in association with this cut-off as a result of localized erosion of the former meander 'neck'. This gravel bar has migrated and

extended downstream slightly since the cut-off event, now forming a very thin bar along the channel centreline immediately upstream of the proposed crossing location. However, the bar has also shrunk appreciably as flows continue to erode its head and flanks. It is expected that continued erosion of the bar, with its current mid-channel position and full exposure to erosive flows, will remove it entirely within the next several years. The bar is thus a short-lived feature formed in direct response to the meander cut-off. Placement of the pier along the downstream limit of this thin, remnant bar is not recommended, from a fluvial geomorphological perspective, as the pier would likely be positioned in the thalweg in several years and be exposed to direct and regular impacts from rafted ice and large woody debris.

The currently proposed pier position is close to the west bank of the river, in a small 'alcove' between the main bank and a small side-channel bar (depositional area) immediately downstream, at a transition between the thalweg (on the east) and slackwater and possible back-eddy flow (on the west). The thalweg is expected to align itself closer to the channel centreline, over time, in response to continued erosion and removal of the mid-channel bar immediately upstream. Currently, the focus of erosion along the west bank, as a result of the meander cut-off and new meander pattern, is approximately 110 m upstream of the proposed pier position. The gradual alignment of the thalweg into the middle of the channel is expected to moderate and ultimately eliminate this western bank erosion, thus posing no risk to the pier position in the long-term.

The pier is anticipated to cause localized scour around and immediately downstream of its base, where flow velocities are concentrated and capable of eroding the gravelly to cobbly bed material. The pier will be constructed to withstand such scour. The head of the small side-channel bar immediately downstream may be 'trimmed' slightly by this localized scour, although the propensity for continued deposition in this point bar-like position is expected to maintain the bar and its role in protecting the west bank from significant erosion. Relatively little scour may occur around the west side of the pier, given how close it is to the west bank and its sheltering from the thalweg by the bar immediately downstream. A deep, yet small pool is expected to be formed and maintained on the east and downstream side of the pier, which may be attractive to fish species seeking deep water refuge. Ultimately, the pier is expected to cause very localized and minor changes in morphology, with no adverse effects on fish habitat or fisheries productivity.

The noted gravel bar is upstream from the currently proposed bridge alignment by 10 m. The bridge designers have chosen the proposed pier location to be as close to the normal high water mark as possible, essentially creating a clear span of the main river channel. This reduces the likelihood of debris accumulation and scour around the pier and also improves constructability by allowing easy access for pile driving equipment working from the shore. The pier is designed to take loads and impacts from ice and debris and is complete with a steel diaphragm connecting the 4 piles together that will distribute horizontal loads and prevent debris from catching between the pier piles.

The geomorphological assessment conducted also provided insight into the creation and stability of the noted gravel bar. Based on this assessment, it was not recommended to place the bridge pier on the eroding gravel bar as the pier would likely be positioned in the thalweg in several years and be exposed to direct and regular impacts from rafted ice and large woody debris.

R410. A mitigation strategy for the cabin located at the southern edge of a proposed borrow pit and what if any measures will be in place to ensure continued access. In addition, identify whether the owner has been contacted or not. If so, please provide information regarding the outcome of this contact.

A description of the cabin and a photo is provided in the Heritage Baseline (Appendix 18B of the Proposal). The cabin is described as a “modern resource” and located on the Freegold Road Upgrade portion of the access road at what was previously known as "Mile 40". The cabin is located outside of the proposed Freegold Road Upgrade alignment and outside of the proposed borrow pit, though it is located on the south edge of a proposed borrow pit and access to the cabin may be affected during construction of the Freegold Road Upgrade.

Mitigation Measures

There are multiple cabins along the Freegold Road, with multiple users (placer mining, quartz claim owners, trappers, recreational, etc.). CMC has made a number of commitments to ensure continued access to these cabins. As the Project nears the construction phase, increased communication will be required with land owners to ensure they are aware of the proposed construction, the potential impacts, and the measures available to mitigate the potential impacts.

CMC’s commitments include:

- **Commitment 6**: CMC will work with First Nations to arrange for access as appropriate consistent with the access road management plan as approved by First Nations and Yukon Government.
- **Commitment 16:** Road Use Plan: CMC will develop a final plan prior to construction and operations. The final plan will include a table of commitments with mitigation measures developed through the environmental assessment process, and terms and conditions of any applicable licences, permits and approvals required for Project operation. It is the intent of CMC to negotiate a Freegold Road Extension Access Management Agreement with the Government of Yukon, SFN and LSCFN to address how the private road and access control could be managed to meet the Project requirements with consideration of existing tenure holders and individuals.
- **Commitment 132**: To mitigate against changes to access to traditional land, mineral tenures, and recreational lands CMC commits to:
    - Working with First Nation and Yukon Government to ensure management of the Freegold Road Extension does not interfere with the rights of other existing tenure holders.
    - Implement access management measures and associated monitoring and communication plans.
    - Ongoing communication with FN and local stakeholders.

Efforts to Contact Owner

The cabin is located on overlapping placer and quartz claims, claims P 41778 owned by George S. Wilson and claim 39171 (DONALDA 3) owned by 0878950 B.C. Ltd., respectively. There is also a quartz lease (number OW00199) adjacent to the cabin location on the DONALDA 3 claim. George S. Wilson is also the owner of a current Class 1 notification in the area. The cabin may also cross onto Little Salmon/Carmacks A-Block settlement land LSC R-8A. As such, it is difficult to know who exactly owns the above cabin; however, letters to George S. Wilson and corporation 0878950 B.C. Ltd. were sent out June 9, 2015 to notify users of the proposed Casino Project, and inviting them to speak to CMC regarding the proposed project, in addition to consultation conducted in 2013 and 2014, as summarized in the response to R408. No return correspondence has been received from either user.

If the cabin is owned by a member of Little Salmon/Carmacks First Nation (LSCFN), there has been no contact with CMC on this matter during the extensive consultation CMC has been conducted with LSCFN. As the Project nears the construction phase, increased communication will be required with all land owners to ensure they are

aware of the proposed construction, the potential impacts, and the measures available to mitigate the potential impacts.

Approach for Cabin Owners on the Freegold Road

Yukon Government has noted that typically, once a detailed design is completed, cabin owners/land owners that may be affected by proposed works are identified. Once a detailed plan for road upgrades is in place and prior to the start of road upgrades HPW determines which cabin owners or land owners could be affected, and determines how and if further engagement and discussions are required. From this point, a plan for engagement and potential mitigations could be developed. As part of developing a work and design plan for the upgrades and the by-pass, HPW would engage and consult with land owners, cabin owners, other road users, and First Nations.

B.4.5.1.2 R2-9

R2-9. Camp details including:
a. Information regarding surface water within the camp footprint and any diversions,
b. Supporting information on the appropriateness of a septic system,
c. Details for reclamation of camp site, and
d. Volumes of vegetation to be cleared and disposal methods.

Details of the current construction camp plan are discussed below. The proposed construction camp location at Big Creek is shown in more detail on Figure B.4.5-2. The details of the camp location, preparation activities and layout will be provided in the Road Construction Plan, required under the Quartz Mining Act as part of an application for a Quartz Mining Licence (Yukon Government, 2013).

The temporary camp used for the construction of the Freegold Road Extension will be much like other temporary camps frequently established by contractors as required for short term maintenance contracts in remote areas. The camps typically consist of a kitchen and wash-up trailer and possibly 8 - 12 ATCO type trailers to be used for living quarters, laundry and offices.

Potable water may be trucked in, or the contractor may choose to install a well. The contractor may choose to have a septic pump-out system or install a septic leach field. The camp will be kept clean and free of any domestic waste that may attract wildlife. Camp related waste will be disposed of at an approved dump site or incinerated. The camp will be entirely decommissioned after the project is complete.

All temporary construction camps will comply with, and acquire permits for, as necessary, all Yukon and Federal Acts and regulations as they apply to the construction and operation of camp facilities, including those summarized in Table B.4.5-1.

a. *Surface water:* Figure B.4.5-2 shows that there are no significant water courses within the camp footprint and therefore no water diversions are expected to be required for the proposed location.

b. *Septic system:* The final design may incorporate a septic pump-out system or install a septic leach field, subject to applicable regulatory approval as required by the Quartz Mining Act or the Yukon Water Act.

c. *Reclamation of camp site:* The area on the south side of Big Creek has multiple quartz and placer claims with extensive pre-existing disturbance (Figure B.4.5-3). The existing placer mine just east of the proposed construction camp location indicates that camp construction is viable in this location. As the area has already experienced extensive disturbance, reclamation activities for the camp site are not expected to be significant.

d. *Volume of vegetation to be cleared and method of disposal:* The area on the south side of Big Creek has multiple quartz and placer claims, with extensive pre-existing disturbance (Figure B.4.5-3). As a result of the existing disturbance, the volume of vegetation to be cleared is expected to be minimal. Any clearing will consist of clearing trees and brush from the area but little or no grubbing is expected to be necessary. Cleared material will be disposed of by burning.

CMC also commits to complying with the following guidelines when preparing its detailed design:

- Site preparation will be kept to a minimum as the facilities are temporary and designed to be easily transported, erected and dismantled;
- Camp preparation will consist of clearing trees and brush from the area but little or no grubbing is expected to be necessary. Cleared material will be disposed of by burning;
- Where utilities are required utilities will be run in utilidors wherever possible;
- The general area will be filled using native material and graded to promote the drainage of water and prevent inundation during periods of high runoff (e.g. during freshet). Drainage channels may be constructed to divert water;
- Imported granular fill will be used in areas of traffic to provide a suitable driving surface for construction vehicles and heavy equipment; and
- Wherever possible the fill material will be native unprocessed material from a local borrow pit.
- All temporary construction camps will comply with, and acquire permits for, as necessary, all Yukon and Federal Acts and regulations as they apply to the construction and operation of camp facilities.

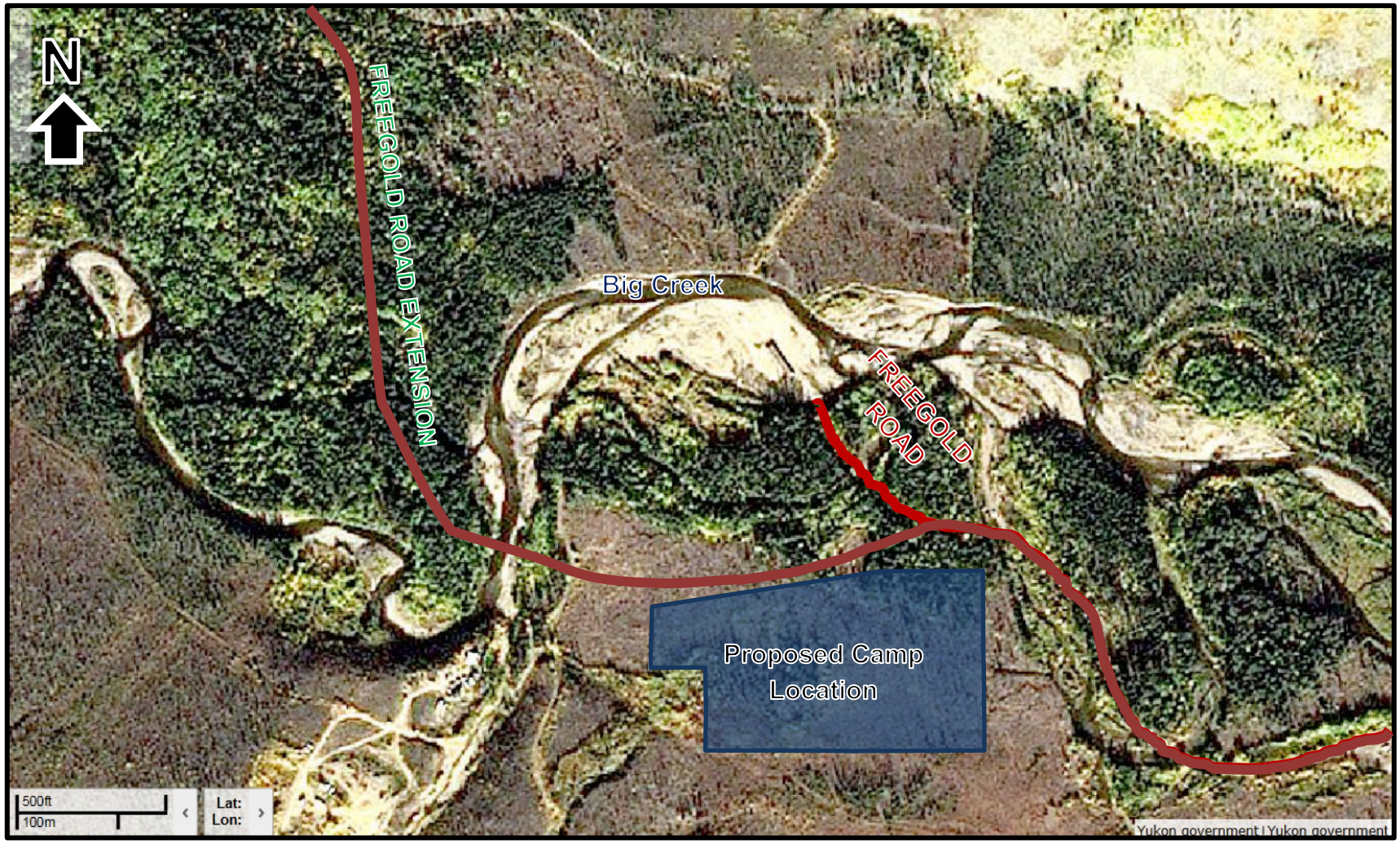


Figure B.4.5-2 Freegold Temporary Construction Camp Preliminary Location

Figure B.4.5-3 Big Creek Bridge Area

B.4.5.1.3 R2-10

R2-10. A description and assessment of the two possible scenarios for the Freegold Road extension:
a. Road closure and reclamation including methods, objectives, and timelines,
b. Continued road use including management, access, and effects.

The following narrative describes the two possible scenarios for the Freegold Road extension at the completion of the Project: road closure and reclamation, and continued road use.

a. *Road Closure and Reclamation:* As outlined in Section 4.5.4.1, the decommissioning objective for the Freegold Road Extension will be to "enable human and wildlife utilization in the area to revert to pre-development levels and types" in accordance with the Mine Site and Reclamation Closure Policy (Yukon Government, 2013). All on-site roads, trails, and access corridors will be decommissioned unless the Minister responsible under the Highways Act provides written notification of a public interest in maintaining the road for public use (Yukon Government, 2013). Decommissioning measures will include, as applicable:

    - Removal of bridges, culverts, ramps, and landings;
    - Stabilization of road cuts and fills;
    - Installation of diversion berms on steep slopes;
    - Scarification of road surfaces; and
    - Re-establishment of streambeds and stabilization of banks.

    Any borrow sites associated with construction of the access road will be progressively reclaimed to ensure that they present no significant hazard to people and wildlife, either through backfilling or through embankments and ditching.

    Road construction, operation and closure will be in accordance with the new regulation pursuant to the *Territorial Lands (Yukon) Act*. The intent is to manage the construction, operation and maintenance and finally decommissioning and reclamation of access road over the life of the project. The new regulation is expected to address 6 key issues that are missing in the current regulations:

    - Ability to tie the life of the permit to the life of the main project;
    - Provide for appropriate security consistent with other policy direction (i.e. mine site reclamation policy);
    - Ensure that resource roads do not become public;
    - Ensure decommissioning plans are developed;
    - Provide compliance and enforcement tools for road management; and
    - Ability to manage and restrict access.

    It is also expected to include an ability to authorize multiple permit holders and facilitate agreements for multi-use as may be allowed under a management plan.

    To be clear, the Proposed Project includes decommissioning of the access road in accordance with Territorial regulations. Access to the site to conduct maintenance activities will be via air, with some heavy machinery left on-site for maintenance requirements.

b. *Continued Road Use:* CMC plans to decommission and reclaim all on-site roads, trails, and access corridors at the completion of the Project including the Freegold Road extension. Any change in road use of the scope described by YESAB in this request would likely be considered a significant modification to the Project and would require changes to existing permits and approval by YESAB and/or the Yukon Government.

B.4.5.1.4 R2-11

R2-11. Clarification if project traffic predictions and the project effects assessment include empty vehicles, and if not, updated predictions and corresponding effects assessments.

The updated projections now include all inbound and outbound vehicles. The updated projections do not significantly change the results of the effects assessment that the incremental effect of Project-related traffic remains within the range of historic traffic on the proposed routes. The detailed effects assessment is contained in the response to R2-12.

Updated Projections

An omission of 12 empty vehicles (8 copper concentrate and 4 molybdenum concentrate) resulted in an imbalance of vehicles leaving the facility compared to those returning to the facility in the response to R21 in SIR-A. These two values should always be equal. The response has been recalculated and an updated projection of Project-related highway traffic volumes is reproduced in Table B.4.5-2. The updates to the projections do not significantly change the effects assessment.

Table B.4.5-2 Projected Traffic Volumes during the Operations Phase

Vehicle Type	FHWA Classes	Inbound[1.] (loads per day)	Outbound (loads per day)
LNG Fuel	8-13	11	11
Diesel and Lubricants etc.	8-13	4	4
Lime (as backhaul)	8-13	6	0
Grinding Media (as backhaul)	8-13	3	0
Camp and Catering Supplies	3-7	2	2
Copper Concentrate	8-13	8	17
Molybdenum Concentrate	8-13	4	4
Other (QTY: FHWA Classes)	(5:3-7), (5:8-13)	10	10
Buses, vans, light vehicles	3-7	20	20
TOTAL		**68**	**68**

1. Daily and seasonal variations will occur. Peak outbound results can arise from years of higher than life-of-mine average copper concentrate production. For example, copper concentrate outbound loads can reach 24 loads per day in some years

B.4.5.1.5 R2-12

R2-12. An analysis of potential effects along the Klondike Highway, for all affected sections.

Generally, total average daily traffic, including the incremental effect of Project-related traffic, is expected to be well within the range of historic traffic throughout the proposed route. The potential effects analysis is detailed below.

There will be three major highway routes for Project-related traffic during operations:

1. LNG fuel trucks will travel northwest on the Alaska Highway from Fort Nelson, British Columba via Watson Lake to Whitehorse. These vehicles will turn north onto the North Klondike Highway to the Carmacks by-pass. Trucks transporting other supplies may also follow this route;
2. Copper/molybdenum concentrates will be trucked from the mine site to Skagway, Alaska, with grinding media and lime backhauled from Skagway to the mine site; and
3. Additional supplies are anticipated to be procured in Whitehorse and transported to the mine site.

Personnel will be flown into site via the Casino Airstrip.

Yukon Government, Department of Highways and Public Works (HPW), Transportation Engineering Branch has adapted the standard United States Federal Highways Administration (FHWA) classification scheme for Yukon. For planning purposes, FHWA classes are often grouped into light vehicles (classes 1-3), single-unit truck vehicles (classes 4-7) and heavy trailer truck vehicles (classes 8-13) (Yukon Government, 2014).

Single unit trucks (FHWA Classes 3-7) are not expected to have an effect on other highway users (Yukon Government, 2014). Trailer trucks are bigger and longer, accelerate and travel more slowly, and turn more widely than light vehicles (HPW, 2011).

Average daily Project-related one-way trips by route segment is summarized in Table B.4.5-3, and an assessment of the effects on the Alaska Highway – Whitehorse corridor, Alaska Highway – between Watson Lake and Carcross cutoff, the North Klondike and South Klondike is provided below.

The Yukon highway routes, and 2011 traffic volumes (HPW, 2011) are provided in Figure B.4.5-4.

Table B.4.5-3 Projected Traffic Volumes during the Operations Phase inbound and outbound by Vehicle Type

Vehicle Type	Alaska Hwy South of Carcross cutoff	South Klondike	Alaska Hwy Whitehorse Corridor	North Klondike to Carmacks By-pass
LNG Fuel	22	-	22	22
Diesel and Lubricants etc.	8	-	8	8
Concentrates, including backhauls	-	42	42	42
Camp and Catering Supplies	4	-	4	4
Other (QTY: FHWA Classes)	20	-	20	20
Buses, vans , light vehicles	-	-	40	40
TOTAL	**54**	**42**	**136**	**136**

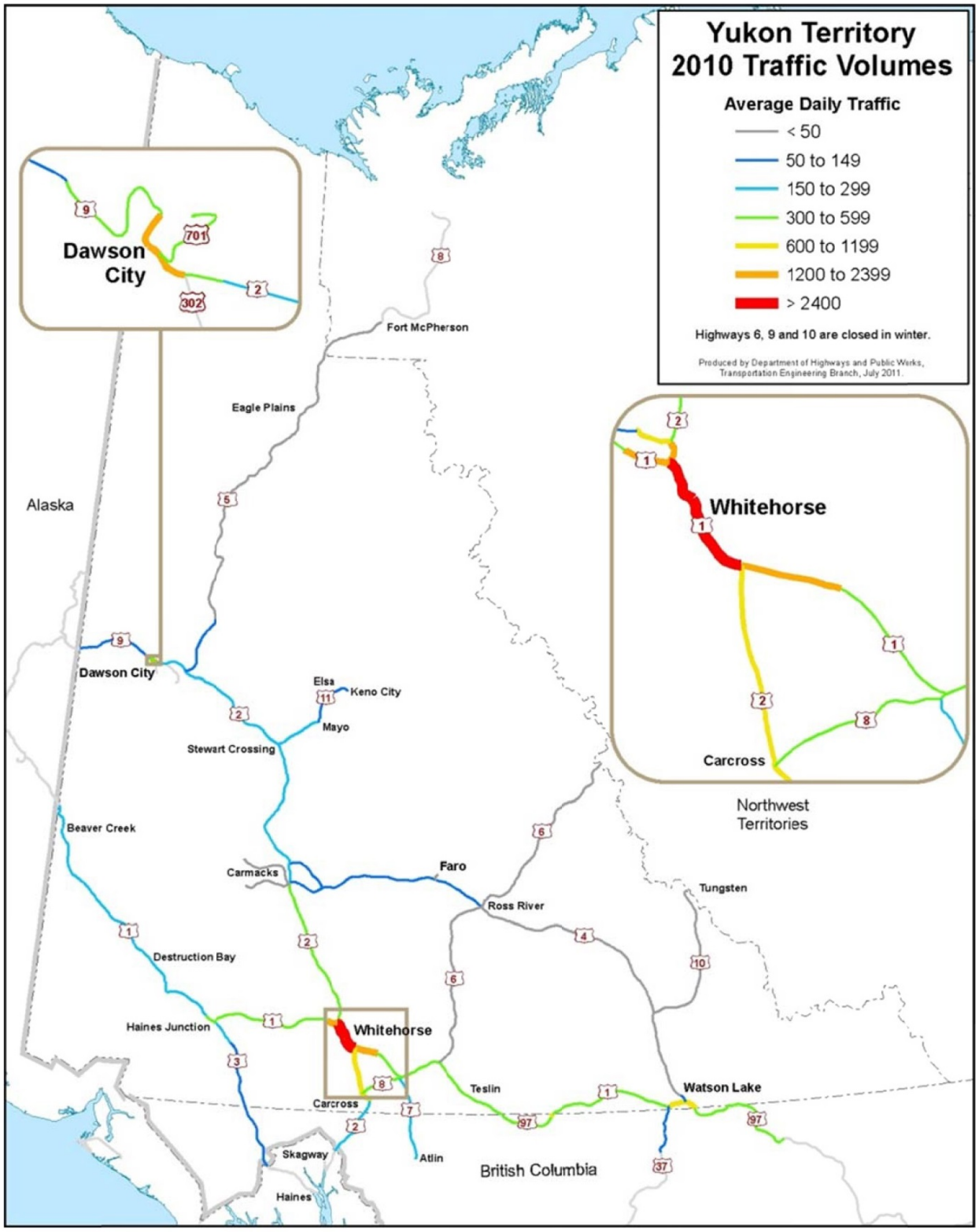


Figure B.4.5-4 Yukon Highway Schematic and 2011 Traffic Volumes (Yukon Government, 2011)

Alaska Highway – Whitehorse Corridor (connection between North Klondike and South Klondike)

Total average daily traffic, including the incremental effect of Project-related traffic, is expected to be well within the range of historic traffic in the Whitehorse Corridor.

All Traffic

Traffic along the Alaska Highway between the North Klondike and South Klondike is measured at the Fox Farm Road (km 1411.6) and CEE & CEE Gravel pit (km 1435.2) (HPW, 2011). Traffic through this section is the highest of any in the Yukon and has been steadily increasing from 3,147 average annual daily traffic (ADT) in 1990 to 4,166 ADT in 2011 (HPW, 2011). This is the most used route by Project related traffic as all Project related traffic will travel this stretch (i.e., 136 vehicles per day - Figure B.4.5-5).

Truck Traffic

Truck traffic figures along the Alaska Highway between the North and South Klondike were collected over 1-2 weeks at various locations in the Whitehorse Corridor during the summer of 2011 (HPW, 2011), as shown in Table B.4.5-4. The percent of vehicles that were trucks ranged from 6.6% around Whitehorse (km 1426.3) to 8.5% North of the Carcross Cutoff (km 1404.5).

The average daily truck traffic on the Alaska Highway between the North and South Klondike is shown in Figure B.4.5-6. The annual average daily truck traffic along the Alaska Highway between North and South Klondike is ~313 trucks per day, which will increase, on average, to 409 trucks per day.

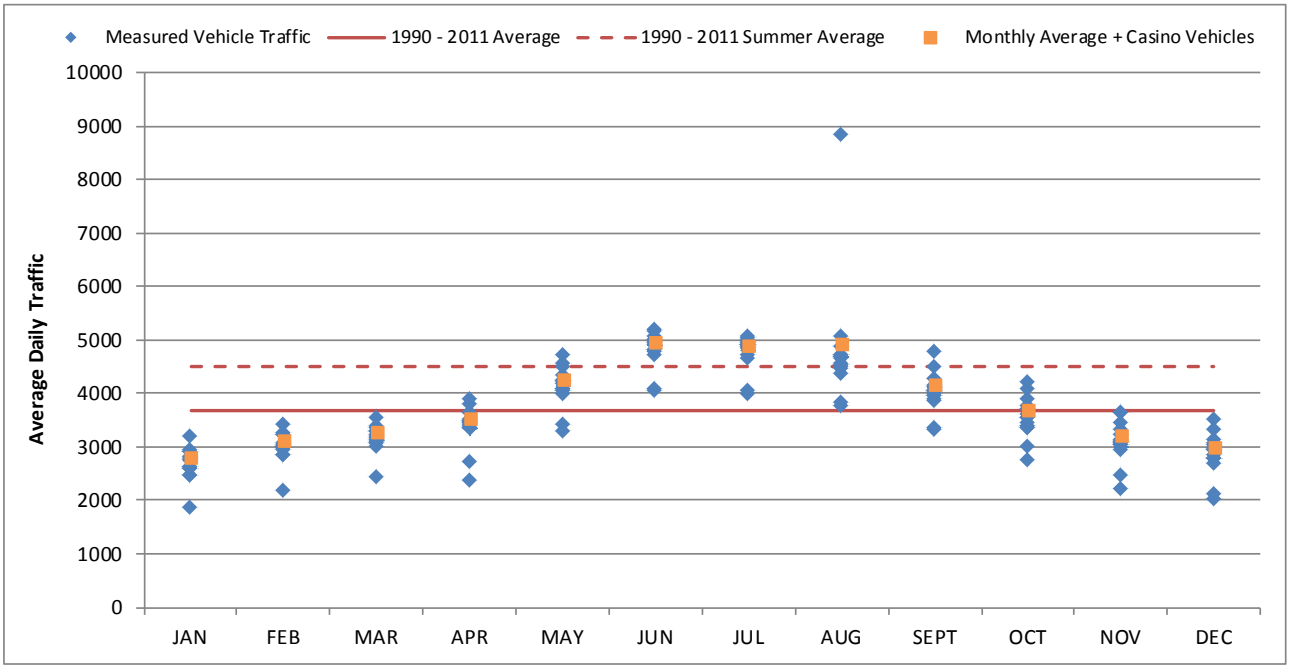
Table B.4.5-4 Traffic and Truck Count Statistics from the Whitehorse Corridor (Summer 2011) and Estimated Project-related Truck Traffic

Location on Alaska Highway	Average Daily Traffic (ADT)[1]	% Trucks[1]	Est. Number of Non-project Trucks/day	Est. Number of Project Trailer Trucks/day
South of Carcross Cutoff (km 1404.2)	2,720	6.9%	188	42
North of Carcross Cutoff (km 1404.5)	4,381	8.5%	372	54
Whitehorse, Two-mile Hill (km 1426.3)	13,480	6.6%	890	96
South of North Klondike (km 1432.2)	6,166	7.7%	475	96
North of North Klondike (km 1437.1)	1,716	12.1%	208	-

1. Yukon Government, 2014

Effects Assessment

The Whitehorse Corridor section of the Alaska Highway is already highly utilized. The increase in average daily traffic is expected to be seven vehicles per hour (1-3 trucks per hour) in an area that regularly experiences from 71 to 562 vehicle trips per hour. Total average daily traffic, including the incremental effect of Project-related traffic, is expected to be well within the range of historic traffic in the Whitehorse Corridor.



*Data from Yukon Highways and Public Works, 2011

Figure B.4.5-5 Vehicle Traffic Measured at Alaska Highway km 1435.2 (North Klondike Junction) and added Casino Vehicles (Highway Data from 1990 – 2011)

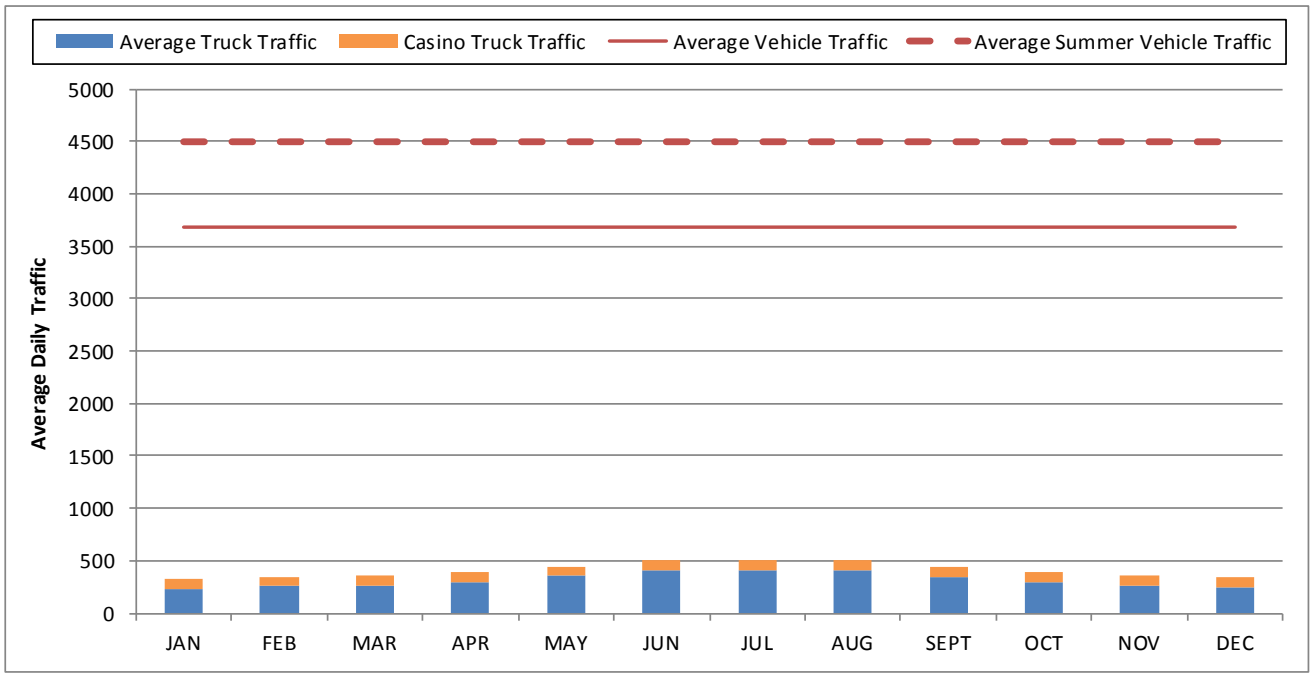


Figure B.4.5-6 Calculated Average and Casino Truck Traffic at Alaska Highway km 1435.2 (North Klondike Junction)

Alaska Highway – between Watson Lake and Carcross cut-off

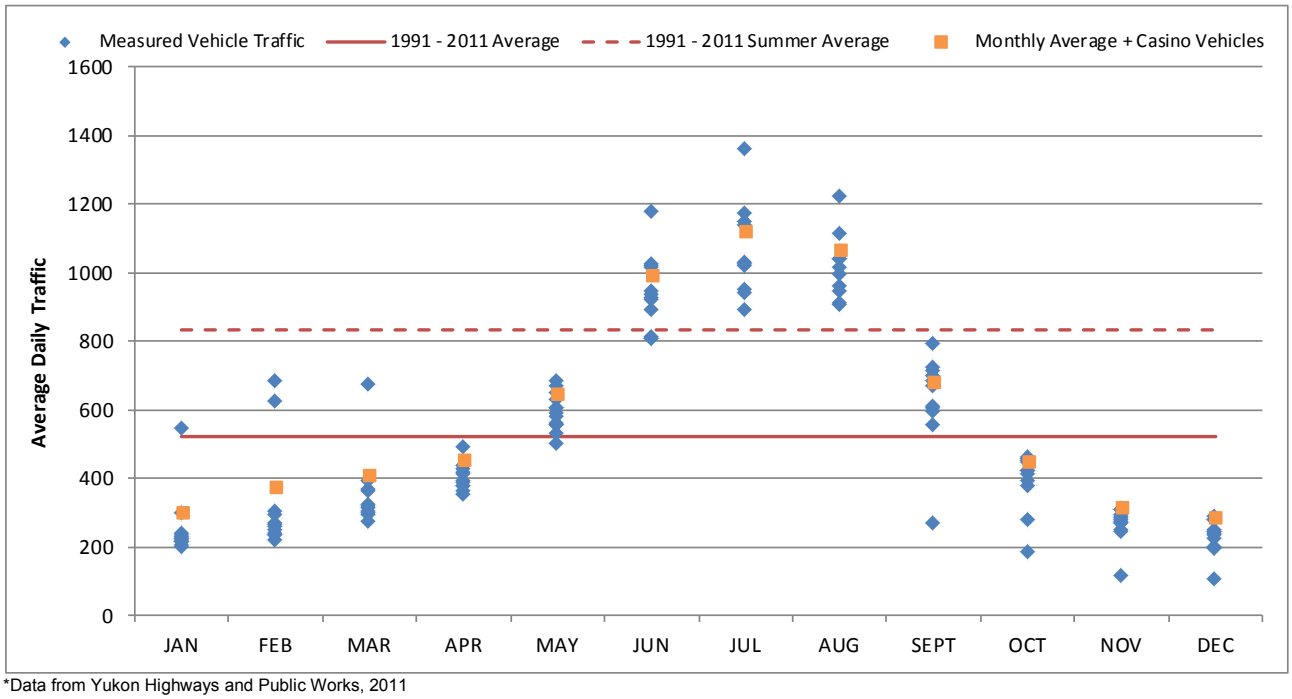
Total average daily traffic, including the incremental effect of Project-related traffic, is expected to be well within the range of historic traffic on this section of the Alaska Highway.

All Traffic

Traffic that travels along the Alaska Highway between the Carcross cut-off and Watson Lake is measured at the Cassiar Junction South (km 1001.5) and the Swift River Grader Station (km 1136.7). Traffic at these stations has been relatively consistent from year to year, with average daily traffic of 568 vehicles per day at km 1136.7 and 523 vehicles per day at km 1001.5. Project related traffic likely to travel along this stretch is related to LNG (11), diesel and lubricants (4), camp and catering supplies (2) and other (10) for a total of 54 trucks both directions. Buses, vans and light vehicles will likely only travel between Whitehorse and the mine site and concentrate vehicles will turn off onto the South Klondike. Average daily traffic, by month, with the added Casino vehicles, for this stretch is shown in Figure B.4.5-7.

Truck Traffic

Truck traffic along the Alaska Highway between the Carcross cutoff and Watson Lake can be assumed to be equal to that South of the Carcross cutoff (6.9%). Assuming 6.9% of total traffic along the Alaska Highway towards Watson Lake are trucks, the average daily truck traffic is shown in Figure B.4.5-8 (blue columns). The cumulative effect of the 54 trucks from the Casino Project is also shown on Figure B.4.5-8 (orange column). The annual average daily truck traffic along the Alaska Highway between the Carcross cutoff and Watson Lake is ~36 trucks per day, which will increase, on average, to 90 trucks per day.



*Data from Yukon Highways and Public Works, 2011

Figure B.4.5-7 Vehicle Traffic Measured at Alaska Highway km 1001.5 (Cassiar Jct. South Side) and added Casino Vehicles (Highway Data from 1991 – 2011)

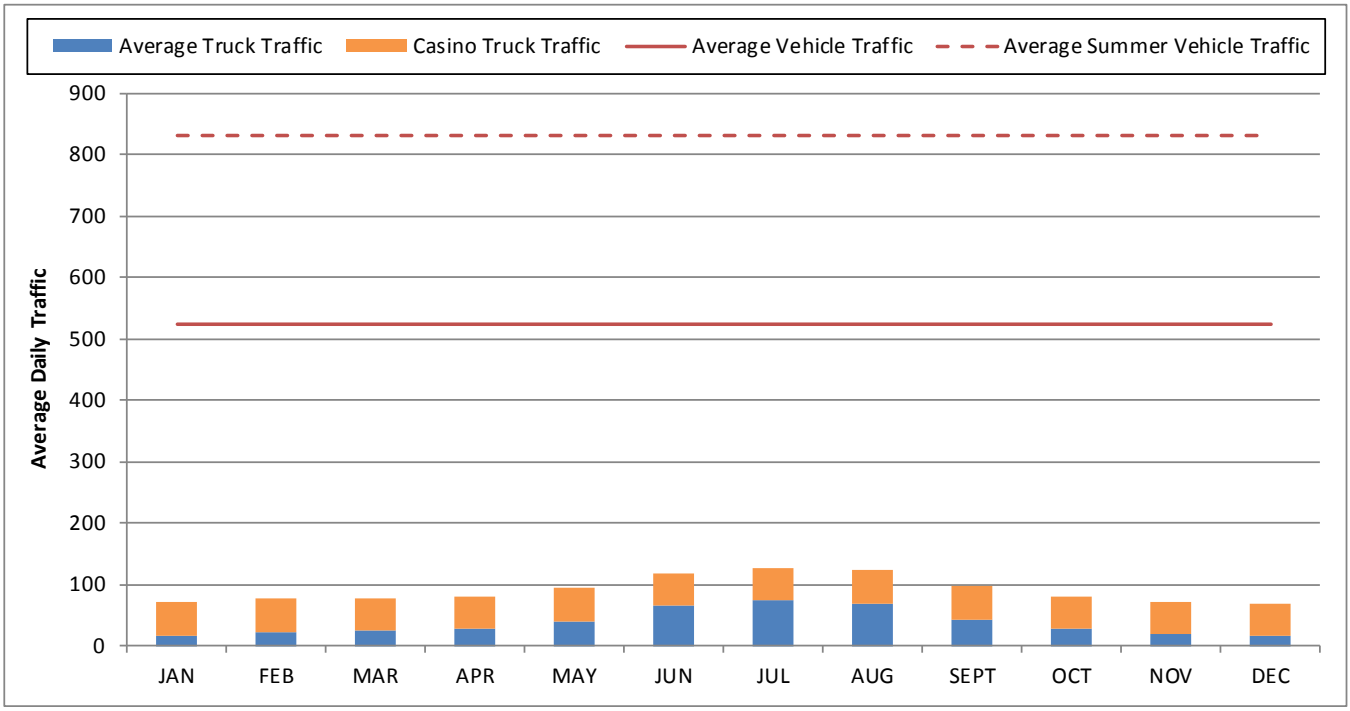


Figure B.4.5-8 Calculated Average and Casino Truck Traffic at Alaska Highway km 1001.5 (Cassiar Jct. South Side)

Effects Assessment

Total average daily traffic, including the incremental effect of Project-related traffic, is expected to be well within the range of historic traffic on this section of the Alaska Highway, as shown as orange squares in Figure B.4.5-7, and as shown by the red lines in Figure B.4.5-8.

North Klondike

Total average daily traffic, including the incremental effect of Project-related traffic, is expected to be well within the range of historic traffic on the North Klondike Highway.

All Traffic

Traffic along the North Klondike Highway is measured at Braeburn, using electronic traffic counters (HPW, 2011). Traffic through Braeburn has been relative consistent from 1996 through 2011, averaging ~436 vehicles per day, which increases to ~597 during the summer (HPW, 2011). All Project related traffic will travel on this section of the highway (i.e., 136 vehicles per day, on average). Average daily traffic, by month, is shown in Figure B.4.5-9, as is the increase in traffic with Casino vehicles.

Truck Traffic

To determine the effect of the Project on truck traffic, truck traffic volumes from the Alaska Highway, North and South of the Klondike, can be used. The volume of truck traffic ranges from 7.7% to 12.1%, therefore, assuming 12% of total traffic along the North Klondike are trucks, the average daily truck traffic on the North Klondike is shown in Figure B.4.5-10. The impact of the 96 trucks (all vehicles excluding the 40 buses, vans and light vehicles) from the Casino Project are also shown on Figure B.4.5-10 (orange columns). The annual average daily truck traffic through Braeburn is currently ~52 trucks per day, which will increase, on average, to 148 trucks per day.

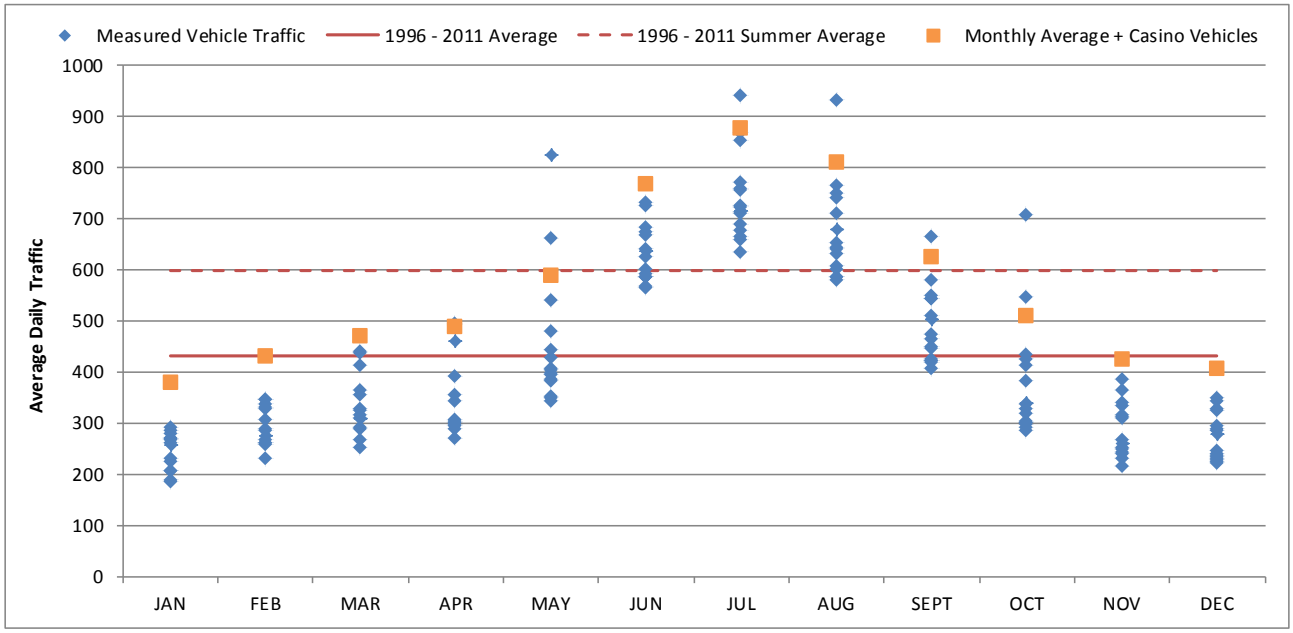


Figure B.4.5-9 Vehicle Traffic Measured at Klondike Highway km 280 (Braeburn) and added Casino Vehicles (Highway Data from 1991 – 2011)

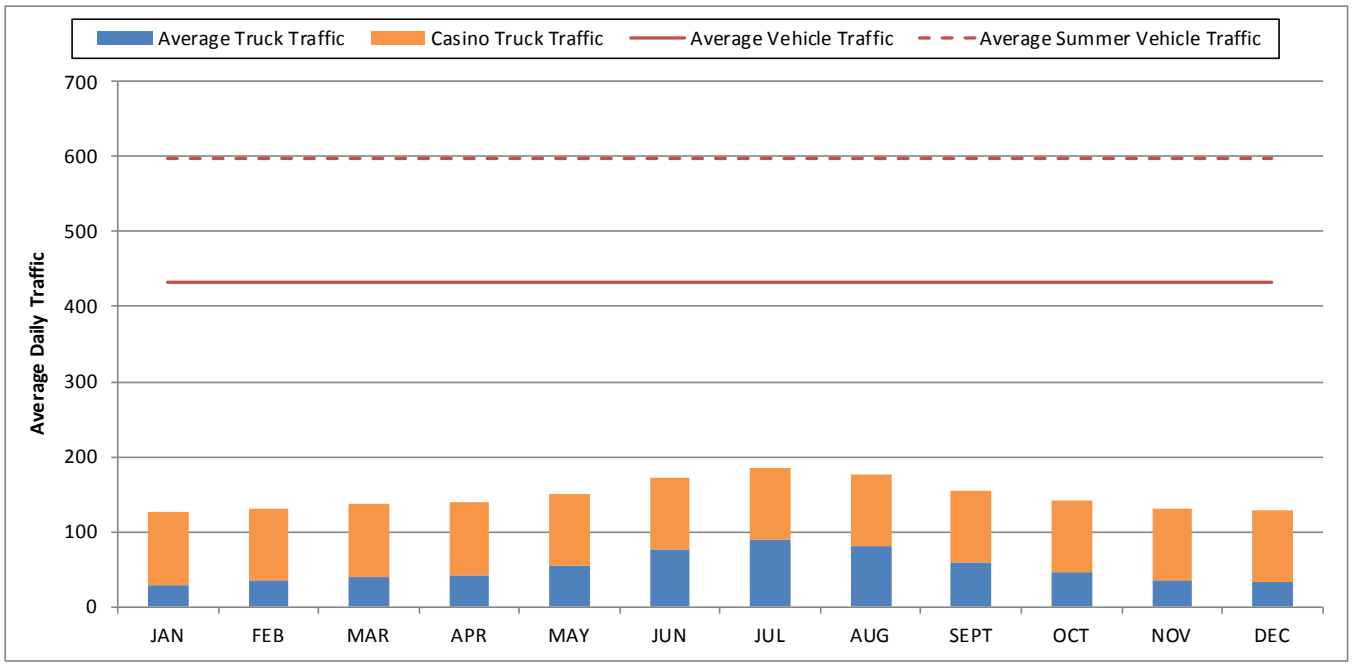


Figure B.4.5-10 Calculated and Casino Truck Traffic at Klondike Highway km 280 (Braeburn)

Effects Assessment

Total average daily traffic, including the incremental effect of Project-related traffic, is expected to be well within the range of historic traffic on the North Klondike Highway, as shown as orange squares in Figure B.4.5-9. Average daily truck traffic will increase, but will be below the overall average vehicle traffic (red lines on Figure B.4.5-10).

South Klondike

42 additional trucks will travel through Carcross (i.e., 21 trucks to Skagway and 21 trucks returning from Skagway) on a daily basis. The effect on average daily vehicle traffic through Carcross is well within the range of historic traffic for this section of road.

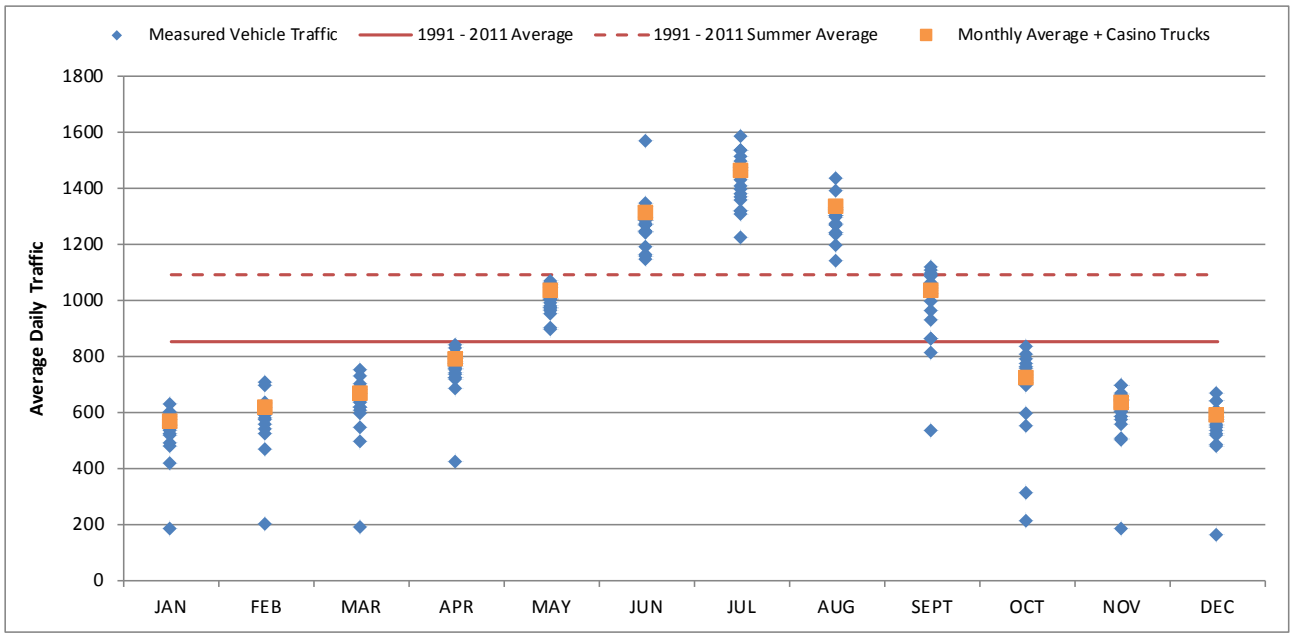
All Traffic

Traffic on the South Klondike Highway is measured on the North and South sides of Carcross, using electronic traffic counters (HPW, 2011). These results provide an estimate of overall traffic, and are not divided into truck, passenger vehicle and bus traffic. Project related traffic on the South Klondike will be concentrate trucks shipping concentrate to Skagway and returning with lime and grinding media, for an average of 21 trucks per day each way, or 42 trucks per day in total.

On average, from 1991 through 2011, 849 vehicles per day pass the traffic counter on the South side of Carcross, with the average increasing to 1,092 vehicles per day during summer months (May 1 through September 30) (HPW, 2011). The total monthly average daily traffic through Carcross, as measured by Yukon Highways and Public Works (HPW) traffic counter on the south side of Carcross on the Klondike Highway #2, is shown in Figure B.4.5-11.

Truck Traffic

To determine the effect of the Project on truck traffic, truck traffic volumes from the Alaska Highway at the Carcross cutoff can be used. The volume of truck traffic ranges from 6.9% to 8.5%, therefore, assuming 8.5% of total traffic along the South Klondike past Carcross are trucks, the average daily truck traffic on the South Klondike is approximately 72 trucks per day (Figure B.4.5-11). The impact of the 42 concentrate trucks (21 trucks in each direction) from the Casino Project are also shown on Figure B.4.5-12 (orange squares). The annual average daily truck traffic is expected to increase to 114 trucks per day.



*Data from Yukon Highways and Public Works, 2011

Figure B.4.5-11 Vehicle Traffic Measured at Klondike Highway km 106.3 (Carcross – South Side) (Highway Data from 1991 – 2011)

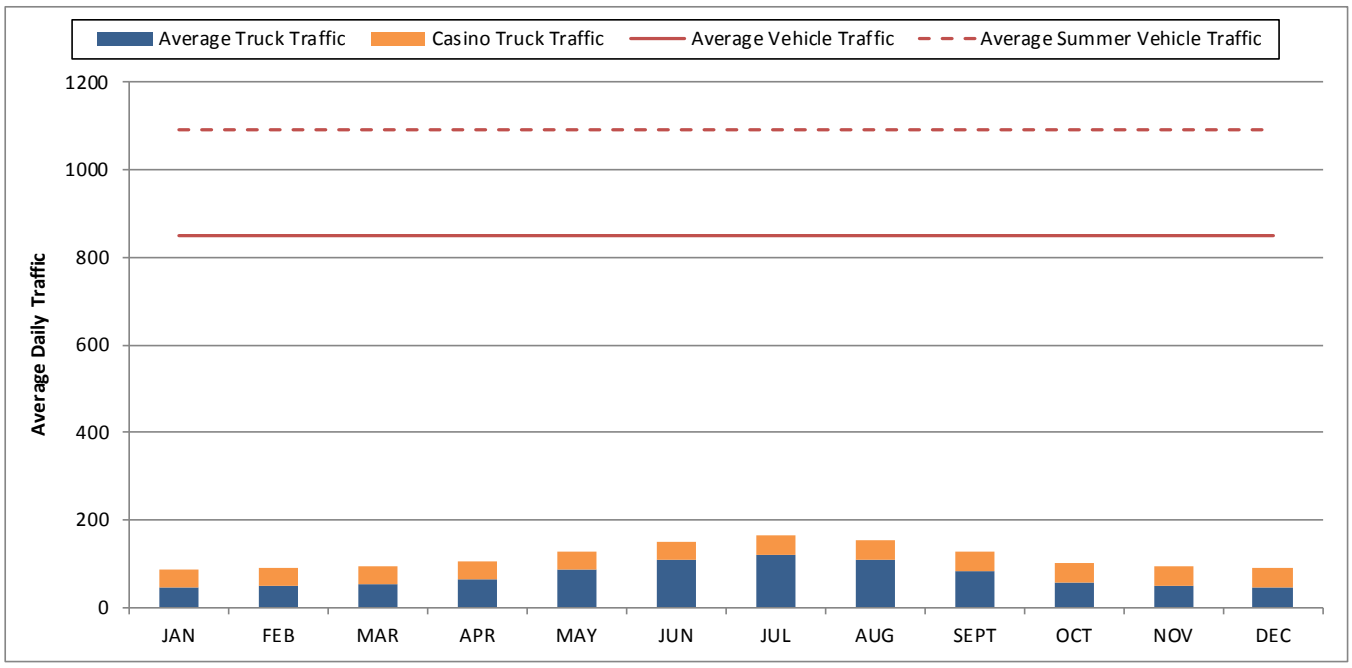


Figure B.4.5-12 Calculated and Casino Truck Traffic on Klondike Highway km 106.3 (Carcross – South Side)

Effects Assessment

The total of the additional 42 trucks through Carcross (i.e., 21 trucks to Skagway and 21 trucks returning from Skagway) on a daily basis and the baseline average daily vehicle traffic through Carcross is well within the range of historic traffic for this section of road (orange square in Figure B.4.5-11).

B.4.5.1.6 R2-13

R2-13. An assessment of and mitigations for potential effects due to traffic in Carmacks and Carcross.

Village of Carmacks

The following mitigation measures should minimize the potential effects that may be experienced by residents of the Village of Carmacks as a result of increased traffic from project-related activities.

Early Construction of Carmacks By-pass

The main mitigation measure proposed by CMC is the construction of the Carmacks by-pass road and bridge over the Nordenskiold River. This routing will minimize traffic through the Village of Carmacks and will minimize effects such as noise, safety, dust, etc.

The Carmacks by-pass will provide a route for construction and mine related traffic to bypass the Village of Carmacks. Yukon Government surveyed the route and prepared a road design in 1997. In 1998-1999 the right of way was cleared, and the first section of By-Pass road was constructed from the Klondike Highway to the east side of the Nordenskiold River (Figure B.4.5-1).

The by-pass construction will be one of the first construction activities completed, and as the right of way is already cleared, the construction is expected to be relatively quick, and as short as practical. Therefore, the effects of subsequent construction traffic through Camacks will be negligible, and will be limited to the construction period when the by-pass is not yet available for use.

Mitigation measures during by-pass construction

- *Routing:* During the construction of the by-pass, the proposed access route for vehicles requiring access to the Freegold Road is outlined in Figure B.4.5-1 and consists of a turn onto Freegold Road from Highway 2, then a left turn onto River Road, which turns into the Freegold Road. The route was chosen as it is the current route for traffic traveling through Carmacks to access the Freegold Road and it minimizes traffic near the school and recreation centre. As detailed in Table 4.3-5, annual average daily traffic is estimated to be 3 “heavy” vehicles and 1 “light” vehicle, for a total of 4 extra vehicles per day during this time.
- *Traffic management and safety procedures*: Vehicles will comply with all standards and guidelines established in the Traffic Management and Road Use Plans and with local speed limits.
- *Scheduling and communication:* CMC will communicate with the Village of Carmacks to indicate proposed construction windows, and as the route will be constructed by the Yukon Government Department of Highways and Public Works (HPW), communication will also be closely connected between HPW, the Village of Carmacks, CMC and the construction contractor. Notice will be given to residents in the surrounding area well in advance of the construction start date.
- *Noise levels:* Based on the existing model and predictions, noise levels in Carmacks during construction are anticipated to be consistent with the maximum daytime and nighttime noise levels predicted for the

Freegold Road Extension during construction (see Figures 9.4-1 and 9.4-2 in the Proposal). These predicted noise levels are below the maximum daytime and nighttime thresholds identified in the OGC guidelines (i.e., 55 dBA during the day, and 45 dBA at night).

Traffic Management Plan

Following construction of the Carmacks bypass, CMC will develop the Traffic Management Plan in support of the Road Use Plan. The final Road Use Plan for the Project will include a discussion of the potential impacts of mine site roads, haul roads and access roads (including the Carmacks by-pass road) and implement mitigation measures to avoid or minimize adverse effects on watercourses, wildlife, and the public, once finalized by the YESAB assessment process.

The Traffic Management Plan is expected to form a large component of the Road Use Plan. It will include a monitoring and reporting requirement that allows adjustments to be made to the plan to ensure the objectives are achieved and adverse effects are avoided or minimized. The Traffic Management Plan will be prepared by CMC and the implementation of it (and the larger Road Use Plan) will become a commitment of CMC and a license requirement for the Project under the Territorial Lands (Yukon) Act and the Quartz Mining License.

Carcross

Traffic passing by Carcross along the South Klondike Highway #2 will be limited to concentrate trucks travelling to and from Skagway for export, which at the maximum, is 24 trucks and 4 trucks per day, or on average, 17 trucks and 4 trucks per day, for copper and molybdenum concentrate, respectively. The highway route through Carcross travels north-south, on the east side of the town. To access the town, vehicles must turn west off of the highway. Traffic travelling along the highway towards Skagway or Whitehorse must comply with speed limits and other highway traffic conditions.

As detailed above, in the response to R2-12, the increase in traffic passing by Carcross on the South Klondike Highway #2 due to the Casino Project is consistent with traffic that residents are used to seeing in an average month, and in most months is below the average summer traffic values.

The traffic increase through Carcross is within the range of existing traffic. Mitigations proposed include compliance with all relevant traffic requirements in the Carcross area, including:

- Weight restrictions – weight restrictions are applied in the spring to protect highways from damage. On the Klondike highway, axle weights are historically reduced to 75% in late March or early April and increased back to 100% in May, with all restrictions rescinded by June (HPW, 2015).
- Speed limits – as posted.
- Air brake restrictions – as posted.
- Considerations for road conditions, including icy, slippery or snowy conditions.
- Applying safe following distances appropriate to the weight and speed of the vehicle.
- All other applicable regulations and safety considerations.

B.4.6 WATER MANAGEMENT PLAN

B.4.6.1 Conveyance of Water

B.4.6.1.1 R2-14

R2-14. Additional analysis regarding the appropriate PMP value for the design of the mine facilities. Specifically, utilize the full period of rainfall record as discussed by EcoMetrix (YOR 2014-0002-399-1), discuss the PMP contours presented in TP-47, and utilize other available methods of predicting PMP such as more recent publications regarding PMP estimates for eastern interior Alaska.

To clarify, the probable maximum precipitation (PMP) and 1:1,000 year return period rainfall event values were calculated to inform the selection of an appropriate Inflow Design Flood (IDF) for the Tailings Management Facility. The CDA Dam Safety Guidelines require that an appropriate IDF is an event equal to "one third between 1,000 years and the Probable Maximum Flood (PMF)" event (CDA, 2007). This value is used to calculate the storage required during operations. During closure, the IDF has been defined as the PMF. For the short-term Stage I TMF (preproduction and Year 1 of operations) the 72-hour 1:1,000 year event was adopted.

The IDF and PMF are derived from the PMP and potential snowmelt during occurrence of the PMP, to provide an estimate of flooding potential. The resulting total potential runoff depth from a combined return period rainfall event and snowmelt for the 24-hour and 72-hour events are:

- 72-hour 1:1,000 year total runoff depth = 201 mm;
- 24-hour PMP total runoff depth (24-hour PMF)= 175 mm; and
- 72-hour PMP total runoff depth (72-hour PMF) = 371 mm.

With an inflow catchment of 35 km^2, the resulting IDF flood volumes are:

- Starter Dam = 72-hour 1,000 year event = 7.0 million m^3;
- Operations Phase = 1/3 value between 1,000 year and 72-hour PMF event = 9.0 million m^3; and
- Closure Phase = 24-hour PMF = 6.1 million m^3.

Therefore, when storage requirements are most needed, during operations of the facility because an overflow spillway is not constructed, a PMP of 258 mm is actually used in the design.

Current estimates for PMP and PMF are initial values suitable for assessment purposes and will be reviewed for detailed design and construction purposes. As the project progresses into basic engineering and through the permitting process these values, including the data sources and methodologies used to establish these values, will undergo rigorous examination and review. The design of the TMF and HLF will be based upon the final determination of the PMP and PMF values developed by the EOR, as reviewed by the IERP, and reflected in the design documents submitted for regulatory review and license application processing. See Figure B.4.2-1 for a description of how initial values for key design features are incorporated into the design, construction and operation continuum.

CMC also notes that EcoMetrix states that *"… there is sufficient information available to assess implications during evaluation of the Project"* (YOR 2014-0002-399-1). CMC concurs with this statement and requests the

Executive Committee proceed with assessment recognizing CMC's commitment to examine the issue in greater detail in the basic engineering and permitting phases of the Project.

B.4.6.1.2 R2-15

R2-15. Typical cross-sections and design drawings of alignments for diversion ditching across the project site with particular focus around the HLF including:
a. confining embankment;
b. access road section; and
c. event ponds area.

Typical ditch design and alignment of the diversion ditching around the HLF is provided in Figure B.4.6-1. Diversion ditches around the heap leach facility will be constructed to intercept and divert surface runoff. The initial HLF development (Stage 1) will also include the complete development of the confining embankment, events pond and perimeter diversion ditches prior to commencing ore stacking and leaching. A series of diversion ditches will be constructed around the perimeter of the staged HLF to intercept overland surface runoff and convey flows to the TMF. Intermediate ditches within the HLF footprint will be constructed and decommissioned as necessary. Diversion ditches will be sized to convey the 100 year peak flow (Table B.4.6-1).

The alignments of the HLF diversion ditches are shown on Figure B.4.6-1. Diversion ditch requirements and dimensions are provided in Table B.4.6-1. At start-up, (Year -3), a temporary ditch (Ditch C) approximately six metres wide will be constructed that will divert surface runoff from the upper portion of the final HLF pad footprint. This temporary ditch will be decommissioned in Year 3 when the footprint of the HLF extends beyond El 1264 m.

Table B.4.6-1 HLF Diversion Ditch Requirements

Ditch Name	Length (m)	Water Depth 100 year event (m)	Total Ditch Width (m)	Velocity (m/s)	Flow Capacity (m^3/s)
Ditch A1	350	0.43	5.9	1.64	2.73
Ditch A2	930	0.27	4.3	4.04	2.77
Ditch A3	1110	0.37	4.7	5.29	5.36
Ditch A4	210	0.47	6.1	3.15	5.83
Ditch A5	110	0.32	4.5	6.77	5.72
Ditch B1	350	0.47	5.1	2.85	3.93
Ditch B2	1910	0.32	4.5	4.8	4.05
Ditch B3	120	0.48	5.1	2.9	4.13
Ditch B4	130	0.28	4.3	5.85	4.19
Ditch C	1250	0.49	6.2	1.51	2.95
Ditch A2	930	0.27	4.3	4.04	2.77

As described in the Water Management Plan (Appendix 4C), diversion ditches will typically be lined with vegetation, riprap, or other stable material, and are designed to divert non-contact surface runoff around mine facilities to downstream areas. Additionally, the topography of the HLF is such that should failure of the diversion ditches occur, surface runoff will simply be collected in the HLF and subsequently collected in the leachate

collection sump. Should failure of the leachate collection system occur, any discharge will be collected in the events pond, and finally, should failure of the events pond occur, all material will be collected within the TMF.

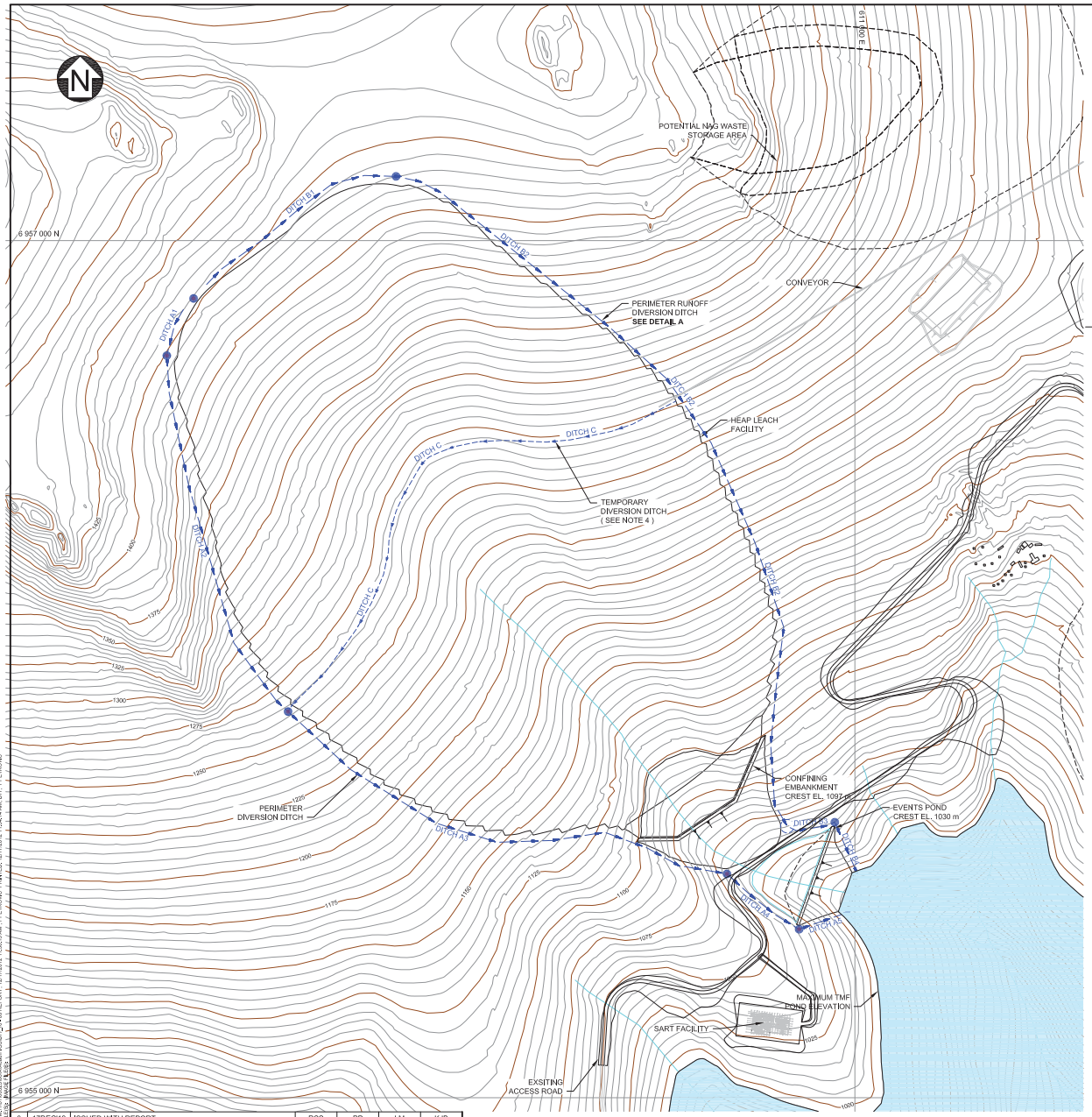
A series of diversion ditches will be installed upstream of the ore stockpiles to minimize the contact of runoff water with the ore stockpiles and divert surface flow to the TMF basin. Based on the topography at the Casino mine site, the total diversion ditch widths will range between 3-4 m for the protected ditch sections and 4-5 m for the shallow-grade earth lined sections. The diversion ditching system will meet the following design criteria:

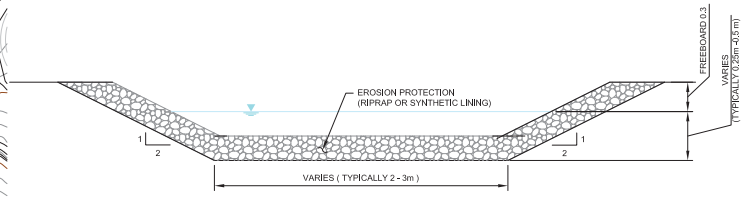
- Design storm conveyance: 1 in 100 year 24-hour duration storm event;
- Minimum freeboard = 0.3 m;
- Maximum design storm flow depth = 0.5 m;
- Minimum ditch grade = 0.01 m/m; and
- Minimum channel side slope = 2H:1V.

Sediment control fencing will be placed around the down-gradient perimeter sections of the ore stockpiles to prevent sediment discharge from the stockpiles.

At the Open Pit, a diversion ditch will be constructed to divert Canadian Creek around the Open Pit when the pit footprint intercepts the creek (approximately Year 10). Diversion ditches along the north and west pit crest are required to divert the surface runoff away from the pit during operations. These surface runoff ditches will capture and divert the majority of all runoff and snowmelt before the water flows into the pit and will reduce power requirements for pumping from the deeper levels of the pit. Ditches will need to be modified for different stages of pit development. It may be appropriate to include low permeability glacial till or synthetic liner materials along sections of these ditches in order to reduce ditch leakage.

Design drawings for the diversion and collection ditches will be prepared during the basic engineering phase (see Figure B.4.2-1), and designs will be provided in the Heap Leach Facilities Design and Construction Plan, the Storage Facility Design Plan, the Road Construction Plan and the Mine Development and Operations Plan, required for quartz mining under the Quartz Mine Act (Yukon Government, 2013).





A - DETAIL TYPICAL DITCH
SCALE B

LEGEND:

- TEMPORARY DIVERSION CHANNEL
- PERMANENT DIVERSION CHANNEL

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 5 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. TEMPORARY DIVERSION DITCH TO CONTROL DRAINAGE, TO BE CONSTRUCTED AT START OF HEAP LEACH FACILITY CONSTRUCTION AND PRIOR TO ORE LOADING.
5. REFER TO TABLE IN REPORT FOR MINIMUM DITCH DIMENSIONS

SCALE A 100 50 0 100 200 300 400 500 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	17DEC12	ISSUED WITH REPORT	RSS	PP	LM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

HEAP LEACH FACILITY WATER MANAGEMENT PLAN

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF NO. 9

Figure B.4.6-1 | REV 0

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B.4.6.2 Probability of Failure Analysis of Infrastructure Components

B.4.6.2.1 R2-16

R2-16. Details and rationale on the selection of return period design criteria for all the WMP components during all phases of the Project, including long-term closure. Details should include calculation of the failure probabilities.

The data provided in Table A.4.7-1 includes the 'Probability of Design Exceedance' for the design return period. This is calculated by:

$$p_e = \left(1 - \frac{1}{T}\right)^n$$

Where p_e = probability of exceedance

T = return period (e.g., 10 year, 200 years, 1000 years)

n = design life (years)

Table A.4.7-1 is included in this response. Further explanation of the rationale for each design criterion is provided after the table. The comment numbers (1 through 14) correspond to the numbers identifying each rationale in Table A.4.7-1.

(1) Design guidelines by (BC MELP, 2001)

During the early years of construction the WMP will serve strictly as a sediment control pond, and as such the pond will constantly discharge through a low level outlet. The storage in the pond will be able to accommodate the flow volume of the 10 year 24 hr storm event, with the pond overflowing through the spillway during the occurrence of a more extreme storm event. During such an event, the discharge and sediment load in the receiving waters will be so great that any discharge from the pond would not materially affect the downstream water quality.

During the later years of construction and throughout operations, the WMP will serve to manage both sediment loading and other water quality constituents. The low level outlet will be decommissioned and water levels will be controlled by continuous pump-back of water to the TMF. The current design concept is that the pond storage capacity has been set at the flow volume of the 10 year 24 hour storm event, with the understanding that any flood volume exceeding this would overflow through the spillway to the receiving waters. As discussed in the sediment pond rationale, the discharge of the receiving waters would be so great during such extreme flow events that any potential water quality affects would be de minimis. Design criteria for this structure, as well as design capacity of the pump back systems, will be reviewed and adjusted, if required, in discussions with regulatory agencies during the next level of design for the permitting phase of the project.

Table A.4.7-1 Summary of Design Criteria and Probability of Exceedances for Water Management Components

Report	Components	Return Period Design Criteria	Design Life Phase	Design Life (years)	Probability of Design Exceedance	Rationale	Reference (Page)
Water Management Plan Report	Water Management Pond (WMP)	10 yr, 24-hr storm event	Construction and Operation	33	97%	Design guidelines by (BC MELP, 2001) **(1)**	12
	WMP Overflow Spillway	200 yr, 24-hr storm event	Operation	33	15%	Small structure and mid to low consequence of exceedance **(2)**	12
		200 yr, 24-hr storm event	Closure	100	39%	Structure must operate in perpetuity **(3)**	15
	Coffer Dams	10 yr, 24-hr storm event	Construction	1	10%	Temporary structures **(4)**	12
	Diversion Ditches	100 yr, 24-hr storm event	Construction and Operation	33	28%	Reasonably low consequence of exceedance **(5)**	14
	Sediment Settling Ponds	10 yr, 24-hr storm event	Construction	2	19%	Design guidelines by (BC MELP, 2001) **(6)**	
	Sediment Settling Pond Spillway	200 yr 24 hr storm event	Construction	2	1%	Design guidelines by (BC MELP, 2001) **(7)**	13
Tailings Management Facility Report	TMF Pond and Spillway	Pond: 1000 year 72-hour storm	Up to Year 1 of Operation	3	0.3%	Large structure. Based on CDA Guidelines. **(8)**	
		Pond: 1/3 between the 72-hr 1000 yr storm and 72 hr PMF	Operation	28	0.03%		
		Spillway: PMF, 24-hr PMP + 100 year snowpack	Closure	-	By definition, the PMF cannot be exceeded.		
Heap Leach Feasibility Design Update Memo	HLF Spillway	200 yr, 24-hr storm event	Operation	33	15%	Small structure and mid to low consequence of exceedance. **(9)**	10
	HLF In-Heap Storage	Total capacity of 172,600 m^3 (90,000 m^3 for normal operating capacity and 82,600 m^3 for storm capacity based on 25 yr, 24-hr storm event)	Construction and Operation	33	74%	Low consequences if storage is exceeded. Overflow will discharge into the TMF. **(10)**	
	HLF Embankment Spillway	200 yr 24 hr storm event	Construction and Operation	33	15%	Small structure and mid to low consequence of exceedance. **(11)**	
	HLF Events Pond	74,000 m^3 of storage capacity based on the 100 yr storm event (rainfall + snowmelt)	Construction and Operation	33	28%	Storage capacity to contain excess HLF leachate and surface runoff. Reasonably low consequence of exceedance. **(12)**	29
	Events Pond Spillway	200 yr, 24-hr storm event	Construction and Operation	33	15%	Small structure and mid to low consequence of exceedance. **(13)**	29
	Diversion Ditches	100 yr, 24-hr storm event	Construction and Operation	33	28%	Reasonably low consequence of exceedance. **(14)**	31

(2) Small structure and mid to low consequence of exceedance

According to the Canadian Dam Association (CDA), a small structure with a mid to low consequence of exceedance should be have an inflow design flood with a return period between 1/100 years and 1/1000 years. The spillway will be designed for a 1/200 year flood flow, which is within this range. For the 33 year mine life, this event has a calculated probability of exceedance of 15%. However, as with most overflow structures, the spillway will be sized with freeboard (0.5 m in this case), which will effectively increase the flow capacity by a substantial amount such that the actual probability of exceedance would be much less than 15%. (For example, the discharge capacity of a 5 m wide and 1 m deep trapezoidal spillway is doubled if one includes the flow capacity of 0.5 m of freeboard).

(3) Structure must operate in perpetuity

This statement is incorrect. The structure must operate until the water quality meets discharge requirements. The period of required operation is not known. The water management plan states that “In closure, the TMF water management pond will be replaced by a larger pond.” When this larger pond is designed for construction prior to closure, an appropriately sized spillway for the structure will be included as part of the design, which will be based on information collected during the operational life of the Casino project. Furthermore, a wetland may be constructed downstream of the water management pond in closure, which will act as a dissipating filter to slow the release of water to the receiving environment.

(4) Temporary structures

The cofferdams are temporary structures and have a low consequence of failure. Furthermore, the spillways will be sized with 0.5 m of freeboard, which will effectively increase the flow capacity by a substantial amount such that the actual probability of exceedance over a 1 year period would be much less than 10%. As with the WMP, the design basis for these structures will be reviewed and adjusted, if need be, during the next level of design for the permitting phase of the project.

(5) Reasonably low consequence of exceedance

Exceedance of the design criteria of a diversion ditch will result in localized erosion with minimal consequences because the water and sediment will discharge into the TMF. The calculation for the Inflow Design Flood (IDF) for the TMF assumes that all ditches fail during the design storm event (the PMF).

(6) Design guidelines by (BC MELP, 2001)

The sediment ponds will be designed according to standard guidelines. The storage in the ponds will be able to accommodate the flow volume of the 10 year 24 hr storm event, with the ponds overflowing through spillways during the occurrence of more extreme storm events. During such events the discharge and sediment load in the receiving waters will be so great that any discharges from the ponds would not materially affect the downstream water quality.

(7) Design guidelines by (BC MELP, 2001)

The spillways for the sediment ponds will be designed according to standard guidelines. The spillways will be designed to pass the peak flow resulting from the 200 year 24 hr storm event, with 0.5 m of freeboard. This freeboard will effectively increase the flow capacity by a substantial amount such that the actual probability of exceedance in any 2 year period would be less than 1%.

(8) Large structure. Based on CDA Guidelines. The rationale for selection of the design events for the TMF pond and spillway is detailed in the TMF Feasibility Design Report (Appendix A.4D)

(9) Small structure and mid to low consequence of exceedance.

According to the CDA, a small structure with a mid to low consequence of exceedance should be have an inflow design flood with a return period between 1/100 years and 1/1000 years. The spillway will be designed for a 1/200 year flood flow, which is within this range. For the 33 year mine life, this event has a calculated probability of exceedance of 15%. However, the spillway will be sized with 0.5 m of freeboard, which will effectively increase the flow capacity by a substantial amount such that the actual probability of exceedance would be much less than 15%. Furthermore, the HLF will be located upstream of the TMF, so the consequences of failure are very low since the TMF will be able to contain any runoff. The TMF will be designed assuming that all upstream structures exceed their design criteria during the design storm event (the PMF).

(10) Low consequences if storage is exceeded. Overflow will discharge into the TMF.

(11) Small structure and mid to low consequence of exceedance.

The spillways for the HLF will be designed to pass the peak flow resulting from the 200 year 24 hr storm event, with 0.5 m of freeboard. This freeboard will effectively increase the flow capacity by a substantial amount, reducing the probability of exceedance.

Failure of a HLF spillway will result in localized erosion with minimal consequences because the water and sediment will discharge into the TMF. The TMF will be designed assuming that all upstream structures exceed their design criteria during the design storm event (the PMF).

(12) Storage capacity to contain excess HLF leachate and surface runoff. Reasonably low consequence of exceedance.

The storage in the events ponds will be able to accommodate the flow volume of the 10 year 24 hr storm event, with the ponds overflowing through spillways during the occurrence of more extreme storm events. All overflows will discharge into and be contained in the TMF.

(13) Small structure and mid to low consequence of exceedance.

The spillways for the HLF events pond will be designed to pass the peak flow resulting from the 200 year 24 hr storm event, with 0.5 m of freeboard. This freeboard will effectively increase the flow capacity by a substantial amount, reducing the actual probability of exceedance.

Failure of a HLF events pond spillway will result in localized erosion with minimal consequences because the water and sediment will discharge into the TMF. The TMF will be designed assuming that all upstream structures exceed their design criteria during the design storm event (the PMF).

(14) Reasonably low consequence of exceedance.

Failure of a diversion ditch will result in localized erosion with minimal consequences because the water and sediment will discharge into the TMF. The TMF will be designed assuming that all ditches exceed their design criteria during the design storm event (the PMF).

B.4.7 HEAP LEACH FACILITY

B.4.7.1 Liners

B.4.7.1.1 R2-17

R2-17. Additional supporting evidence to demonstrate the sufficiency of a 30 cm thick soil liner based on the actual conditions at the mine site (e.g. shear strength, slope stability, stack height, bedrock conditions).

See response to R2-18.

B.4.7.1.2 R2-18

R2-18. An outline of plausible mitigation strategies (e.g. intermediate liners; additional and/or higher standard liners) to ensure performance objectives of the HLF are achieved.

It is apparent that there is some confusion as to the design intent and function of elements of the liner system proposed for the Casino HLF. Please refer to the description of the liner system and function as described on pages 24 & 25 in Section 5.2 of the VA101-325/8-9 Rev 0. Please also refer to Figure 5.6, Liner and Embankment Detail. Two liner systems are described.

The first liner system is used up-slope of the area where ponding may occur and where the gradient of the lined area expedites the flow into the lower region (potential pond area) as depicted in Figure 5.6. What is referred to as a single liner system is used for this area. The single liner system consist of a single 80 mil LLDPE geomembrane under which there is a 300 mm layer of low permeability soil liner. Acting together they present two horizontal barriers to vertical flow. The 1 m thick over-liner is comprised of crush ore or natural soil with comparatively high permeability with two primary functions a) to conduct leachate flow to the leachate collection system described in Section 5.3, b) to provide physical protection of the 80 mil geomembrane from damage during ore placement.

The second liner system, referred to a double liner, is used in that portion of the leach pad where hydraulic loading from ponded leachate can occur. This liner system consists of an 80 mil geomembrane liner on top of a 300 mm low permeability soil liner over a second (60 mil in this instance) geomembrane liner. Together they present three horizontal barriers to vertical flow. The double liner is used in this area of the leach pad because this area is subject to a hydraulic head form ponded solution.

The geomembrane liners provided are high quality and of a thickness appropriate for the service and consistent with good design practice. In particular, the use of a 300 mm low permeability soil liner between the low-density polyethylene geomembrane and geotextile layer is typical of a valley-fill heap leach. In CMC's previous response, the Brewery Creek heap leach facility was brought forward as an example of a facility which had a 300 mm soil liner. Additionally the Eagle Gold Project also specifies a 300 mm soil liner, which is of a similar scale to the Casino project heap leach.

There are no intermediate liners included the design. Test work completed to-date and engineering evaluation of the expected material properties of the crushed ores does not indicate a need for the use of intermediate liners. As is the case for all heap leach operations, performance of the system will be monitored during operations to detect any loss of conductivity or other concerns. If such was to occur, design solutions or procedural changes will

be implemented. The change control procedure outlined in R2-02 would be used to effect a design change including seeking the necessary regulatory approval to implement the change.

B.4.7.2 Leak Detection and Recovery

B.4.7.2.1 R2-19

R2-19. Clarification on how one portion of the pad versus another portion will be isolated if a leak is detected. In addition, please provide a full detail design diagram of the components used in the heap leach facility including placement of the LDRS components and how they interact.

The HLF is comprised of 16 independent cells and solution emitters are configured in a manifold in such manner that solution flow can be turned off for any specified cell if a leak is suspected within that cell. As the HLF has 16 independently monitored “cells” there will also be a correspondent 16 independently controlled barren solution manifolds.

In the event that a leak within the independent cell cannot be repaired CMC operations will abandon the effected cell, following measures outlined in closure (Section 4.5.2.2), CMC will rinse down the effected cell, decommission barren solution plumbing and delivery for the cell in such manner that contamination from other cells will not be possible. This decommissioned cell will still have in operation its LDRS components, and monitoring of the cell would continue.

The Leak Detection and Recovery System is described in the response to R2-20 below.

B.4.7.2.2 R2-20

R2-20. Details on the maintenance and repair of LDRS sumps.

The Leak Detection and Recovery System (LDRS) is designed to capture and convey any solution which leaks through the overlying geomembrane and low permeability soil layers. As presented in the detail in Appendix A.4C Feasibility Design of the Heap Leach Facility, there are two components to the LDRS, the LDRS under the double lined area and the LDRS under the single lined area.

The LDRS under the double lined area consists of a 0.3 metre thick sand layer which is embedded with 100 mm diameter perforated CPT collection pipes. A non-woven needle punched geotextile overlies the LDRS sand layer to prevent particles from the above low permeability soil layer from entering the LDRS, clogging the sand and impeding drainage flow.

The LDRS under the single lined area consists of a network of drainage ‘trenches’ which contain 100 mm diameter perforated CPT collection pipes surrounded by drainage sand. The trenches are aligned underneath the ‘Collection Header’ and ‘Main Collection Header’ pipes which are part of the Leachate Collection system embedded in the above overliner layer. These drainage trenches ‘feed’ into the LDRS layer underlying the double lined area in the lower heap leach portion.

Any leakage recovered by the LDRS will be conveyed into the LDRS sump at the toe of the confining embankment. A level-switch controlled submersible sump pump will transfer the recovered solution up the embankment slope via a pipe installed within the LDRS sand layer and connect into the main solution recovery line for processing. Monitoring of the leakage recovery will be undertaken through continuous monitoring of the pump hour records.

In order to facilitate advanced leak detection source identification, the entire heap leach pad leachate collection system is sub-divided into 16 independently monitored areas or “cells” separated by small cell division berms. Each of these cells has a dedicated leakage detection collection system comprising a drain gravel layer beneath the inner composite liner system which conveys the leakage to a 100 mm diameter perforated collection pipe within the LDRS collection trench. The LDRS ditches flow by gravity at a minimum 0.5 % slope towards the LDRS collection sump structures, located along the right and left sides of the leach pad. The flow rates from the dedicated collection pipes are continuously monitored and measured prior to discharging into a sump. A float switch within the sump triggers a submersible pump which pumps the accumulated solution via a pipeline (located between the two liners on the confining embankment) back onto the heap pad.

LDRS sumps will be inspected for integrity on a regular basis. Maintenance personnel will visually check the condition of the sumps and will repair or replace the sump on an as-needed basis. Materials for repair of LDRS pumps will be inventoried by CMC maintenance. Any repairs or service will be recorded by CMC and monitored for performance.

Common monitoring for LDRS sumps includes:

- Vibrating wire piezometers installed in the sump to monitor fluid levels;
- Monitoring and return of any collected solution using submersible pumps covered with carbon steel pipes slotted to avoid migration of the LDRS drain aggregate into the pipes; and
- Visual inspections for flow and pumping as required.

B.4.7.3 Leachate Solution and Water Flows

B.4.7.3.1 R2-21

R2-21. Details on the pipelines, pumps, and related infrastructure connecting the components of the HLF including SART, cyanide, and gold extraction facilities. Include details on pipeline alignments and leak detection measures.

Pregnant Leachate solution (PLS) is transferred from sumps, located within the lined heap leach pad, via submersible pumps to the PLS distribution tank, located within the enclosed process facility, through an insulated and heat traced HDPE pipeline. Reclaimed solution from the lined events pond is transferred to the PLS distribution tank or to the Barren Leachate Solution (BLS) distribution tank as circumstances require via an insulated and heat traced HDPE pipeline. Note the events pond pump is not normally operating and is used infrequently in the event of solutions accumulating in the pond or to remove rainfall or snow melt. A submersible pump installed in a lined sump returns any leakage captured from the events pond by the leak detection system back to the events pond.

The BLS distribution tank is a partially in-ground & covered concrete tank located adjacent to the process facility building. BLS is pumped from this tank by vertical turbine style pumps installed on the tank. The approximate distance from the heap leach pad to the processing facility housing the distribution tanks is about 600 m. BLS pipelines from the BLS tank and pump to the heap leach pad are insulated and heated traced.

All PLS & BLS pipelines connecting the heap leach pad to the process facilities are located within a HDPE lined containment ditch protected by a 2m high chain-link fence. Where the lines must pass under a road the pipelines are installed inside larger diameter pipes that provide physical protection to the operating pipelines as well as double containment. See containment sketch. Details of the pipeline alignments, profiles and road crossings will

be provided to the Regulator as part of the Quartz Mining License and Yukon Water Use License applications during the detailed engineering phase.

The lined containment ditch and insulated pipeline will be visually monitored for condition and performance by CMC operations personnel.

Please refer to drawings 050-FS-003 & 004 in Appendix A.4M for more details.

B.4.7.3.2 R2-22

R2-22. Clarify whether CMC intends to seek certification under the International Cyanide Management Code and conduct independent third-party auditing of its conformance with the cyanide management standards of practice. If so, clarify whether results of independent audits would be made available for review by interested stakeholders.

On July 08, 2015 Western Copper and Gold Corporation (and consequently wholly owned subsidiary CMC) became a signatory of the International Cyanide Management Code (ICMC). As a signatory, CMC will comply with the Principles and Standards of Practice that make up the ICMC. Once operational, CMC will seek certification in compliance with the ICMC, which will require meeting performance goals and objectives as detailed by the International Cyanide Management Institute (ICMI, 2015).

As a signatory, CMC will undergo a third-party Verification Audit for certification under the ICMC to confirm that the operations, including cyanide production, transportation or handling suppliers, meet the ICMCs Principles and Standards of Practice for these activities (ICMI, 2015). Summary Audit Reports and any Corrective Action Plans will be posted for public review by the ICMI (ICMI, 2015).

B.4.7.4 Ore Stacking Rate

B.4.7.4.1 R2-23

R2-23. Indication when results are expected from the additional test work and how these results will be provided in a timely manner iteratively throughout the screening process.

At this time, no additional testing of heap leach material is underway other than ongoing geochemical characterization of leached material, from which results will be submitted when complete. Additional reports received since the submission of SIR-A are included as part of this submission in Appendices B.4E and B4F. CMC has no immediate plans to initiate any further metallurgical or material characterization work on the heap leach material.

B.4.8 TAILINGS MANAGEMENT FACILITY

B.4.8.1 Design Methodology and Feasibility

B.4.8.1.1 R2-24

R2-24. An updated TMF dam hazard classification that is informed by the IGRP-overseen risk assessment and related dam breach/inundation study. Where relevant, also include details regarding the impacts to dam design and mitigation strategies as a result of this additional work.

The TMF risk assessment is provided in the response to R2-4. The dam breach inundation study, and corresponding environmental and socio-economic evaluations of impacts are provided in Appendix B.4C. There has been no change to the dam hazard classification and no change to the proposed design at this time; however, at each phase of the design process, the risk assessment will be re-visited to determine if reviews or updates to the design have changed the risk ratings.

As described in the Report on the Feasibility Design of the Tailings Management Facility (Appendix A.4D), during the closure phase, the ultimate TMF dam is designed to pass the probable maximum flood (PMF) through the spillway and is capable of withstanding a maximum design earthquake (MDE). It therefore meets the most stringent design criteria suggested by the CDA Dam Safety Guidelines (CDA, 2007), equivalent to an “extreme” dam classification. Changing the design flood criteria for operations would not fundamentally change the TMF design. Larger storm events can be accommodated in the design by modifying the dam staging and by raising the intermediate crest elevations.

Concerns regarding the TMF dam classification appear to be based upon the following comments from EcoMetrix (2014-0002-399-1) and SNC-Lavalin Inc (2014-0002-403-1), which CMC has addressed below:

1. In the review of R65, EcoMetrix states that “the reviewer notes that major impact to fish population (threatened or other species) and habitat is not of relatively small concern” (page 25). CMC concurs with this statement but notes that there are no threatened species in the area likely to be impacted by a breach. The value of downstream fish and fish habitat has been incorporated into classification of the dam as “High” (per CDA, 2007). An assessment of effects of the dam breach inundation on fish and aquatic resources is provided in Appendix B.4C.
2. EcoMetrix also states several times in the review document that the proposed dam is “unprecedented” and uses this argument to support their contention that the dam should therefore be classified as Extreme. There are in fact several existing dams in operations, undergoing reclamation, and planned that are very comparable to the Casino dam (see Table B.4.8-1). These examples include cyclone sand dams that have:
    - Placement of sand at higher throughputs;
    - Greater dam heights (exceeding 300 m);
    - Dams in regions of higher seismicity; and
    - Placement of sand at temperatures far below freezing (up to -40 ºC).

    Re-classifying the dam to extreme is not justified based on the argument that there is no precedent.

Table B.4.8-1 Summary of Existing Cyclone Sand Tailings Dams

	Casino	Cerro Verde	Quillayes	El Mauro	KSM SE Dam	Highland Valley L-L Dam
Status	Design	Operating	Closure	Operating	Design (Approved)	Operating
Starter dam height[1] (m)	105	95	85	85	105	45
Maximum height of cyclone sand[1] (m)	200	195	220	235	155	115
Total height of dam[1] (m)	285	305	300	310	280	180
Owner	CMC	SMCV	Antofagasta PLC.	Antofagasta PLC.	Seabridge Gold Inc.	Teck
Engineer	Knight Piésold	MWH	Geotecnica	Geotecnica	KCB	Bechtel / KCB
Reference		Obermeyer and Alexieva, 2011	Barrera, Valenzuela and Campana, 2011		Klohn Crippen Berger, 2012	Klohn Crippen Berger, 2012

1. Note that dam height is measured from the lowest point in the general foundations to the crest of the dam (ICOLD, 1932)

3. In their review of Section A.4.9 of the SIR-A, SNC-Lavalin states “For example, a dam classified as High would be designed for exceedance probabilities of 2/3 between 1/1000 and PMF (not 1/3 between 1/1000 and PMF which is recommended for dams meant to last for decades)” (page 19). To clarify, the TMF is designed for exceedance probabilities of 1/3 between 1/1000 and PMF only during the 22 year operating phase. Post-closure the design for the spillway is for the PMF.

4. EcoMetrix and SNC_Lavalin also make multiple mention of re-evaluation of design criteria, such as the OBE, MDE, PMP, PMF and IDF. The verification of these values will be part of the design updates conducted as part of standard engineering refinement (see Figure B.4.2-1). Further, CMC proposes to have the IERP review the design basis for the TMF including, but not limited to: data sources, data quality, underlying assumptions and methodologies used to determine key design values throughout the design process. This includes values for OBE, MDE, PMP, PMF, IDF, and others. Other reviews to be conducted by the IERP are outlined in the response to R2-1.

B.4.8.1.2 R2-25

R2-25. Additional comparison information about natural analogies within similar environments. Include estimates of the hydraulic gradient(s) for the TMF dam, throughout its lifecycle (i.e. in perpetuity), and include a discussion that reflects on the findings of the Bjelkevik (2005) report (i.e. compare the estimated hydraulic gradient of the TMF with the hydraulic gradient of natural analogies that have demonstrated long-term stability).

Exceeding the hydraulic gradients observed in nature does not necessarily mean that a structure will not be stable in the long term. Hydraulic gradients in natural analogues are not applicable standards to the design of large engineered structures. However, CMC has provided information regarding existing facilities. As described above in the response to R2–24, the existing Los Quillayes, El Mauro and Cerro Verde mines, as well as the regulatory approved KSM mine have tailings impoundment facilities that are directly comparable to the proposed Casino TMF in terms of overall height and depth of cyclone tailings sand used in the downstream shell to provide strength to the structure. These operations establish ample precedent for the Casino design approach.

The Gibraltar (Klohn Crippen Berger, 2014), Highland Valley (Klohn Crippen Berger, 2012), and Kemess (Lysay, Davidson, and Martin, 2007) mines are Canadian operations with tailings impoundments where cycloned tailings sands are being placed and compacted in cells similar to that proposed for Casino at temperatures well below freezing. Gibraltar and Highland Valley are located in a continental climate region and Highland Valley has placed and compacted sands to -10°C. Kemess is located in a sub-arctic region and the placement and compaction of coarse sands down to -40°C has been documented by Lysay, Davidson, and Martin (2007). KSM and Casino projects will both be constructed and operated in sub-arctic regions with temperature regimes comparable to that of Kemess.

The *Dam Guide: Expectations and Required Information* (YESAB, 2012) clearly sets out the information requirements for Assessment and Regulatory review purposes. Information provided to-date demonstrates that the Casino TMF design is consistent with good engineering practice, within the bounds of current industry experience and best practice. It is fully recognized that additional information will be provided as the TMF design progresses through engineering design (Figure B.4.2-1) and further details may be provided through the licensing process as stated in the Dam Guide.

B.4.8.1.3 R2-26

R2-26. Additional information regarding the factor of safety including:
a. The factor of safety under pseudo-static condition, since the minimum factor of safety for slope stability under seismic loading is 1.0 and not less than 1.0 (refer to Table 6-3 of Canadian Dam Safety Guideline, 2007).
b. Was the excess pore pressure during the construction period and before the embankment rise considered?
c. Confirmation that the stability analysis during different stages of construction and impounding meets the minimum factor of safety proposed by CDA such that: the minimum factor of safety of 1.3 "Before the reservoir feeling" and FOS of 1.5 at the "normal reservoir level".

Design details and code or regulation compliance issues, such as factors of safety, will be further addressed during the basic engineering phase and reflected in the final design basis (Figure B.4.2-1). All key aspects of the final design basis will be established at that time, reviewed by the IERP and the final design basis will be provided in the Quartz Mining Licence and Water Use licence applications. Current CDA Dam Safety Guidelines will form the basis for all design for the construction and operation of the TMF.

CMC will design, construct and operate the Casino facilities in compliance with current codes and regulations; verifiable through the regulatory review and licensing process. For purposes of Assessment, YESAB should presume that all proposed CMC facilities, including the TMF and HLF, will be designed, constructed and operated in full compliance with code requirements, license terms and conditions and that the appropriate regulator will fully discharge its obligations to protect the public interest.

In response to request R2-26:

a. The factor of safety under pseudo-static condition will exceed 1. The pseudo-static analysis applies a horizontal force (seismic coefficient) to the model to simulate earthquake loading. In embankment stability analyses the seismic coefficient is commonly taken equal to one-half the peak ground acceleration at bedrock level, as suggested by Hynes-Griffin and Franklin (1984). This conservative method implies limited deformations (smaller than 1 m) are acceptable during an earthquake. The peak ground acceleration of the 1 in 10,000 year earthquake at Casino is 0.22g, which leads to a seismic coefficient of 0.11.

   The yield acceleration is the threshold acceleration acting upon a sliding mass above which permanent deformations occur. The yield acceleration for the main embankment is approximately 0.3 g, as described in Appendix C of the TMF design report (Appendix A.4D). Since the seismic coefficient for the 1 in 10,000 year earthquake is smaller than the yield acceleration, stability analyses result in a factor of safety exceeding 1.

   More detailed stability analyses will be conducted during detailed design.

b. Excess pore pressure was not considered during feasibility design, as the components that dominate the stability of the TMF Main Embankment are the shell zone and the foundation strength. The shell zone will be constructed from free draining cyclone sand material that will not result in excess pore pressures during construction. Additional drainage provisions will be included as required to satisfy the free draining nature of the embankment shell. The embankment foundation is not sensitive to excess pore pressures due to the removal of overburden materials.

   The potential for development of excess pore pressures will be further evaluated in detailed design.

c. The stability analysis during different stages of construction and impounding meets or exceeds a factor of safety of 1.5. Additional stability analyses to demonstrate the TMF meets or exceeds a factor of safety of 1.5 during operations will be provided during basic and detailed engineering.

B.4.8.1.4 R2-27

R2-27. A conceptual operations, maintenance and surveillance (OM&S) plan to demonstrate how the TMF will be managed in both the operational and closure periods. At a minimum, this plan will meet the current Mining Association of Canada's (MAC) guidance material for tailings management facilities. The OM&S plan must:
a. Comprehensively address how custodial transfer will occur for all liability associated with this project. This aspect of the plan will include criteria for custodial transfer (e.g. to whom; timing; security funding; other obligations) and consider scenarios such as abandonment and end-of-mine life transfer. Provide examples of successful custodial transfer of comparable projects.
b. Include supporting information that addresses monitoring and remediation activities that may be required during closure including the extent of remediation required in event of a maximum design earthquake. The plan must also consider response to multiple maximum design earthquakes that may occur considering the TMF is proposed to remain in perpetuity.
c. Evaluate the potential effects of climate change on the Project through all phases, in perpetuity.

Preliminary plans that will guide the design, construction, operation, and eventual closure and post-closure activities of the Casino TMF have been prepared and are provided in the following Appendices:

- Guide to the Management of the Casino Tailings Facility (Appendix B.4A);
- Casino Project, Operation, Maintenance and Surveillance Manual (OM&S) (Appendix B.4D).

Western Copper and Gold (and consequently wholly owned subsidiary CMC) is a member of the Mining Association of Canada (MAC) and these two plans are being developed based upon MAC guidelines. The CMC plans will be consistent with the intent and requirements of the MAC guidelines and will be implemented in the detailed engineering phase. CMC wishes to acknowledge and thank MAC for their support and assistance in the preparation of these important documents.

The preliminary plans clearly indicate the comprehensive scope and content of the plans. The plans provide a management and training guide as well as defining a comprehensive monitoring and reporting plan to ensure a safe and environmentally responsible development and operation of the Casino TMF. Further development of these plans will be conducted during the detailed engineering phase when the necessary supporting design documents become available. As per the Dam Guide (YESAB, 2012) the completed guides will be submitted in support of the Quartz Mining Licence and Yukon Water Use Licence applications.

In response to request R2-27:

a. Custodial transfer of the TMF, and indeed the entire Casino mine site, will be discussed during the Quartz Mining License application process. The criteria to be met to affect a custodial transfer as well as timing, security requirements and other considerations for such a transfer will be agreed upon through these discussions.

b. As stated previously, analysis of the TMF structure by the EOR indicates that minimal deformation of the dam is likely to occur under the design earthquake conditions. As an example, the Los Quiallyes dam in Chile (which is comparable to the Casino dam) has experienced large earthquakes with minimal deformation (Barrera, Valenzuela and Campana, 2011).

   As a practical precautionary approach, it would be prudent to set levels for seismic events and for flood events that would trigger the requirement for a site inspection to determine if any remedial work is required. The trigger levels will be included in the final OM&S manual and in the final dam design criteria established in the design stage.

c. As more fully discussed in the response to R2-2, the effects of climate change will be addressed in the periodic (5 year) assessments of the TMF facility during operations and in post-closure.

B.4.8.1.5 R2-28

R2-28. Detail on the care and maintenance costs in perpetuity. This estimate will be supported by the OM&S plan, which will document the ongoing care and maintenance requirements during the closure and post-closure period. This estimate must consider costs for all liability associated with the mine site infrastructure including accidents and malfunctions

As described in the Guide to the Management of the Casino Tailings Management Facility (Appendix B.4A), the TMF will be designed for closure, including protection of public health and safety, mitigation of negative environmental impacts and acceptable post-closure use within a feasible technical and economic framework. Decommissioning and closure of the TMF will be conducted in accordance with the criteria and procedures outlined in Section 9 of Appendix B.4A, and includes:

- Being in conformance with design;
- Providing continued protection of the environment and public health and safety;
- Mitigating negative environmental impacts;

- Meeting regulatory requirements, land use objectives, financial assurance commitments, company policies and standards, sound engineering and environmental practices, and commitments;
- Providing for long-term care and maintenance; and
- Ensuring long-term stability of tailings, dams, related facilities and structures.

The Operation, Maintenance and Surveillance (OM&S) Manual (preliminary version provided in Appendix B.4A) will be updated in advance of closure to:

- Identify and assess new environmental concerns that have become apparent since the plan was approved;
- Identify and assess potential environmental impacts that may be caused by the implementation of closure; and
- Assess alternative technology for closure.

A review of the progressive reclamation and reclamation and closure research conducted during operations will be conducted to update the closure plan with the most up-to-date information and techniques.

Risk management tools prepared for the closure period will include:

- Risk management plans to minimize the likelihood of adverse safety or environmental impacts, which will evaluate the risks associated with possible triggers and failure modes, identify possible impacts on the environment, public health and safety and determine the parameters that can have an impact on these triggers and failure modes;
- Contingency plans; and
- Emergency preparedness and response plans, which will identify possible accident or emergency situations, detail responses to emergency situations and prevent and mitigate on- and off-site environmental and safety impacts associated with emergency situations, as well as establishing procedures for periodic review, testing and distribution of the emergency preparedness and response plans within the organization and to potentially affected external parties.

A checking and corrective action procedure will be implemented, which will include periodic inspections to ensure compliance with regulatory requirements and conformance with design objectives, plans and commitments. The periodic review and subsequent audit and assessment of the TMF will be conducted to:

- Verify design assumptions against actual conditions and performance;
- Revisit or update the decommissioning and closing design and/or plans;
- Re-evaluate downstream risks;
- Update the risk assessment; and
- Evaluate the need for changes or updates to risk management plans, contingency plans and emergency preparedness and response plans.

And corrective action will be undertaken and documented as required.

Finally, an annual tailings management review for continual improvement will be conducted, to:

- Evaluate the performance of the tailings management system, considering inspection, audit and assessment reports, changing circumstances, monitoring results, spills and other incidents, recommendations and the commitment to continual improvement;
- Evaluate the continuing adequacy of, and need for changes to, policies and objectives and performance of the tailings management system;
- Address the need for changes to commitments to communities of interest; and
- Report the observations and conclusions of this annual review of tailings management to the accountable executive officer.

Preliminary post-closure monitoring and maintenance costs were provided in the response to R144 and included feasibility level values for monitoring and inspections and annual passive treatment of pit water. For a 200 year period of post-closure activity, at a 3.5% discount rate, the present value for post-closure monitoring and maintenance was ~$20M.

The executive committee has requested that the cost estimate for on-going care and maintenance during the post-closure period be extended to include accidents and malfunctions. As requested, the cost estimate has been updated to include event driven inspections and repairs of the tailings management and heap leach facilities. While these costs will only arise should a major environmental event occur (i.e., earthquake, extreme precipitation, forest fire), they have been incorporated into the annual cost to express the worst case scenario for post-closure monitoring. This update results in a present value of $32M over 200 years, equivalent to approximately $1M per year. These updated costs have been reflected in the overall security estimate provided in R2-85 as well.

For costs into perpetuity, after 200 years, the incremental cost at a discounted rate become negligible. For example, at 200 years, the cost is $31,963,313, after 400 years, the cost increases $32,854 to $31,996,166 and after 1000 years the cost increases only a further $34 to $31,996,200.

Table B.4.8-2 Post-Closure Care and Maintenance Cost Estimate

	Units	Quantity	Unit Cost	Cost
Water Quality Monitoring	bi-annually	2	$50,000	$100,000
Water quality sampling in TMF, HLF, Open Pit, Casino Creek and Dip Creek				
Site Water Management				
Compile data on flows, runoff, water quality for reporting and ongoing management of water control system	annually	1	$50,000	$50,000
Tailings Management Facility				
Dam and spillway geotechnical inspections: Annual Inspection	annually	1	$50,000	$50,000
External inspection and audit	every 3 years	0.3	$20,000	$6,667
Dam and spillway geotechnical inspections: Dam Safety Review	every 5 years	0.2	$100,000	$20,000
Event driven inspection	As required	n/a	$10,000	$10,000
Event driven repairs (e.g., repair rip rap in spillway, repair erosion on face of dam after major rain event, rair dam crest to correct settlement from an earthquake, repair berms in wetland due to settlement or high flow damage)	As required	n/a	$200,000	$200,000
Wetland maintenance and monitoring	annually	1	$50,000	$50,000
Open Pit				
Operation of water control system (remote control of valves)	annually	1	$2,000	$2,000
Inspection of energy system (solar cells, batteries, etc)	annually	1	$2,000	$2,000
Replacement of energy system components	every 10 years	0.1	$2,000	$200
Inspection of piping/valves, repair/replacement as needed	annually	1	$2,000	$2,000
Passive treatment of pit water	As required	1	$500,000	$500,000
Heap Leach Facility				
Inspect/repair erosion on face of dam after major rain event	As required	n/a	$50,000	$50,000
Provide nutrients for bio-reactor (not expected for long-term)	annually	1	$2,000	$2,000
Other Requirements				
Transportation	each	1	$40,000	$40,000
Power and heat (5 months per year)	monthly	5	$5,000	$25,000
General administrative expenses (5 months per year)	monthly	5	$2,000	$10,000
			Annual post-closure costs	$ 1,119,867
			Discount rate for calculation of net present value of post-closure cost	3.5%
			Years of post-closure activity	200
			Present Value of payment stream	**$ 31,963,303**

B.4.8.1.6 R2-29

R2-29. Demonstrate how the TMF dam will be able to achieve a steady state condition for passive care during the post-closure of this project (i.e. in perpetuity).

Design of the TMF dam was based on steady state conditions for the closure of the facility. In other words, the TMF was "designed for closure" and construction and operational components are designed to meet the ultimate closure objectives. For example, the minimum acceptable factor of safety for the tailings embankment under static conditions is 1.5 for long-term (steady-state and post-closure), which was incorporated into the embankment design. During closure, TMF components are designed to the highest possible standard (e.g., flood routing for the PMF) with redundant design components such as construction of the spillway in bedrock through the dam abutment. Other examples of TMF components designed to the highest possible standard include:

- Closure freeboard will meet CDA Dam Safety Guidelines at closure, and pond storage will increase in time due to settlement of tailings.
- The crest of the dam will be armored to protect against erosion, and to provide frost protection for the top of the core of the dam.
- The downstream face of dam will be vegetated and contoured to control erosion.
- Runoff will be directed into rip rap lined channels on the dam, and abutment slopes where feasible.
- No active care will be required to maintain any part of the TMF.

Passive care of the TMF during closure will consist of:

- Inspections (see the response to R2-28);
- Reading and maintenance of instrumentation;
- Periodically, as required:
    - Repair of any erosion due to extreme precipitation;
    - Repair of rip rap in non-bedrock segment of spillway;
    - Periodic removal of large trees; and
    - Restore vegetation after forest fire, and control erosion.

B.4.8.2 TMF Dam Failure

B.4.8.2.1 R2-30

R2-30. A dam breach analysis with water/tailings inundation modeling. Include information related to the IGRPs oversight and review of this work. The analysis must be consistent with the Canadian Dam Association's (2007) dam safety guidelines and include:

a. probable maximum flood inundation map showing the maximum extent of flooding relating to a sudden full storage embankment breach extending to when expected flooding is within the natural water channels;
b. an assessment of environmental and human impacts associated with a release of tailings;
c. an assessment of potential impacts to First Nation Settlement Lands;
d. an assessment of impacts to downstream infrastructure;
e. mitigation measures in the event of a tailings breach; and,
f. for each proposed breach scenario, a cross section of the critical TMF embankment, proposed loading factors, and each scenario's factor of safety.

The Dam Breach Inundation Study is provided in Appendix B.4C, and is accompanied by environmental and socio-economic impact assessments. As stated in the response to R2-24 the preliminary design basis including the key design values of PMP, PMF, and IDF will be reviewed in the process of establishing the final design basis for the Project. This review will be informed by the results of the inundation study and the final design basis will also reflect the critical review by the IERP. The resulting final design basis will be fully consistent with the CDA Dam Safety Guidelines and will be the basis of the project application for regulatory review and license application.

B.4.8.3 Quantity and Quality of Borrow Source Materials

B.4.8.3.1 R2-31

R2-31. Detailed information on the sources and quantities for all borrow materials that are required for all mine site infrastructure, the airstrip and airstrip access road, and the Freegold road upgrade and extension, throughout all phases. This information will be based on site investigations and will include: confirmation of the depth and areal extent of the proposed aggregate borrow sources; and, characterization of the physical and chemical variability of materials (i.e. quality and suitability for intended use) required for mine site infrastructure.

Mine Site and Yukon River Pipeline Access Road

The required quantities for borrow materials at the mine site are summarized in Table B.4.8-3 and the locations for borrow are provided in Figure B.4.8-1, Figure B.4.8-2 and Figure B.4.8-3. Further details of quantities are provided in Appendix A.4Q Mine Site Borrow Materials Assessment Report.

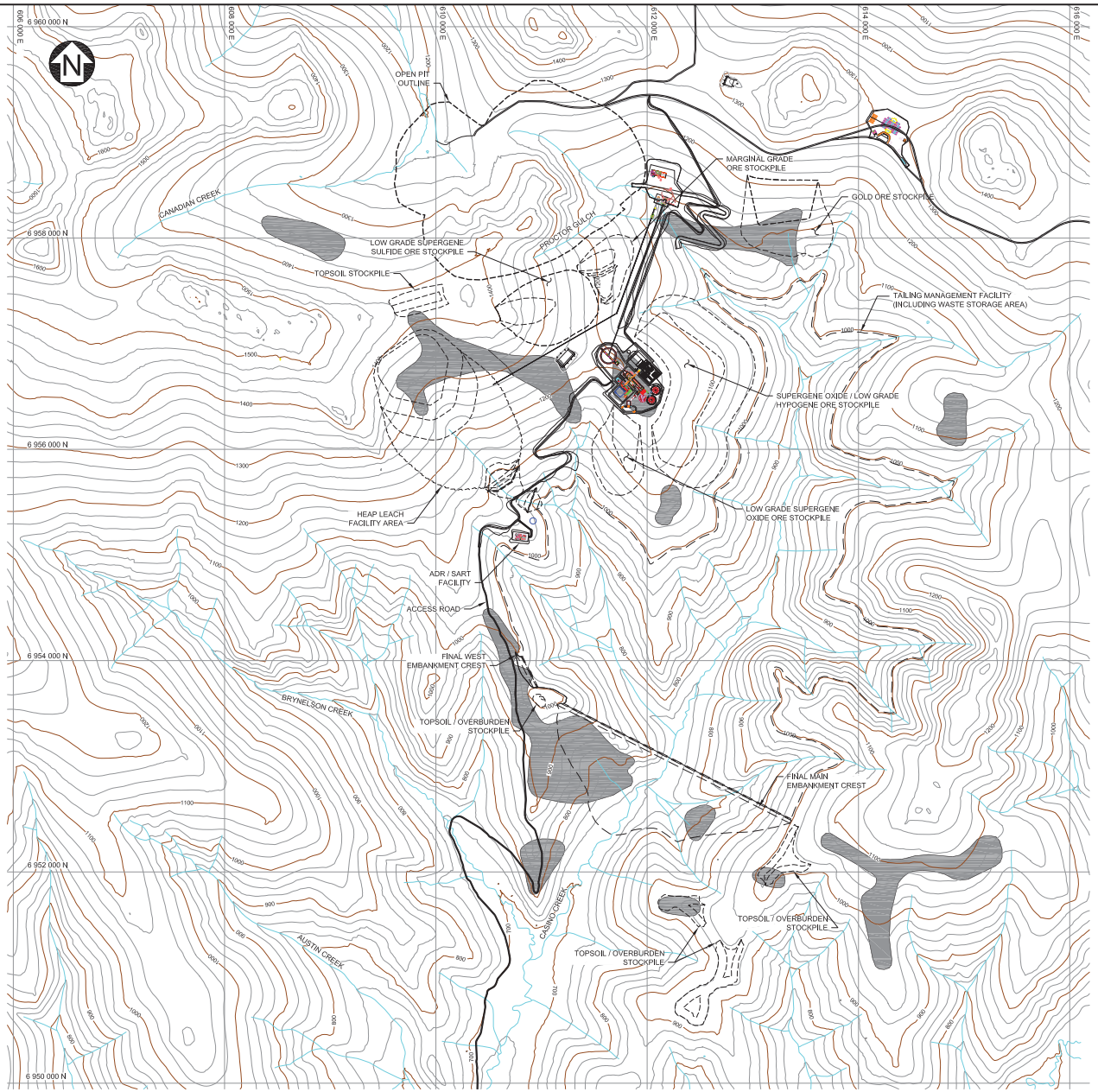
A geochemical assessment of these materials is provided in Appendix A.7K, and indicate that the borrow material from the majority of locations has a very low ML/ARD potential as the majority of samples have total sulphur values < 0.1% and little or no sulphide-sulphur mineralization. However, there is very little carbonate content and portions of the borrow material from the areas underlying the low grade stockpiles, the heap leach facility and the main power plant, may initially have mildly acidic paste pH values (paste pH < 5).

Organic acidity rather than sulphide acidity appears to be responsible for the depressed pH from these samples as demonstrated by the organic carbon content. These materials will not be a source of ARD.

ML/ARD management for the mine site is further described in the ML/ARD Management and Monitoring Plan (Appendix A.22H).

Table B.4.8-3 Mine Site Borrow Material Requirements

	Line Item	Required Volume (m^3)	Available Quantity (m3)
Low Permeability Material	Tailings Management Facility – Starter Dam	3,400,000	3,700,000
	Tailings Management Facility – Final Dam (excluding Starter Dam)	6,800,000	
	Heap Leach Facility	530,000	
	Miscellaneous (allowance for small ponds and other structures)	500,000	
Filter and Transition Zone Material	Tailings Management Facility – Starter Dam	250,000	6,500,000
	Tailings Management Facility – Final Dam (excluding Starter Dam)	1,350,000	
	Heap Leach Facility	1,840,000	
	Miscellaneous (allowance for small ponds and other structures)	200,000	
General Fill Material	Tailings Management Facility – Starter Dam	7,300,000	32,370,000
	Tailings Management Facility – Final Dam (excluding Starter Dam)	1,000,000	
	Heap Leach Facility	2,290,000	
	Miscellaneous (allowance for small ponds and other structures)	500,000	
Aggregate	Fine Concrete Aggregate	20,000	70,000
	Bedding Sand	45,000	
	Coarse Concrete Aggregate	40,000	300,000
	Structural Fill	220,000	



LEGEND:

LOW PERMEABILITY MATERIAL BORROW AREA

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. OPEN PIT IS SHOWN AT ITS FINAL OUTLINE AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).
5. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
6. HEAP LEACH PAD IS SHOWN AT ITS MAXIMUM SIZE.
7. ORE AND TOPSOIL STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.

SCALE A: 400 200 0 400 800 1200 1600 2000 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	10MAR'15	ISSUED WITH REPORT	SB	TAM	GRG

CASINO MINING CORPORATION

CASINO PROJECT

LOW PERMEABILITY MATERIAL BORROW AREAS

Knight Piésold CONSULTING

P/A NO. VA101-325/16

REF NO. 3

Figure B.4.8-1

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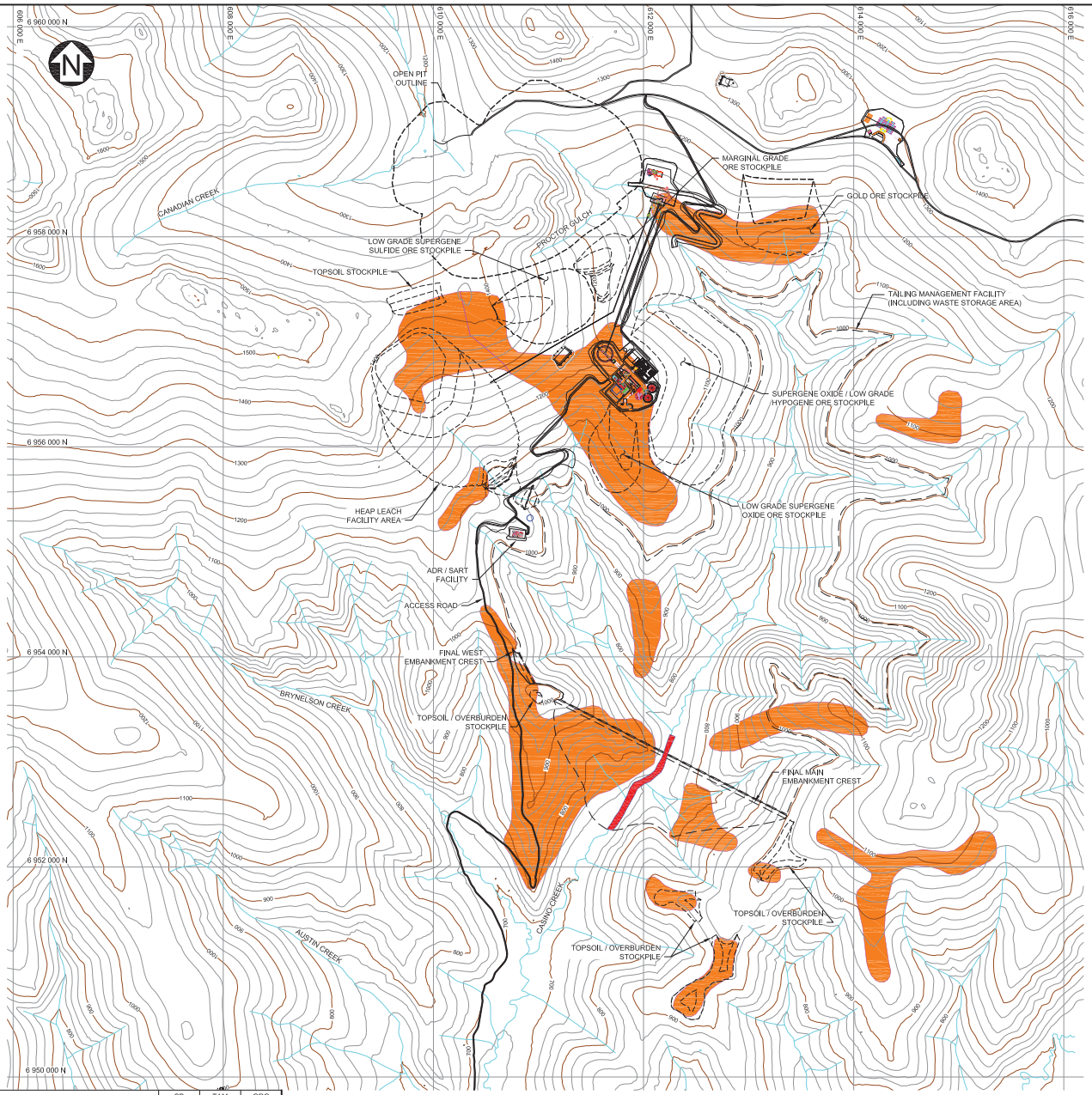

LEGEND:

FILTER AND TRANSITION ZONE MATERIAL AND GENERAL FILL BORROW AREA - RESIDUAL SOIL AND BEDROCK

FILTER AND TRANSITION ZONE MATERIAL AND GENERAL FILL BORROW AREA - ALLUVIAL CHANNEL DEPOSIT

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. OPEN PIT IS SHOWN AT ITS FINAL OUTLINE AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).
5. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
6. HEAP LEACH PAD IS SHOWN AT ITS MAXIMUM SIZE.
7. ORE AND TOPSOIL STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.

SCALE A: 400 200 0 400 800 1200 1600 2000 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	10MAR'15	ISSUED WITH REPORT	SB	TAM	GRG

CASINO MINING CORPORATION

CASINO PROJECT

FILTER AND TRANSITION ZONE MATERIAL AND GENERAL FILL BORROW AREAS

Knight Piésold CONSULTING

P/A NO. VA101-325/16

REF NO. 3

Figure B.4.8-2

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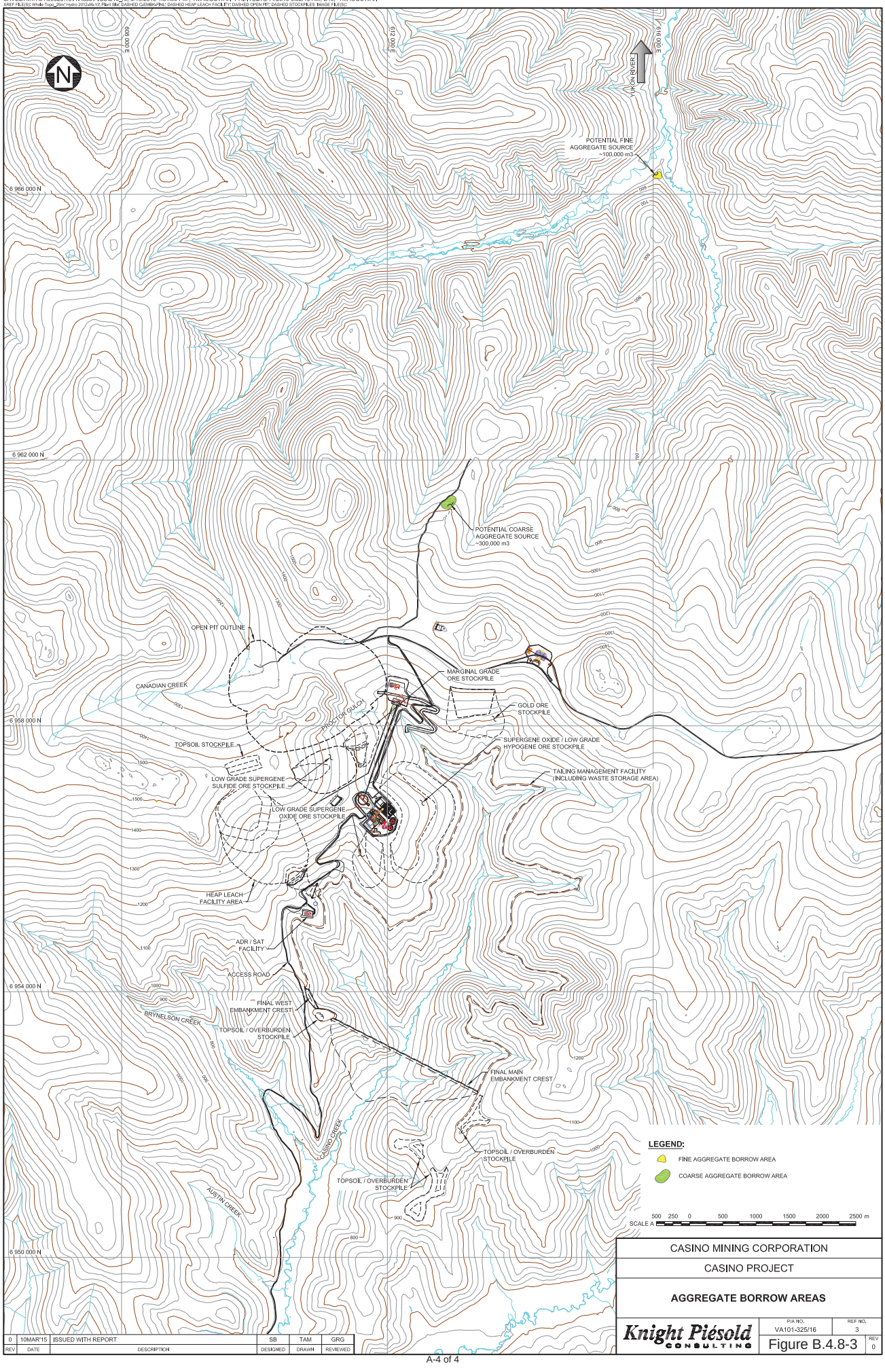
XREF FILE(S): White Topo_25m; Hydro 2012-06-12; Plant Site; DASHED C-EMBK-FINL; DASHED HEAP LEACH FACILITY; DASHED OPEN PIT; DASHED STOCKPILES IMAGE FILE(S):



REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	10MAR'15	ISSUED WITH REPORT	SB	TAM	GRG

CASINO MINING CORPORATION

CASINO PROJECT

AGGREGATE BORROW AREAS

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-325/16	3

Figure B.4.8-3

REV 0

Access Road

Most of the fill required for road construction will be developed from borrow pits located along the road alignment and then hauled to where it is needed. The section of road from the Selwyn River to the mine is located in soil that is mainly suitable for road embankment construction and can be utilized for fill. Further soil testing may reveal other locations with borrow suitable for road construction which will result in shorter haul distances, reduced road construction costs, and reduced disturbance to areas outside of the road right of way.

Sources of bedrock and granular material are proposed along the Freegold Road extension at an average spacing of 3.8 km. The estimated volume of material available from these sources far exceeds the anticipated 1,300,000 m3 of borrow required for road construction. As a result, only a portion of some borrow pit areas will be required. On the Freegold Road upgrades, preliminary geotechnical investigations have been carried out, and material types identified. However further geotechnical field testing is required to determine the suitability and volume of material available.

The chosen borrow sites are located as close to the road alignment and fill areas as possible to reduce haul distances and impact on the environment. Any areas in close proximity to flood plains, watercourses, unstable terrain, and environmentally sensitive features have been avoided. Other areas have been avoided because they are known or suspected to be ice-rich or acid generating.

Proposed borrow sites are shown in Appendix C of the Freegold Road Report (Appendix 4B).

Geochemical analysis of these sites is provided in Appendix A.7J Casino Road: Preliminary Risk Assessment of Metal Leaching and Acid Rock Drainage. The risk assessment indicates that the majority of the road is low risk for ML / ARD; however, there are 16 sections of road over 38.25 km of the total 133 km long alignment that are deemed to have moderate-low risk or greater. These sections are generally in the final 50 km of the road alignment: from kilometer station 86+500 to 98+300 and 108+030 to 124+430. There are three exceptions to this, kilometer station 1+290 to 5+960, 13+420 to 18+400 and 78+420 to 79+010 also have an overall risk that is considered moderate-low or greater.

These sections were found to have a high enough ML / ARD risk potential that further work in these areas is recommended. This should include further sampling along these 16 sections of road, ideally by drilling in areas where bedrock will be disturbed. As fish sampling has not taken place in the westernmost sections, over a distance of roughly 50 km of the proposed road alignment, further characterization of the streams along this section of the road alignment will allow for an improved understanding of the risk to aquatic ecosystems in this area, and may reduce the potential risk of some of the road sections in this area. Additional rock and surficial material sampling will also be necessary once quarry locations are finalized in order to ensure that the material will not cause ML / ARD.

ML/ARD management for the access road is further described in the ML/ARD Management and Monitoring Plan (Appendix A.22H).

Airstrip and Airstrip Access Road

Three borrow sources are proposed near the Dip Creek Valley, and will be the source of fill material required for the airstrip and access road construction (Appendix 4B).

Four samples were collected from the airstrip borrow area, the samples indicate that the borrow material in these areas are non-acid generating as the paste pH values are high (> PpH 7) and the total sulphur values are low (0.01% or lower) (Appendix A.7K).

Additional exploration for suitable borrow material is required and will be done in the subsequent engineering and construction phases of the project. CMC does not propose to initiate further field investigation of borrow sources until the project is authorized to proceed.

CMC notes that EcoMetrix stated that CMCs response to R43 (detailed information on the sources and quantities of suitable borrow materials) "is considered to be adequate" (2014-0002-399-1).

The availability of suitable borrow material is really a commercial risk for the Project. In the event that more material be required than is available, CMC would need to bring in material from elsewhere, increasing costs but not disturbance.

B.4.8.4 Earthquakes

B.4.8.4.1 R2-32

R2-32. An explanation on the likelihood and implications of saturation of the TMF dam's foundation, drains, and lower portions.

TMF underdrains are installed to prevent saturation of the cyclone sand shell. The underdrain system is installed beneath the Main Embankment, and incorporates a 0.3 m thick gravel drainage blanket with perforated collection pipes to convey collected water away from under the embankment. The layout of the collection pipes has been designed with pipes installed at four phases during development, Year 1, Year 4, Year 10 and Year 22. The collection pipes will be spaced approximately every 230 metres as the footprint of the embankment increases with staged expansions. As the embankment height increases, it is expected that the perforated pipes will deform and likely collapse due to the embankment loading, however the majority of infiltration drainage from the cyclone sand operation is anticipated to be complete at this stage and any remaining drainage will still infiltrate through the gravel drainage blanket.

The drain design may be modified as construction of the foundations progresses if field observations and measurements of native ground inflows indicates inflows greater than assumed in the original design. Such design changes will be accomplished following the change management process described in the response to R2-2. For example, it may be necessary to use rock fill in the lower portions of the dam shell as an added contingency and to ensure saturations conditions do not occur.

The foundation and drain designs will be developed during the detail engineering design phase. The analysis of drains design requirements will take into account inflows from the native ground and excess water from the cyclone sand deposition.

B.4.8.4.2 R2-33

R2-33. The references used to guide the factor of 1.5 and a discussion about the applicability of the reviewed cases to this project.

Stability analyses were carried out to investigate the stability of the Main Embankment under both static and seismic loading conditions (Appendix C in the Report on Feasibility Design of the Tailings Management Facility – Appendix A.4D). These comprised checking the stability of the embankment arrangement for each of the following cases:

- Static conditions during operations and post-closure

- Earthquake loading from the Operating Basis Earthquake (OBE) and the Maximum Design Earthquake (MDE); and
- Post-earthquake conditions using residual (post-liquefaction) tailings strengths.

The stability analyses were based on a typical cross-section through the Main Embankment for the final TMF with a supernatant pond elevation of 995 m and an embankment crest elevation of 998 m.

The stability analyses were carried out using the limit equilibrium computer program SLOPE/W. In this program a systematic search is performed to obtain the minimum factor of safety from a number of potential slip surfaces. Factors of safety have been computed using the Morgenstern-Price method.

In accordance with international recommendations (ICOLD, 1995) and standard industry practice, the minimum acceptable factor of safety for the tailings embankment under static conditions is 1.3 for short-term operating conditions and 1.5 for long-term (post-closure) of the TMF. A factor of safety of less than 1.0 is acceptable under earthquake loading conditions provided that calculated embankment deformations resulting from seismic loading are not significant and that the post earthquake stability of the embankment maintains a factor of safety greater than 1.2, implying there is no flow slide potential. For the post earthquake case the tailings deposit was conservatively assumed to be fully liquefied, and an appropriate low residual strength was applied.

The results of the stability analyses satisfy the minimum requirements for factors of safety and indicate that the proposed design is adequate to maintain both short term (operational) and long term (post-closure) stability. The seismic analyses indicate that any embankment deformations during earthquake loading from the OBE or MDE would be minor, and would not have any significant impact on embankment freeboard or result in any loss of embankment integrity. The results also indicate that the embankment is not dependent on tailings strength to maintain overall stability and integrity. Details of the embankment stability analyses, including the adopted material strength parameters are presented in Appendix C of Appendix A.4D.

Please refer to the Report on the Feasibility Design of the TMF (Appendix A.4D) and Appendix B of that report for a discussion on the seismicity assessment that has been carried out for the Casino Project, including a review of the regional seismicity and a seismic hazard analysis.

As previously stated in response to R2-14 and elsewhere, the final design basis for the TMF & HLF will be in full compliance with current codes and regulations. The factors of safety pertaining to the construction, operating and closure & post-closure phases of these facilities will be demonstrated to be in full compliance with the current codes and regulations. The final design will reflect the review and input from the IERP. The designs with supporting data and documentation will be provided with the license application to enable the Regulator to verify code compliance. The Regulator will not grant a license to construct until CMC can demonstrate compliance with applicable codes and regulations.

B.4.8.4.3 R2-34

R2-34. The measured shear wave velocity for the foundation material.

Please refer to the Report on the Feasibility Design of the TMF (Appendix A.4D) and Appendix B of that report for a discussion on the seismicity assessment that has been carried out for the Project, including a review of the regional seismicity and a seismic hazard analysis.

Section B.3.1 Ground Motion Attenuation of that report provides the basis for the ground motion assumption used for preliminary engineering purposes. The peak ground accelerations and spectral accelerations predicted using the attenuation relationships are for soft rock/very dense soil site conditions, assuming an average shear wave

velocity in the upper 30 meters (defined as the Vs30 value) of 560 m/sec (range of 360 to 760 m/sec). This corresponds to Site Class C, as defined by the National Building Code of Canada (NRC, 2010). Any colluvial apron material and other ice-rich soils will be removed from the dam foundation. The resulting dam foundation will primarily be constituted of Granodiorite bedrock. The selected Site Class C is conservative for these site conditions, resulting in conservatively high peak ground accelerations. This is a provisional value that may change when the balance of the planned geotechnical field investigations are completed during the basic and detail engineering phases. CMC will conduct geophysical data interpretation along the thawed zones to confirm the shear wave velocity and establish the value for ground acceleration to be used for design.

As previously stated in response to R2-14 and elsewhere, the final design basis for the TMF & HLF will be in full compliance with current codes and regulations. The factors of safety pertaining to the construction, operating and closure, and post-closure phases of these facilities will be demonstrated to be in full compliance with the current codes and regulations. The final design will reflect the review and input from the IERP. The designs with supporting data and documentation will be provided with the license application to enable the Regulator to verify code compliance. The Regulator will not grant a license to construct until CMC can demonstrate compliance with applicable codes and regulations.

B.4.8.4.4 R2-35

R2-35. Mean PGA as derived from EZ-FRISK.

Refer to the response to R2-34.

B.4.8.5 Flood Modeling

B.4.8.5.1 R2-36

R2-36. Information regarding PMP and the IDF including:

a. An updated PMP estimate using more robust storm expansion techniques. This modelling must be done by a trained meteorologist with a background in PMP derivation;

b. Justification for using the 100 year snowpack combined with the PMP for computing the PMF instead of a more conservative return period; and

c. Evidence demonstrating that the IDF represents the worst case in terms of volume of inflow.

a. As detailed in the response to R2-14, the probable maximum precipitation (PMP) and 1:1,000 year return period rainfall event values were calculated to inform the selection of an appropriate Inflow Design Flood (IDF) for the Tailings Management Facility using current techniques by trained professionals in the field.

   Current estimates for PMP and PMF are provisional values suitable for assessment purposes and will be reviewed for detailed design and construction purposes. As the project progresses into basic engineering and through the permitting process these provisional values, including the data sources and methodologies used to establish these values, will undergo rigorous examination and review. The design of the TMF and HLF will be based upon the final determination of the PMP and PMF values developed by the EOR, as reviewed by the IERP, and reflected in the design documents submitted for regulatory review and approval. See Figure B.4.2-1 for a description of how provisional values for key design features are incorporated into the design, construction and operation continuum.

b. The use of the 100 year snowpack in combination with the PMP is as per the CDA Dam Safety Guidelines (2007), which state that the PMF is to be computed "with spring PMP and snow accumulation with frequency of 1/100 year".

c. The inflow design flood (IDF) used during operations is one third between 1,000 years and the Probable Maximum Flood (PMF) event for 72 hour storm duration and the IDF for closure is the PMF. The IDF during operations is not derived from a "worst case" scenario, but from guidance from the CDA (2007 & 2014). The IDF during closure is the PMF, which, by definition is the theoretically largest flood resulting from a combination of the most severe meteorological and hydrologic conditions that could conceivably occur in a given area.

B.4.8.6 Spillways

B.4.8.6.1 R2-37

R2-37. Following an updated dam hazard classification as requested in section 2.7.1 include a description of how the IDF design will protect the TMF dam from overtopping.

As stated in the response to R2-14, the IDF and PMF are derived from the PMP and potential snowmelt during occurrence of the PMP, to provide an estimate of flooding potential. For a dam classification of "High" the IDF is one third between 1,000 years and the PMF; for a dam classification of "Very High" the IDF is two thirds between 1,000 years and the PMF; and for a dam classification of "Extreme" the IDF is the PMF (CDA, 2014). However, the CDA Dam Safety Guidelines do not specify which storm duration to extend the event over (e.g., 24-hour or 72-hour). To calculate the IDF, CMC has conservatively used the 72-hour 1,000 year return period event for the starter dam, the 72-hour 1,000 year return period and 72-hour PMF for the operations phase, and the 24-hour PMF for the closure phase, which is equivalent to a risk classification of "Extreme".

The design of the TMF embankments includes storm storage volume requirements for the IDF above the operating supernatant pond elevation, plus an additional two metres for wave run-up protection.

Continuous climate and hydrological monitoring throughout the mine life will provide a more appropriate estimate of the climate at closure and final closure, and 5 year reviews will take into account any changes in meteorological conditions observed during the life of the mine.

Current estimates for PMP and PMF are provisional values and will be reviewed during detailed design and construction. As the project progresses into basic engineering and through the permitting process these provisional values, including the data sources and methodologies used to establish these values, will undergo rigorous examination and review. The design of the TMF and HLF will be based upon the final determination of the PMP and PMF values developed by the EOR, as reviewed by the IERP, and reflected in the design documents submitted for regulatory review and license application processing. See Figure B.4.2-1 for a description of how provisional values for key design features are incorporated into the design, construction and operation continuum.

B.4.8.6.2 R2-38

R2-38. Further discussion on the implications of ice build-up in the spillway and how this will be monitored and managed. In addition to ice build-up, describe how the spillway will be monitored and maintained in perpetuity post-closure – this must consider any changing circumstances

and/or conditions that may compromise the function of the spillway.

It is common to install barriers (pillars) upstream of a spillway to limit the size of ice blocks in the vicinity of the spillway. The spacing of the barriers limits the size of ice blocks so that they cannot form an ice jam at the spillway. This feature may be provided for the Casino TMF.

Site maintenance and management will also be conducted to prevent any blockages, which will be detailed in the OM&S plan prepared by CMC (preliminary plan provided in Appendix B.4D).

Continuous climate and hydrological monitoring throughout the mine life will provide a more appropriate estimate of the climate at closure and final closure, and planning will be updated to account for these records.

Refer to the response to R2-2 as to how changing circumstances and changed conditions are addressed during the design and construction stage and in perpetuity.

B.4.8.6.3 R2-39

R2-39. Mitigations, with appropriate thresholds for implementation, and monitoring activities for closure spillway related erosion, both in the spillway channel and downstream water bodies.

The upper and middle portions of the spillway will be cut into bedrock that is erosion resistant. The design also includes a plunge pool to dissipate the energy of cascading water and to minimize potential erosion effects below the plunge pool and in the downstream watercourses. Erosion protection requirements and design features for the lower section of the spillway and watercourses will be determined in the detailed design stage. The objective of the design will be to minimize or eliminate downstream erosion effects, thereby reducing or eliminating on-going maintenance of this section.

A preliminary OM&S which discusses the mitigation measures with appropriate thresholds for implementation, and monitoring activities for closure spillway related erosion, in both the spillway channel and the downstream water bodies, is provided in Appendix B.4D.

B.4.8.7 HLF Failure

B.4.8.7.1 R2-40

R2-40. Ensure that the risk assessment requested in section 2.2.2 considers the likelihood and consequence of an HLF failure that results in displacement of water in the TMF.

Failure of the HLF embankment and the resulting release of leach solution and embankment material into the TMF is considered in the Risk Assessment provided in the response to R2-4. The maximum volume reporting to the TMF in the event of a failure is approximately 246,000 m^3, which is insignificant (~3%) compared to the storage capacity available over maximum operational level (freeboard) of 9,000,000 m^3.

B.4.8.8 TMF Dam Core and Downstream Filter

B.4.8.8.1 R2-41

R2-41. An expansion of CMC's response related to core and filter thickness by providing a review of comparable designs. Also, provide a detailed analysis that describes the deformation response of the core and the downstream filter during different stages of construction.

Examples of existing cyclone sand tailings dams are shown in Table B.4.8-1. The following discusses core and filter thickness off comparable TMF designs:

- *KSM:* The TMF for the proposed KSM project in BC includes a tailings dam of similar total height to the proposed Casino TMF dam (Table B.4.8-1). Both projects propose rockfill starter dams with ongoing centerline raises using cyclone sand. The thickness of the core for the Casino main embankment is 20 m for that portion of the dam above the starter dam crest. The thickness of the core for the KSM Southeast dam is also 20 m above the starter dam crest.
- *Highland Valley Copper:* The L-L Dam at the operating Highland Valley Copper mine is a centreline cyclone sand dam that has a core thickness of 15 m (Singh et. al., 2009).
- *Cerro Verde:* The dam at the Cerro Verde mine in Peru is one of several successful cyclone sand dams in South America that do not include a core zone (Obermeyer and Alexieva, 2011). The Cerro Verde mine employs a geomembrane on the upstream face of the starter dam and relies on the impounded tailings to provide hydraulic resistance to seepage through the dam for ongoing raises above the crest of the starter dam.

CMC will undertake an analysis of potential deformation of the dam components to inform the design of the core, filter and transition zones during the detail design phase of the project. The results will be reflected in the final design submitted with the applications for Quartz Mining and Water Use licences.

B.4.8.8.2 R2-42

R2-42. A comprehensive description of the tailings beach design including but not limited to: beach length, width, slope, deposition strategies, construction QA/QC and monitoring/maintenance requirements in perpetuity.

The general description of the design and operation of this system, design criteria, process flow diagrams (PFD), process and instrumentation diagrams (P&ID), and considerable detail of this system is provided in the Casino Project Tailings Cyclone and Transport Study, provided in Appendix E of the Feasibility Design of the Tailings Management Facility (Appendix A.4D). In particular refer to drawings 5277-3-001, Rev.0 and 5277-3-103, Rev.0 and also the section entitled "Casino Jacking Header Summary".

The tailings beach as described and depicted in the TMF Feasibility Design (Appendix A.4D) varies over the course of operations generally as follows:

- *Beach length:* The length of the beach is essentially that of the main dam crest until the tailings approach the elevation of the West Saddle dam. At this point the spigotting system will be modified to develop a beach along the West Embankment, resulting in a beach length that includes the main dam crest length and that of the West Saddle dam.

- *Beach Width:* A minimum beach width of 250 m for normal operating pond levels was adopted for the design (page 15 of Appendix A.4D). The primary objectives of this beach above water are to facilitate future embankment raises and to reduce the hydraulic gradient through the dam, resulting in lower seepage rates and improved stability. The beach width will be re-evaluated as part of detailed design.
- *Beach Slopes:* The beach slopes are a function of the discharge velocity and tailings slurry characteristics including density, gradation and solids content. The coarser fraction of the discharged tailings will settle rapidly and accumulate near the discharge points, forming a beach above water. Experience at similar operations suggests the beach slope above water should average about 0.3%. As the tailings flow into the supernatant pond it forms a submerged beach with a steeper slope, typically in the order of several percent. Finer tailings particles will travel further out into the supernatant pond before settling at flat slopes. Further study may be required as part of detailed design. However, the tailings deposition system at Casino is adaptable to manage a range of tailings characteristics and will be operated such that the requirements for the minimum beach above water geometry are met.
- *Deposition strategy:* The formation of the tailings upstream beach is managed by opening or closings the branch lines off the cyclone overflow jacking header. Normally one off-take will be open to directly discharge cyclone overflow material or whole tailings as operating conditions require (page 70 of Appendix A.4D). The branch lines off the jacking header are spaced at 100 m interval for this purpose. This system provides a high degree of flexibility and control over the beach development and allows adaptation to changing operating conditions.
- *QA/QC:* During operation the facility operators manage the deposition to achieve the design requirements, maintaining the design beach width. A QA/QC requirement during operations by site management is to ensure the minimum beach width and freeboard is maintained by controlling beach development and through water management. Annual internal audits & scheduled external audits verify that beach widths and water levels are consistently maintained in accordance with the design and operating criteria.
- *Maintenance:* Post-operations the beach width is controlled by the invert elevation of the spillway. A vegetation cover is provided for the beach above water after closure to control erosion and to prevent fugitive dust. On-going maintenance consists of annual inspection and repairs to the cover if needed.

B.4.8.8.3 R2-43

R2-43. Quantification of the reduction of seepage and hydraulic gradient throughout the various phases of the TMF dam based on the chosen design. Provide an estimate of how the seepage and hydraulic gradient may change in perpetuity.

The quantification of the seepage from the TMF is discussed in detail in the Revised TMF Seepage Assessment provided in Appendix A.4L. This report details the following information related to seepage:

- The estimated seepage rate at each phase in the life cycle of the TMF facility, including pre-production, various years of operation and at closure and post closure (long-term).
- Figures 3.1 to 3.6 in Appendix A.4L indicate the predicted phreatic surface at each stage of the project and illustrate that the phreatic surface drops to downstream shell foundation drain elevation at all stages. The cyclone sands forming the downstream shell are drained (unsaturated) at all times.

- The report details the analysis of the seepage flows throughout the operating life of the structure and in post-closure. The peak seepage occurs at operating year 22 at 40 l/s and similar seepage flow is anticipated for post-closure (i.e., long-term seepage value).
- The analysis indicates approximately two thirds of the seepage is into original ground and only about one third passes through the dam. Further, the analysis indicates that flow through the dam is not particularly sensitive to the core permeability, as per the sensitivity analysis conducted in Appendix A.4L, which indicates that reducing the permeability of the embankment core zone from 1 x10^{-5} cm/s to 1 x 10^{-6} cm/s reduces the predicted seepage rates by only approximately 10%.

B.4.8.9 Use of Cyclone Sand in Embankments

B.4.8.9.1 R2-44

R2-44. The results of laboratory tests conducted to assess whether 12 percent fines sand would be free-draining including under the very high stresses in the proposed dam and frost susceptible of this material. Additionally, if applicable, provide the implications of the 12 percent fines sand not being free-draining or being frost susceptible.

The results of laboratory testing performed on Casino tailings can be found in the Report on Laboratory Geotechnical Testing of Tailings Materials provided in Appendix A.4R. The test results indicate that even at extreme pressure, the permeability of the cyclone underflow product (coarse sands fraction used for dam construction) will remain greater than 1 x 10^{-4} cm/sec and hence will be free draining. This is consistent with other operations processing copper ore and with similar primary grind. It is also consistent with direct observations by others of how rapidly and effectively cyclone sands, in this grind regime, drain and can be efficiently compacted to the design density.

The test work referenced above also indicates that the design target of 15% fines in the cyclone underflow is achievable, consistent with the experience at other operations, and that the percent by weight of <0.02 mm fines present in the underflow is about 6%. Frost susceptibility of this material may range from very low to high. A maximum fines content of 12% has been adopted for the Feasibility design.

Construction of the cyclone sand tailings at the Kemess mine was successfully conducted at temperatures as low as -40°C (Lysay, Davidson and Martin, 2007). The gradation of the Casino cyclone sand is very similar to Kemess. Lysay et al. mention fines contents of up to 15% are permissible in the downstream shell of the Kemess dam. Gradation testing indicates fines contents are consistently below this target and generally average about 12%. Ice lenses in the cyclone sand shell are generally absent as verified using test pits.

CMC intends to conduct test work to confirm a number of parameters with respect to the use of cyclone tailings for dam construction including permeability testing, frost susceptibility testing, and other during the basic engineering phase and prior to construction. In the event that either permeability or frost susceptibility are identified as problematic, the engineer of record will develop solutions to address these issues, incorporate the necessary design changes in the appropriate design documents, which will be provided for review and approval throughout the QML licencing process. See response to R2-2 for more details on change management procedures and the role of the engineer of record.

B.4.8.9.2 R2-45

R2-45. Information regarding sand properties including:
a. Explanation why the more conservative 30° angle of internal friction for angular sands was not selected for the Casino dam design;
b. Explanation why the same value can be assumed to apply to the tailings generated from processing of all of the three ore types; and,
c. Implications if the more conservative value of 30° is applied to the tailings generated from processing of all of the three ore types.
d. Confirmation whether the maximum anticipated stress for placed cyclone sand is supported by completed testing.

a. To clarify, the friction angle of 36° quoted by EcoMetrix (2014-0002-399-1) was not used for stability analysis. A strength envelope was assigned which is a function of stress, not just a friction angle, as explained in Appendix C of the Report on the Feasibility Design of the Tailings Management Facility (Appendix A.4D). Conservatively, the relationship based on angular sand was used, not the lower bound rockfill. All strength test results indicate strengths higher than the angular sand envelope. Also, the effects of height on sands specifically for copper porphyry, as is the case for Casino, are detailed by Barrera et al. (2011). The design values used in the CMC study are consistent with the demonstrated, successful application of cyclone sands for high dams in Chile and elsewhere.

b. There is a reasonable expectation that similar values will be obtained from all ore types. CMC plans to conduct additional confirmatory test work after a decision to proceed with the project is made and the results of this investigation will be reflected in the final design basis.

c. Please refer to (a) above.

d. The strength envelope discussed in (a) above does assign a lower friction angle for higher stresses. Specialized test work will be performed to confirm the values to be used in detailed design.

B.4.8.9.3 R2-46

R2-46. Identification the actual source of the discrepancy present in the specific gravity values for the tailings sand products through repeat testing. If repeat testing is not possible, describe the implications of this discrepancy using conservative assumptions.

The specific gravity of copper porphyry ore typically ranges between 2.70 and 2.80, as is the case for Casino. The specific gravity for bulk tailings and cyclone overflow for Casino were determined by testing. The specific gravity for cyclone underflow was back-calculated from a hydrometer test. Back-calculation is a less reliable method of calculation than testing. The range of values is not significant (~4%) at this level of design and therefore there is no significant implication to the design arising from this minor discrepancy. As previously stated, this discrepancy will be resolved in the basic and detail engineering phase after a decision to proceed with the project has been made.

B.4.8.9.4 R2-47

R2-47. A response to the concerns articulated by EcoMetrix regarding 2 m lifts.

The following is a more detailed description of how the coarse sands are placed and compacted on the tailings dam downstream shell to achieve consistent design density/compaction requirements, as per .

- A bull dozer is used to construct a temporary confinement berm (1-2 meters high) by pushing up previously placed, drained and compacted sand to form a cell to contain fresh slurry and allow the solids to drop-out and to decant the water from the cell (Figure B.4.8-4). Tailings slurry is directly discharged into the cell (or paddock) that has been constructed by the bull dozer.
- The coarse sands in the slurry drop-out quickly and the sand drains readily such that the bull dozer can spread and compact the sands concurrently with the inflow of slurry or shortly thereafter.
- Water is removed from the cell by a portable/moveable decant box.
- The action of the dozer in spreading and leveling the deposited coarse sand results in the compaction of the sands in effectively thin layers and consistently achieves the design degree of compaction and density (Figure B.4.8-5). This method has proven very successful at various operations, including:
    1. Kemess: This methodology has demonstrated consistent placement and compaction to design density even in very cold weather.
    2. Highland Valley Copper: “cyclone sand slurry floods each construction cell to depths of 0.5 m to 2.0 m, and is heavily track packed by sand cat dozers” (Sing et al., 2009).
- The process continues until the total depth of the coarse sand deposited and compacted within the cell reaches the limit of the temporary confinement berm. The slurry is then re-directed to the next pre-prepared cell and the process is repeated.

QA/QC will be conducted to ensure specified densities are achieved. Adjustments to the construction process will be implemented as required, although changes are expected to be minor based on the above mentioned experiences with successful operations.

Figure B.4.8-4 Confinement Berm Construction

Figure B.4.8-5 Sand Cell Compaction

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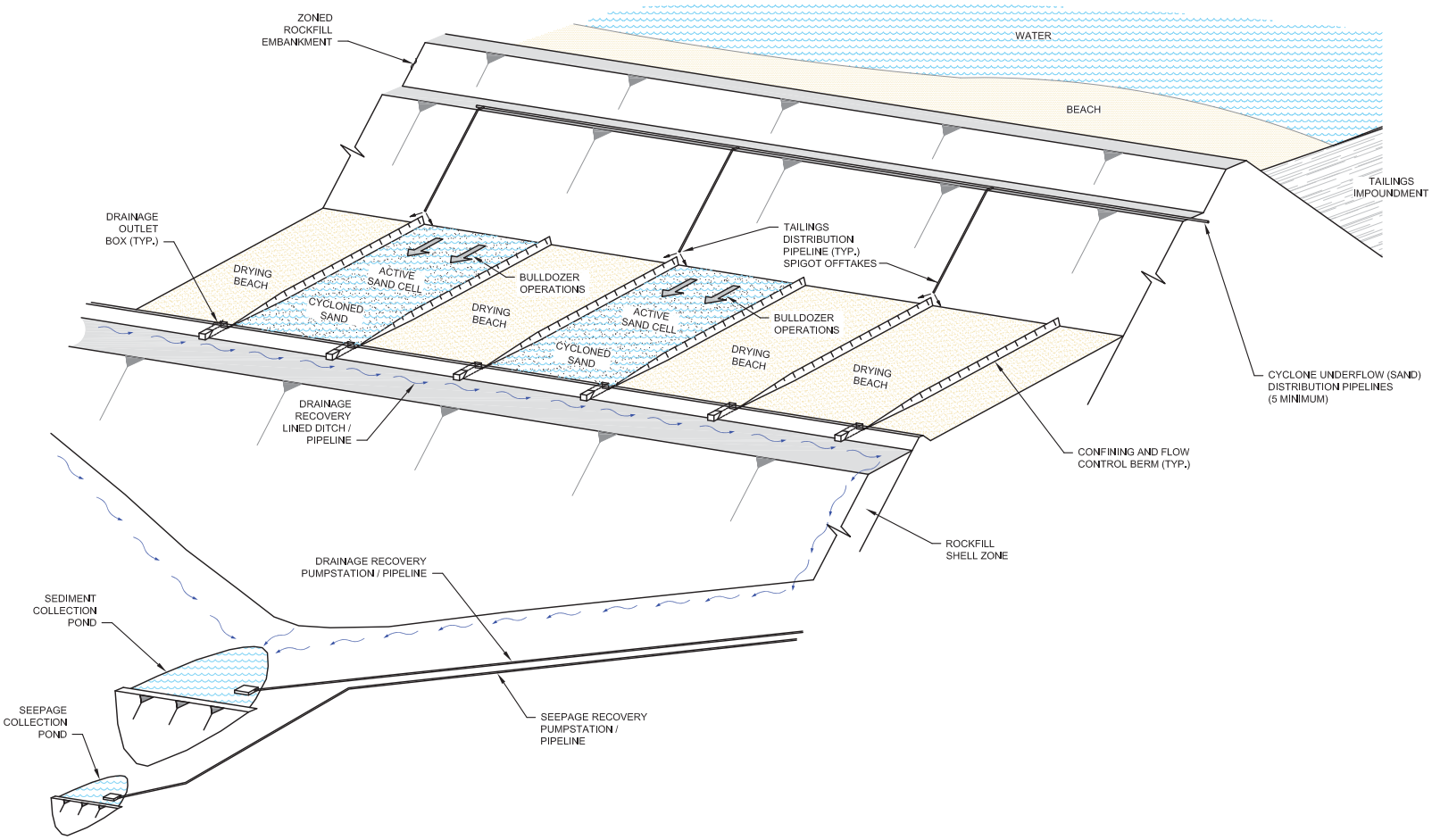

NOTES:

1. SAND CELL PLACEMENT OPERATIONS OCCUR SIMULATANEOUSLY IN TWO OR THREE CELLS.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	19MAY'10	ISSUED WITH REPORT	AG	RP	GRG	KJB

WESTERN COPPER CORPORATION

CASINO COPPER -GOLD PROJECT

CYCLONE SAND DEPOSITION SCHEMATIC

Knight Piésold CONSULTING

P/A NO. VA101-325/3

REF NO. 2

Figure B.4.8-6

REV 0

B.4.8.9.5 R2-48 through R2-56

R2-48. Supporting evidence for the absence or presence of faults and fractures within the TMF and embankment areas including their activity. Specifically:
a. Confirm whether lidar data has been collected to determine the presence or absence of young faults near the tailings dam;
b. Provide the detailed joint surveying along the dam foundation and the abutments and update the seepage analysis report; and,
c. Provide a geostatistical model that represents the permeability characteristics of the bedrock below the dam foundation.

R2-49. Additional drill results and associated foundation characterization (e.g. packer testing, trenching), with detailed analysis and discussion, to provide an accurate characterization of the hydraulic conductivity and identification of fault/shear zones within the embankment foundation.

R2-50. A description of how grouting can be successfully performed given the challenges presented by permafrost. Also, update the responses for R89 a – e of the ARR in accordance with the response to R2-49.

R2-51. The rationale behind "the material is assumed to be isotropic" knowing the horizontal permeability is greater than vertical permeability in embankment dams that is constructed in several stages. Also assuming an isotropic permeability for the rock, will not be a valid assumption due to preferential seepage in the rock mass.

R2-52. The justification on why no seepage barrier is proposed for the dam foundation despite the calculated seepage rate.

R2-53. The anticipated seepage problems surrounding the storage area.

R2-54. Details regarding permafrost and permafrost conditions in relation to the TMF, including:
a. confirmation that an assessment of the hydraulic properties of the permafrost under the embankment structures studies will be conducted during the detailed design;
b. a winter construction execution plan that details measures and procedures for embankment placement of fill that ensures the fill soils are not frozen at the time of placement and compaction;
c. QA/QC plan for construction during the cold season;
d. details on permafrost conditions of the foundation materials before the construction and during the embankment raise;
e. a discussion regarding the potential segregation of solids and water fractions, with the formation of discrete ice lenses within the tailings mass and its implication for tailings management; and,
f. a discussion regarding the integrity implications of the potential frozen and unfrozen fill co-existing within the structure.

R2-55. A detailed schedule for the works required to construct the TMF before and during operations. Consideration should be given to key QA/QC requirements and contingency planning for scheduling delays and freezing conditions.

R2-56. QA/QC measures during the lifetime of the embankment to ensure the effectiveness of insulation and the core structure will not be affected by the action of freezing. Please also provide confirmation regarding if permafrost aggradation potential has been considered into the TMF containment structure? If permafrost aggradation has not been considered, provide a discussion regarding the potential of permafrost aggradation into the TMF.

Requests R2-48 through R2-56 relate to foundation design and detailed geotechnical matters. CMC has provided all information available on these matters in the Project Proposal and the SIR-A. This level of information is consistent with the Project's current stage of development. The matters described in requests R2-48 through R2-56 need to be, and will be, addressed during regulatory review to demonstrate that the project is in compliance with CDA and other applicable codes or regulations.

Further field investigations are planned to support detail engineering and this work will progress once the project proceeds past the assessment phase. This work will be performed to provide a firm design basis and will be submitted in support of CMC's application for a Quartz Mining License and Water License consistent with the regulatory review and permitting process. New information or different interpretation of the conditions in the field discovered by the extended field geotechnical investigations or revealed upon excavation of the foundations of the TMF will be dealt with appropriately as described under Change Management Framework described in the response to R2-2.

It is also important to note that during their review of CMC's SIR-A, both of YESAB's consultants, EcoMetrix and SNC Lavalin, either deemed CMC's previous responses to be *"Adequate"* or had no further comments. In some instances, the above-noted consultants offered comments or suggestions for actions during the detail engineering phase. These comments demonstrate their understanding of the evolutionary process to progress a project from preliminary design through to final design and that there are expected limitations on the availability data, extent of design, understanding of risks, etc. during the preliminary design phase.

B.4.8.9.6 R2-57

R2-57. Additional detail to understand the implication of shorter than expected construction windows for the TMF dam and specifically:
a. Describe the implications of suspensions in fill placement operations if CMC is unable to operate in November and/or March. Also consider the implications of not being able to operate for additional months should they prove too cold. Describe how CMC will manage these implications.
b. Clarification if the likelihood of one or more very cold years for the construction window has been evaluated. If so, describe the implications. Describe how CMC will manage these implications.

Implications of shorter than expected construction windows that are not significantly different from normal temperature ranges are accounted for in normal project planning and contingency allowance. In the event that extreme weather impacts the construction schedule to the extent that cannot be mitigated by reasonable measures, it may be necessary to delay aspects of the work in order to meet necessary quality standards. This may or may not result in an overall project schedule delay but in any event represents a business risk, not a threat to the integrity of the constructed facilities. A more detailed discussion follows:

a. To clarify, the "suspension in fill placement operations" refers only to the placement and compaction of coarse sands on the downstream shell of the TMF dam. It should be noted that CMC expects that placement can be achieved 75% of the time (i.e. equivalent of 9 out of 12 months per year). As discussed in R2-7, experience at

other operations has demonstrated that coarse tailing can be placed and compacted to specification at temperatures down to -40°C. CMC has applied a conservative threshold to not place tailings during the seasons where the daily minimum temperature falls below -30°C. In the 2008 through 2014 site meteorological record, there were 51 days (of 793, or 6%) where the minimum daily temperature fell to below -30°C. Over the 2008-2014 site record only two days were, on average, less than -25°C (bold values Table B.4.8-4). However, a 75% placement assumption due to inclement weather has been conservatively assumed.

Table B.4.8-4 Average Minimum Temperatures at Casino Mine Site 2008 - 2014

Day of the Month	Average Minimum Temperature (2008 - 2014)				
	November	December	January	February	March
1	-12	-21	-20	-16	-13
2	-13	-21	-21	-15	-12
3	-14	-19	-21	-16	-14
4	-13	-18	-20	-17	-14
5	-10	-15	-20	-18	-16
6	-12	-14	-19	-16	-15
7	-13	-14	-15	-14	-14
8	-16	-15	-16	-15	-16
9	-16	-14	-21	-16	-16
10	-16	-15	-24	-16	-15
11	-13	-13	-24	-15	-15
12	-15	-17	-21	-15	-14
13	-15	-18	-24	-17	-17
14	-16	-19	-21	-14	-16
15	-16	-19	-13	-12	-15
16	-19	-18	-14	-12	-16
17	-21	-22	-15	-12	-16
18	**-25**	-21	-13	-10	-16
19	**-25**	-20	-14	-14	-14
20	-24	-19	-14	-11	-15
21	-23	-19	-15	-14	-18
22	-22	-16	-19	-15	-19
23	-18	-18	-17	-15	-17
24	-17	-19	-17	-15	-15
25	-14	-21	-15	-12	-12
26	-14	-19	-17	-14	-11
27	-15	-20	-20	-14	-13
28	-15	-20	-22	-13	-11
29	-17	-19	-22	-17	-9
30	-19	-19	-21		-8
31		-18	-17		-6
Days <-30°C	0	0	0	0	0

In the event that CMC cannot meet its conservative 75% assumption due to inclement weather, there may be an impact on the construction schedule and cost for elements of the Project that cannot be mitigated by reasonable measures. In such a circumstance, it will be necessary to delay aspects of the work in order to meet necessary quality standards. This may or may not result in an overall project schedule delay but in any event represents a business risk, not a threat to the integrity of the constructed facilities.

b. The current project planning is based upon an assumption that the winter weather experienced during the construction duration will be typical for the region. That is to say that the winter weather may range from

colder than average to warmer than average but does not take into account extreme winters. This range is accounted for in normal project planning and contingency allowance.

In the event extreme weather is experienced there may be an impact on the initial construction schedule and cost for elements of the Project that cannot be mitigated by reasonable measures. In such a circumstance, it will be necessary to delay aspects of the work in order to meet necessary quality standards. This may or may not result in an overall project schedule delay but in any event represents a business risk, not a threat to the integrity of the constructed facilities.

Project specifications and procedures, developed during detail engineering, will define limits on work performed during inclement weather and the appropriate measures and controls necessary to maintain QA/QC requirements as is the norm in industry.

In the event that one or more very cold years are experienced during the project construction this development will be handled through the project "Change Control "process as is typical of all major projects and as discussed under R2-2.

B.4.8.9.7 R2-58

R2-58. Further detail on the referenced examples provided in response to R94. Demonstrate how these examples are applicable to this project and how they support the proposed construction schedule and methodology. Include details regarding the equipment and infrastructure required to facilitate winter construction.

Examples of existing cyclone sand tailings dams are shown in Table B.4.8-1. The Gibraltar (Kolhn Cripen Berger, 2014), Highland Valley (Klohn Crippen Berger, 2012), and Kemess (Lysay, Davidson, and Martin, 2007) mines are Canadian operations with tailings impoundments where cycloned tailings sands are being placed and compacted in cells similar to that proposed for Casino at temperatures well below freezing. Gibraltar and Highland Valley are located in a continental climate region and Highland Valley has placed and compacted sands to -10°C. Kemess is located in a sub-arctic region and the placement and compaction of coarse sands down to -40°C has been documented by Lysay, Davidson, and Martin (2007). KSM and Casino projects will both be constructed and operated in Sub-arctic regions with temperature regimes comparable to that of Kemess.

Placement of coarse sands is expected to occur 75% during of the calendar year (i.e. equivalent of 9 out of 12 months per year). The estimated number of days that the Casino site might be expected to see the daily minimum temperature fall below -30°C is approximately 40-50 days per season. This illustrates that the 75% placement assumption due to inclement weather is conservative.

The design, construction, operation, and ultimately, the closure and reclamation of key facilities at the Casino Project (e.g., TMF and HLF) is complex. It may be necessary to modify the design and operating practices at each stage because of new information or advances in technology, changes in regulation, climate change, or a variety of other reasons.

In the event that CMC cannot meet its conservative 75% assumption due to inclement weather, there may be an impact on the construction schedule and cost for elements of the Project that cannot be mitigated by reasonable measures. In such a circumstance, it will be necessary to delay aspects of the work in order to meet necessary quality standards. This may or may not result in an overall project schedule delay but in any event represents a business risk, not a threat to the integrity of the constructed facilities.

The general framework that governs changes to engineering design is outlined in Figure B.4.2-1, providing an overview of the inputs and possible change management outcomes during the conceptual design, engineering design, construction, operations and closure phases of the Project.

Additional and/or complementary information is contained in responses to R2-2, R2-7, R2-25, R2-47 & R2-57.

B.4.8.9.8 R2-59

R2-59. Discuss the implications of potentially incorporating frozen layers within the embankment (e.g. discrete ice lenses within the tailings mass; layers of frozen and unfrozen fill) to the stability and integrity of this infrastructure.

Appropriate QA/QC measures and controls will be developed during the detail engineering phase of the Project that will be applicable to the initial construction and to the on-going construction during operations. Implementation of these QA/QC measures and controls is designed to preclude inclusion of frozen layers within the embankment. In the unlikely event that frozen material is discovered through the QA/QC process or otherwise, CMC will take appropriate action to resolve the matter to ensure the stability and integrity of the structure.

The QA/QC measures and controls will be provided for regulatory review as part of the application for the Quartz Mining License and the Water License.

See also the response to R2-2 with regards to change management and on-going QA/QC, and the draft Guide to the Management of the Casino Tailings Facility in Appendix B.4A.

B.4.8.10 Surface Preparation

B.4.8.10.1 R2-60

R2-60. Provide comprehensive characterization of the depth, extent and nature of permafrost where the TMF is to be constructed. Based on this characterization, confirm that excavation of all permafrost soils will be practical and how this excavation will successfully be achieved.

Permafrost is discontinuous over the TMF embankment area, and is primarily present at the valley bottom, north-facing slopes and shaded areas. The ridges at higher elevations and upper slopes on the west abutment are southeast-facing, and are generally free of permafrost except for some local shaded areas. Permafrost is common in the northwest-facing east abutment area, where test pits were terminated at shallow depths in frozen colluvium and residual soils.

Permafrost has been identified in the organic, silty colluvial apron of the Casino Creek and tributary valley bottoms. The overburden is generally saturated and frozen in these areas, with high ice contents. The site investigation data also indicated ground ice close to tributaries leading to Casino Creek. The average thickness of the colluvial apron is expected to be approximately 10 metres based on the findings of the site investigations.

To ensure the stability and integrity of the TMF dam foundation, CMC plans to perform the following activities:

- Unsuitable soils and all vegetation underlying the TMF dam foundation will be removed. The topsoil will be stockpiled for reclamation purposes.
- Overburden (including topsoil) will be left in place in the impoundment area upstream of the dam. Disturbance of the vegetative mat will be avoided to the maximum extent possible.

CMC has stated that overburden underlying the Main Embankment will be excavated down to bedrock or suitable overburden foundation conditions. SNC-Lavalin has speculated that this may not be practical. While there is the some possibility that it may not be entirely practical, it is important to keep in mind the length and breadth of the excavation is such that large, suitable construction equipment will be able access and excavate to a considerable depth. The EOR working with the construction contractors will develop solutions in the unlikely event that normal excavation and construction methods are unable to completely meet the objective. These kinds of eventualities and challenges are routinely addressed and overcome in major construction projects. For information on change management, please refer to the response to R2-2.

Further information on permafrost conditions and removal, informed by additional investigations, will be provided during the licensing process. The Regulator will not grant a license to construct until CMC can demonstrate compliance with applicable codes and regulations. Furthermore, any deviation from the design basis will be reviewed and approved by the Regulator.

The equipment spread and excavation plan details will be provided in support of the applications for the Quartz Mining License and Water Use License, as appropriate.

B.4.8.10.2 R2-61

R2-61. Details regarding:

a. A clear definition of ice-rich soils and rock;

b. Characterization of the ice content of the near surface soils and rock to assess the potential volume of ice-rich materials to be excavated and disposed;

c. A well-defined and rational methodology and decision making process to identify and characterize permafrost soils and rock that can be used to guide all excavation and stripping work;

d. A detailed permafrost hazard map (predictive) and associated methodology that identifies type, nature, and magnitude of permafrost related hazards in the study area;

e. If the TMF is situated on permafrost soils that are too deep to excavate, consideration of creep deformation of those permafrost soils resulting from placement of the TMF; and,

f. Based on the map above, identification of specific risks to the Project (i.e. minesite infrastructure and the Northern Freegold Road) from identified permafrost hazards. The map should include consideration of climate change, as well, over the life of the Project.

a. *Definition of ice-rich soils and rock:* Permafrost is discontinuous over the TMF embankment area, and is primarily present at the valley bottom, north-facing slopes and shaded areas. The ridges at higher elevations and upper slopes on the west abutment are southeast-facing, and are generally free of permafrost except for some local shaded areas. Permafrost is common in the northwest-facing east abutment area, where test pits were terminated at shallow depths in frozen colluvium and residual soils.

   Permafrost has been identified in the organic, silty colluvial apron of the Casino Creek and tributary valley bottoms. The overburden is generally saturated and frozen in these areas, with high ice contents. The site investigation data also indicated ground ice close to tributaries leading to Casino Creek. The average thickness of the colluvial apron is expected to be approximately 10 metres based on the findings of the site investigations.

b. *On-going characterization of ice-rich soils:* To ensure the stability and integrity of the TMF dam foundation, CMC plans to perform the following activities:

- Unsuitable soils and all vegetation underlying the TMF dam foundation will be removed. The topsoil will be stockpiled for reclamation purposes.
- Overburden (including topsoil) will be left in place in the impoundment area upstream of the dam. Disturbance of the vegetation mat will be avoided to the maximum extent possible.

Overburden underlying the Main Embankment will be excavated down to bedrock or suitable overburden foundation conditions. SNC-Lavalin has speculated that this may not be practical. While there is the some possibility that it may not be entirely practical, it is important to keep in mind the length and breadth of the excavation is such that large, suitable construction equipment will be able access and excavate to a considerable depth. The EOR working with the construction contractors will develop solutions in the unlikely event that normal excavation and construction methods are unable to completely meet the objective. These kinds of eventualities and challenges are routinely addressed and overcome in major construction projects. For information on change management, please refer to the response to R2-2.

c. *Process to identify permafrost conditions:* When the balance of the planned geotechnical investigations (described in the project proposal and referred to in various responses) has been proposed to be completed during the detail engineering phase, a detailed construction work plan will be developed by the EOR and EPCM contractors with input from the construction contractor(s) to guide the work. Informed by the results of the geotechnical investigation, the EOR will characterize and define acceptable parameters and criteria for the excavation of frozen soils and rock. Any deviation from the defined criteria will be dispositioned by the EOR as described in the response to R2-2, in regards to change management.

   The geotechnical engineer representing the EOR will make the determination that the as excavated conditions meet the foundation design requirements. No work will proceed until such time as the EOR declares the foundation preparation to be satisfactory.

d. *Permafrost hazard map:* Terrain mapping and terrain stability mapping was conducted to predict the potential for landslides, snow avalanches and permafrost disturbances, and the results are provided in Appendices 6B, 6D and 6E and summarized in Section 20.3.2. The overall potential effects of terrain instability, in particular permafrost degradation, on the Project is considered not 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. However, 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, which include:

   - 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.
   - 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.
   - 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.

The geotechnical engineer representing the EOR will make the determination that the as excavated conditions meet the foundation design requirements. No work will proceed until such time as the EOR declares the foundation preparation to be satisfactory.

e. *Consideration of creep deformation:* CMC has stated that overburden underlying the Main Embankment will be excavated down to bedrock or suitable overburden foundation conditions. While there is the some possibility that it may not be entirely practical, it is important to keep in mind the length and breadth of the excavation is such that large, suitable construction equipment will be able access and excavate to a considerable depth. The EOR working with the construction contractors will develop solutions in the unlikely event that normal excavation and construction methods are unable to completely meet the objective. These kinds of eventualities and challenges are routinely addressed and overcome in major construction projects. For information on change management, please refer to the response to R2-2.

   The geotechnical engineer representing the EOR will make the determination that the as excavated conditions meet the foundation design requirements. No work will proceed until such time as the EOR declares the foundation preparation to be satisfactory and in compliance with applicable codes and regulations, and the terms of licenses.

f. *Risks specific to the Project from permafrost:* For information on permafrost hazards, please refer to the response to R2-94.

   The geotechnical engineer representing the EOR will make the determination that the as excavated conditions meet the foundation design requirements. No work will proceed until such time as the EOR declares the foundation preparation to be satisfactory and in compliance with applicable codes and regulations, and the terms of licenses.

B.4.8.10.3 R2-62

R2-62. Based on the risk identified in response to the questions above, please provide general options and considerations for engineering design to mitigate the identified risks.

Terrain mapping and terrain stability mapping was conducted to predict the potential for landslides, snow avalanches and permafrost disturbances, and the results are provided in Appendices 6B, 6D and 6E and summarized in Section 20.3.2. The overall potential effects of terrain instability, in particular permafrost degradation, on the Project is considered not 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. However, 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, which include:

- 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.

- 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.
- 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.

The geotechnical engineer representing the EOR will make the determination that the as excavated conditions meet the foundation design requirements. No work will proceed until such time as the EOR declares the foundation preparation to be satisfactory and in compliance with applicable codes and regulations, and the terms of licenses.

For information on change management, please refer to the response to R2-2.

B.4.8.10.4 R2-63

R2-63. Provide a comprehensive assessment of how groundwater flow may be affected due to changing thermal conditions (i.e. melting permafrost). Consideration should be given to all stages of the Project, including in perpetuity for post-closure.

As stated in the response to R2-111 and to R2-112, the numerical groundwater model was conducted at a regional scale, and groundwater flow is assumed to be homogeneous and isotropic at the regional scale for the purpose of regional and project-site scale assessment of groundwater flow. At the regional-scale, the net volume of groundwater discharge to the creek valleys is expected to be independent of permafrost distribution, particularly considering the relatively steep valley slopes that drive groundwater flow at the Project site. It is considered sufficient for the purpose of the regional hydrogeology assessment to consider the subsurface as a homogeneous unit that is permafrost-free.

Additionally, while representation of permafrost in the numerical groundwater model as a barrier to groundwater flow was considered during initial development of the numerical model, permafrost zones with a lower hydraulic conductivity were not represented within the subsurface of the baseline numerical model since the distribution of permafrost is not expected to have a significant effects on the regional-scale seepage pathways from facilities to downstream receptors or impact seepage rates. The relatively steep topography at the site is expected to drive groundwater flow and define groundwater recharge and discharge zones at topographic highs and lows, respectively.

The purpose of the groundwater model is to assess the effects of the Project on the environment, not the effects of permafrost degradation on groundwater flow. The Mine Life Modflow models assumed that permafrost below all facilities degrades or is removed during mine operations. This allows groundwater to flow unobstructed to the downgradient discharge location.

B.4.8.10.5 R2-64

R2-64. Provide further justification of the validity of the baseline model calibration and its potential impact on groundwater flows in the Mine Effects models ensuring permafrost is considered in the calibrations.

Please refer to the response to R2-63.

B.4.8.11 TMF Dam Core Construction

B.4.8.11.1 R2-65

R2-65. Confirm how the dam core will be insulated during construction and include comprehensive details (e.g. properties and characteristics of insulation; methodology for installing insulation; objectives and adaptive management). Provide relevant examples to support the proposed methodology.

CMC plans to manage dam core construction to avoid freezing within the dam core, as follows:

Management methodology

- Construction of the core zone for Casino will not take place during winter months (i.e., December – February) when soil freezing is likely to occur.
- Adequate insulation of the core material will be required for the final dam and for intermediate stages. Insulating layers are to be placed over the core after each lift and removed immediately prior to construction of the consecutive lift. Insulating blankets and tarps will be used to keep lifts from freezing during placement and compaction of the dam.
- Engineers will be in close contact with contractors during the construction phase to verify adequate material quality and compaction, and revise construction procedures as necessary.

Methodology for installation of insulation

Construction of the dam core will not occur during winter months. During the construction period freezing temperatures will be experienced, particularly during the shoulder seasons (spring & fall) and overnight. When freezing conditions are anticipated or present, depending on how cold it is at the time, it may be necessary to protect that area of the core under active construction from the effects of freezing. This is accomplished by using insulated tarps and/or other measures as is commonly done in construction in colder climates. This temporary protection is routine in the construction industry and familiar to any competent civil contractor. The EOR will specify the conditions under which temporary protection is required and what materials and methods are acceptable in the project specification developed in the detail engineering phase of the project.

It should be noted that a completed core lift goes through one winter then the next lift is placed and compacted. Individual lifts do not go through numerous repeated freeze thaw cycles. A protective insulation layer will be provided on top of the final embankment crest to prevent repeated seasonal frost penetration into the upper few meters of the core zone. This cover will likely comprise several meters of coarse, non-frost susceptible fill, similar to the designs at the White Lake Dam and Charlot River Dam in Saskatchewan (Solymar and Nunn, 1983).

Insulation properties and characteristics

Insulated concrete curing blankets that are frequently required to protect curing concrete can be used for this purpose as well as other similar product available to industry (e.g., TarpsNow, 2015). Typically these tarps are made of flexible hydrophobic foam that provides the highest possible R values, up to 7.7.

Adaptive management

The EOR working with the construction contractors will develop solutions in the unlikely event that normal construction methods are unable to completely meet the objective. These kinds of eventualities and challenges

are routinely addressed and overcome in major construction projects. For information on change management, please refer to the response to R2-2.

B.4.8.12 Starter Dam and Tailings Interface

B.4.8.12.1 R2-66

R2-66. An explanation on how the additional transition zones can affect the current analysis.

The purpose of the filter and transitional zones is to prevent the migration of finer graded material into coarser graded material, to limit differential settlement between materials with different properties, and to safely convey any seepage to the downstream area. The filter and transition zones will be sized to meet these criteria, and have been modelled accordingly in the seepage analyses. The strength properties of additional transition zones are similar to the conservative strength properties assigned to the shell zone. Additionally, the effect on the stability is limited due to small size of any additional transition zones relative to the total dam section. Including additional transition zones to the stability model will not result in significant changes to the predicted factors of safety.

It is important to note that both YESAB consultants (EcoMetrix & SNC-Lavalin) found CMC's response to R102 contained in the SIR-A to be adequate.

B.4.9 LIQUIFIED NATURAL GAS AND DIESEL

B.4.9.1 Description of LNG Facilities

B.4.9.1.1 R2-67

R2-67. Identification of potential hazards of wildfire to LNG facilities at the Casino Mine site and a quantitative assessment of the related risk to those facilities. Ensure that risks and procedures associated with forest fires are discussed.

The design and location of the LNG facility are such that a wildfire will have little to no effect on the LNG storage. The concentrator and associated power plant infrastructure is located at ~1,200 masl, beyond the tree line (Figure B.4.9-1 and Figure B.4.9-2). Further, the LNG storage is centralized within the concentrator and infrastructure site, with a minimum distance to forested areas of about 2 Kilometres. (Figure B.4.9-3). With a separation distance of this magnitude a forest fire will have no appreciable impact on the LNG storage tank.

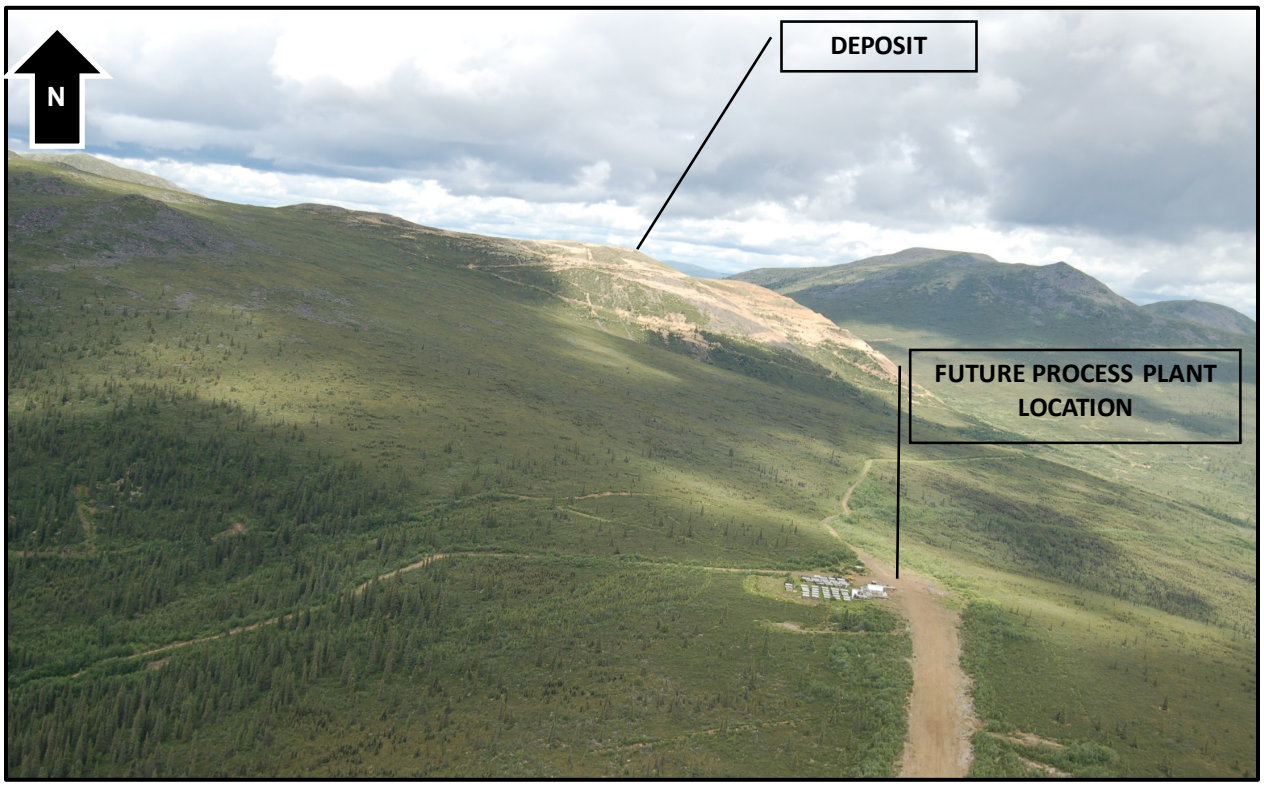

Figure B.4.9-1 Future Process Plant (and LNG facility) location

Figure B.4.9-2 Rendering of Proposed Process Plant overlain on Actual Topography

Procedures and measures associated to forest fires

The LNG storage tank will be constructed and managed in accordance with the National Fire Code, conforming with the Environmental Code of Practice for Above-ground Storage Tank Systems Containing Petroleum Products and Canadian Standards CSA Z-276-11 for LNG facilities.

The LNG tank is insulated by approximately 1,500 mm of perlite insulation as per 7.1.7.3 of CSA Z-276-11. LNG piping is insulated and protected as per 9.2.1.3 of CSA Z-276-11. The tank insulation effectively limits the boil off generated during a hot summer day conditions to less than 0.3% per day. There is no possibility that a forest fire will heat the tank contents to a level that would overwhelm the boil-off control system and tank relief system resulting in conditions that even begin to approach a BLEVE risk.

In the event of a forest fire during the construction, operation, or decommissioning phases, ongoing activities would be suspended in potentially affected areas if conditions were considered to be unsafe by CMC. In the event of a forest fire that is deemed to be of concern, the Emergency Response Management Team will implement appropriate actions as established in the Emergency Response Plan (ERP).

It should be noted that during 2015, the Casino site was threatened by a fire of approximately 400 hectares. This fire burned to the edge of the airstrip of the exploration camp with no physical damage to the camp. During the fire, zero release of the 1,750 litres of pressurized propane occurred. During this fire, the Yukon Wildland Fire Management erected a simple sprinkler system to protect structures.

CASINO

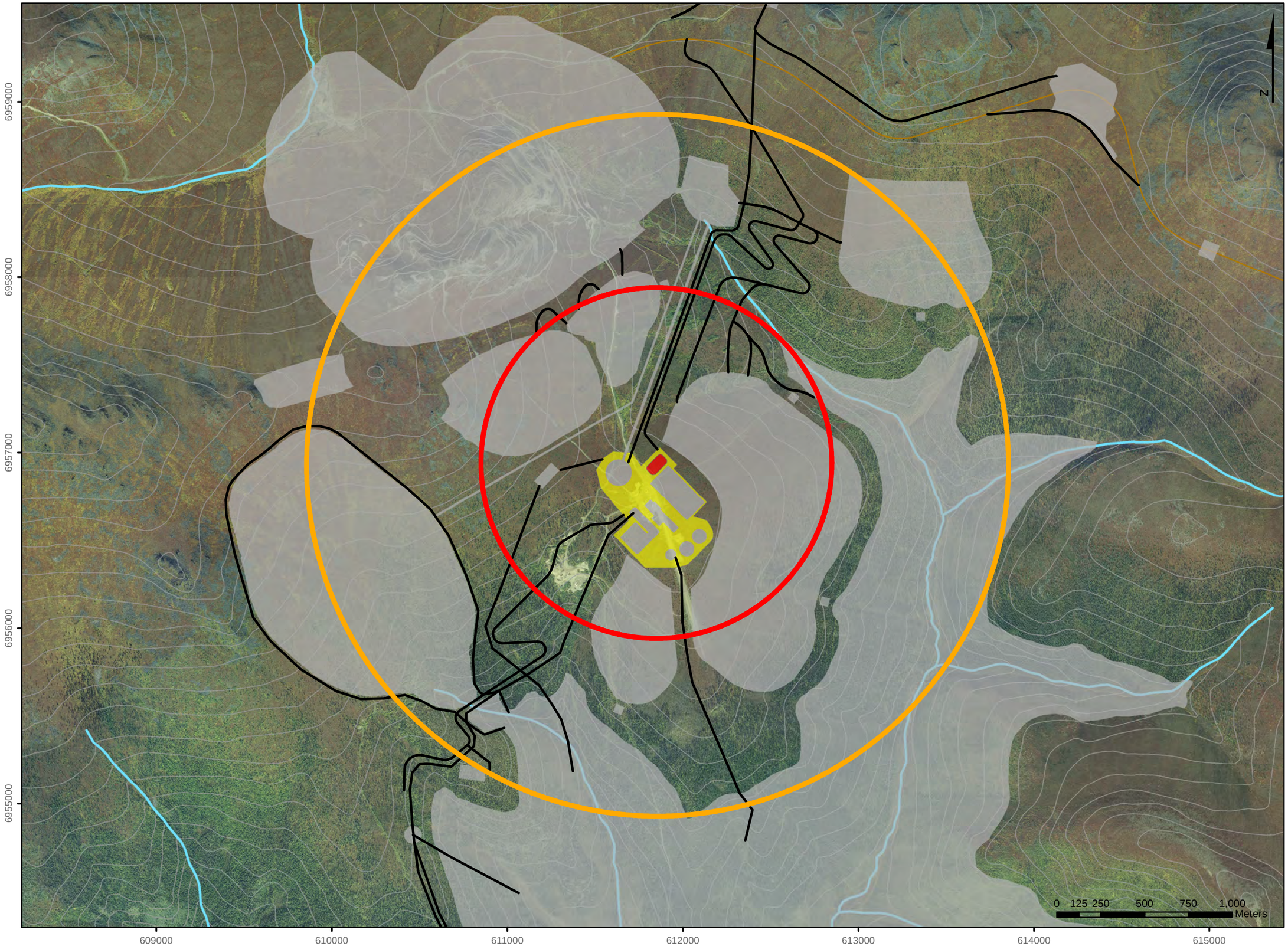

Figure B.4.9-3: LNG Storage Separation Distance to Forested Areas

B.4.9.2 Description of Diesel Facilities

B.4.9.2.1 R2-68

R2-68. For the diesel facilities and fueling stations, provide:
a. a detailed description for all facilities related to diesel including location, design, construction, operation and closure;
b. measures for the safety of project personnel including separation distances from office and living areas; and
c. design measures and operating procedures to prevent a cascading accident.

The design, construction and operation of diesel facilities and fueling stations will be in accordance with the Fuel Storage and Handling Guidebook (INAC, 2002) and National and Territory regulations. Per Yukon regulations, all such installations will require a license to construct and operate and details of each fuel site will be provided to the regulator with the permit applications.

a. *Description of facilities:* Diesel fuel storage and fueling stations will be located near the truck shop, which is at the center of the principle demand, namely the mining fleet and support equipment. However, during the construction phase of the project it will be necessary to provide temporary diesel fuel storage at a number of locations to service the needs of construction equipment and for electrical power generation purposes. The location of these fuel depots is liable to change as the work progresses and operations change. The location of the depots during construction will be determined as part of the temporary infrastructure planning effort during the detailed engineering phase and early construction phase with input from the construction contractors at that time.

b. *Safety measures:* The design, construction, and operation, including consideration of separation distances, will be consistent with the Fuel Storage and Handling Guidebook and applicable regulations (i.e., *Environment Act: Storage Tank Regulations*). CMC will obtain the necessary license and permits to construct and operate the facility from the Yukon Regulatory Agency in compliance with the National and Territory regulations (e.g., storage tank systems permit).

   More specifically, during the construction phase, the preferred diesel fuel storage solution is Double-Walled tanks, as per Section 3.1.2.1 of the Fuel Storage and Handling Guidebook (INAC, 2002). In some instances single walled tanks located within dyked containment areas may be used per Section 3.1.2.2 of the the Fuel Storage and Handling Guidebook.

   Given the volume and extended duration of the diesel fuel storage requirements during operations it is likely that single-wall tanks located within a dyked containment area will likely be used.

c. *Design measures and procedures to prevent cascading events:* The design, construction, and operation, including consideration of separation distances, will be consistent with the Yukon Guidebook (INAC, 2002) and applicable regulations. CMC will obtain the necessary license and permits to construct and operate the facility from the relevant Yukon Government departments (e.g., Department of Energy, Mines and Resources Lands Branch and Department of Environment: Environmental Programs) in compliance with the National and Territory regulations.

B.4.10 CONCEPTUAL CLOSURE AND RECLAMATION PLAN

B.4.10.1 Long-Term Closure and Ongoing Monitoring and Maintenance

B.4.10.1.1 R2-69

R2-69. Further analysis of closure options including long-term and short-term costs, care and maintenance requirements, and long-term environmental risks. The options analysis should include:
a. open pit;
b. tailings management facility;
c. heap leach facility;
d. stockpile areas; and
e. water management and treatment.

All components of the Project were designed for closure. Key in this regard was the alternatives assessment for selection of the best location for the TMF. Selection of practical and feasible closure options were based on: design for closure, placing uneconomic PAG material in the TMF for permanent underwater disposal, and ensuring no enduring post-closure active care of the site. Primary consideration was selecting the best closure technology. Costs were then considered in the evaluation of technically viable solutions. Costs will be further evaluated during the finalization of the closure plan for Quartz Mining Licencing. Options that did not meet these objectives were rejected early in the development of the conceptual closure plan, limiting the remaining options.

To further illustrate this point, the various options have been provided in Table B.4.10-1, with ranking for qualitative long and short-term costs, environmental risks, feasibility, and effectiveness. The comments in the table explain why the selected option was chosen, and what the limitations to the other options are.

The analysis provided in Table B.4.10-1 is in keeping with the requirements of the *Reclamation and Closure Guidance* (EMR, 2013), which state:

“While early initiation of reclamation and closure planning is critical, an RCP will be refined throughout the mine life as specific information is gathered and lessons are learned through reclamation research programs and monitoring programs. Early versions of an RCP, like those prepared during pre-feasibility stages of project planning, may be conceptual in nature and be based upon closure options and assumptions for these options provided that these are based upon the best available information and have sufficient reasoning.”

Table B.4.10-1 Closure Options Analysis

Component / Closure Option*	Long-term costs	Short-term costs	Ranking: Environmental risks	Ranking: Feasibility	Ranking: Effectiveness	Overall Rank	Comments
Open Pit							
1.a. Divert Canadian Creek	Maintain ditch	Upgrade ditch to PMF	Low	High	High	4	Expedited flooding of the pit is desired to minimize pit wall exposure
1.b. Remove Canadian Creek Diversion	None	Remove diversion	Low	High	High	**5**	
2.a. Passive discharge to TMF	Maintain ditch	Construct ditch to TMF	Low	High	High	**5**	• Active pumping and maintenance is undesirable. • Treatment wetland is designed to accommodate peak flows. • Discharge to Canadian Creek would impact Britannia Creek and potentially the Yukon River.
2.b. Active discharge to TMF	• Provide power and personnel for annual operation. • Maintain pond below invert. • Operate pumps for spring/summer discharge to TMF wetland.	Install barge and pump/piping system.	Low	Low	High	2	
2.c. Discharge to Canadian Creek	• Provide power and personnel for annual operation. • Maintain pond below invert. • Operate pumps for spring/summer discharge to Canadian Creek.	Install barge and pump/piping system.	High	Low	High	1	
3.a. Pit water in-situ treatment: Lime treatment	None	Lime addition during waste rock (marginal grade ore) disposal.	Low	High	Moderate	3	May improve water quality in the long term. May not be necessary if pit pond stratifies.
3.b. Pit water treatment: Biological treatment	Intermittent biological treatment of pit water to stimulate microbial activity, if necessary.	Intermittent biological treatment of pit water to stimulate microbial activity, if necessary.	Low	Moderate	Moderate	3	• May be used for complementary water treatment should pit water quality warrant it. • North Wetland will be primary treatment system.
3.c No pit water treatment	None	None	Low	High	Low	2	The North treatment wetland is designed to intercept untreated pit overflow.
4.a. No active pit overflow treatment	None	None	Moderate	High	High	3	• Untreated water from the Open Pit would flow into the TMF and be incorporated into the TMF pond. • Modeling indicates high concentrations of Cd, Cu, Se and U.
4.b. Pit overflow passive treatment	• Wetland monitoring • Wetland maintenance	Wetland construction	Moderate	High	High	**5**	• Treatment wetland design assumes no regulation of flow from the open pit, and is therefore designed to treat for spikes in concentrations and flows. • Environmental risks are only in the case of failure of the treatment wetland. • Failure of the treatment wetland will be muted by the large volume of water in the TMF.

Component Closure Option*	Long-term costs	Short-term costs	Ranking Environmental risks	Ranking Feasibility	Ranking Effectiveness	Overall Rank	Comments
Heap Leach Facility							
1.a. Rinse HLF	None	Detoxification of cyanide via heap rinsing	Low	High	High	**5**	• Rinsing will be continued as long as necessary to flush leaching compounds from the HLF. • If rinsing is not conducted, contaminants will flush from the heap as precipitation percolates through the heap and discharge to the TMF pond. • Contingency: all heap drainages goes to TMF (dilution and wetland treatment)
1.b. Do not rinse HLF	None	None	Moderate	High	Low	1	
2.a. Install downstream passive treatment: Biopass	Following draindown, bioreactor would be shut down and the matrix permanently sealed in place	Installation of bioreactor	Low	High	Moderate	4	• Modeling indicates that post-rinsing, water from the HLF may be elevated in SO_4, F, Cd, Cu, Fe, Mo, Se and U. • A treatment wetland has been designed to intercept runoff from the HLF and will minimize contaminants entering the TMF pond. • The wetland option ensures long-term treatment, instead of short-term treatment via bioreactor. • Environmental risks are only in the case of failure of the treatment wetland. • Failure of the treatment wetland will be muted by the large volume of water in the TMF.
2.a. Install downstream passive treatment: Wetland	• Wetland monitoring • Wetland maintenance	Wetland construction	Low	High	High	5	
2.c. No downstream treatment	None	None	Moderate	High	Low	2	
2.d Low permeability cover to reduce flushing	Minor for maintenance of cover	High	Low	Low	High	2	No local source of good cover material. Slopes are too steep for geomembrane, and would need to be re-countoured.
Stockpile Areas							
1.a. Leave in place and cover	Collect and pump seepage to the TMF	Re-contour and cover stockpiles	Moderate	Moderate	Low	2	• Leaving stockpiles in-place may result in long-term contaminated seepage. • There is insufficient low infiltration cover material. • Stable geomembrane covers require relatively flat slopes in alpine setting. • Depending on market conditions, the marginal grade ore may be milled near the end of operations, therefore, disposing of the material in the TMF during operations would preclude further recovery of the ore. • Disposal in the TMF would increase the storage volume in the TMF, which would necessitate a higher dam. • Disposal in the TMF may impact the pond water quality.
1.b Dispose directly in TMF throughout operations	None – all activities conducted throughout operations	Trucking during operations	Low	Moderate	High	2	
1.c Store on surface and dispose of in pit at closure	Potential treatment of pit water (see Open Pit section above)	Disposal of material in the open pit	Low	High	High	5	
1.d. Store on surface and relocate to TMF at closure	Potential impact to the TMF pond water quality	Disposal of material in TMF	Moderate	Moderate	High	3	
Tailings Management Facility (for operational and design considerations see the full alternatives assessment in Appendix B.4B.)							
1.a Disposal in-place with no cover	• Long-term acid generation issues with flushing of oxidation products. • Long-term water treatment would likely be required.	None	High	High	Low	1	No water cover does not prevent oxidation of PAG materials.

Component / Closure Option*	Long-term costs	Short-term costs	Ranking: Environmental risks	Ranking: Feasibility	Ranking: Effectiveness	Overall Rank	Comments
1.b. De-pyritized tailings and water cover	• Maintenance of the overflow spillway • Polishing of pond water for key parameters required.	Spiggoting and distribution of de-pyritized cover over entire waste rock and PAG tailings surface area	Low	High	High	5	De-pyritized tailings and water cover is best management practice for PAG materials, as determined by site-specific evaluation conducted by Lorax Environmental.
1.c. De-pyritized tailings and dry cover	• Maintenance of the dry cover. • Long-term water treatment would likely be required.	• Spiggoting and distribution of de-pyritized cover over entire waste rock and PAG tailings surface area. • De-watering of remaining water. • Cover of entire surface area with effective low-permeability cover.	Moderate	Moderate	Moderate	3	• Dry cover does not prevent oxidation of PAG materials. • Insufficient low infiltration cover material on-site for the entire area.
2.a Locate TMF further downstream	Comparable to the costs of the current design.	Comparable to the costs of the current design.	Moderate	Moderate	Moderate	3	• Downstream location increases available dilution • Downstream location results in greater flood risk to TMF
3.a Seepage collection and pump back to TMF	Long-term pumping	Installation of seepage collection pond and pump-back system.	High	Low	Low	1	Long-term power requirements for pump back is not a valid closure option, according to the Yukon Government guidelines.
3.b. Reduce seepage through foundation treatment	None	Additional grouting during foundation preparation of the dam.	Moderate	Moderate	Moderate	3	• Grouting may lower the permeability of the subsurface rock. • Grouting will be considered as a complementary method of seepage reduction.
3.c. Seepage treatment	• Wetland monitoring • Wetland maintenance	Wetland construction	Low	High	High	5	• Modeling indicates that seepage may be elevated in SO_4, F, Cd, Cu, Mo, Se and U. • A treatment wetland has been designed to intercept seepage and treat it to acceptable discharge concentrations. • The wetland option ensures long-term treatment, with minimal maintenance. • Environmental risks are only in the case of failure of the treatment wetland. • Ongoing monitoring will ensure the treatment wetland is functioning as required.
4.a Dam embankment topsoil and vegetation cover	Maintenance of vegetated cover	Topsoil and vegetation placement	Low	High	Moderate	4	• Dam embankment is constructed of de-pyritized non-acid generating material. Therefore, the geochemical risk is low. • Vegetation can be an important aspect of erosion control.
4.b Dam embankment low infiltration cover	Maintenance of cover	• Placement of low-infiltration cover • Cover with topsoil and vegetation	Low	Moderate	Moderate	3	Low-infiltration cover not required for non-acid generating material.
Water Management and Treatment							
1.a No treatment	None	None	High	High	Low	1	• Modeling indicates that TMF pond water and seepage will be elevated in SO4, F, Cd, Cu, Fe, Mo, Se and U. • Direct discharge without treatment will result in exceedances of water quality objectives in Casino and Dip Creeks.
1.b. Active water treatment plant	High long-term operating costs	• Installation of a water treatment plant • Treatment plant on-site for cyanide treatment may be re-purposed to treat	Low	Low	High	1	• Active long-term treatment is in contradiction of the stated objectives of the Yukon Government for non-active closure. • Costs for long-term treatment are prohibitive and un-economical.

Component Closure Option*	Long-term costs	Short-term costs	Ranking			Overall Rank	Comments
			Environmental risks	Feasibility	Effectiveness		
		parameters of concern in the TMF pond.					• May be available as a contingency measure during the early years of wetland construction and development. However, the many "design for closure" aspects of the Casino project suggest that this is very low probability (worst ML/ARD risks are eliminated during operations).
1.c. Passive water treatment systems (treatment wetlands)	• Wetland monitoring • Wetland maintenance	Wetland construction	Low	High	High	5	• Installation of wetland treatment systems at various sources (HLF, Open Pit, TMF and downstream of TMF embankment) introduces redundancies in the treatment and creates a treatment train to improve overall water quality. • Environmental risks are only in the case of failure of the treatment wetland. • Ongoing monitoring will ensure the treatment wetland is functioning as required.
1.d. Storage and discharge of seepage in conjunction with treatment wetlands	• Wetland monitoring • Wetland maintenance • Maintenance of seepage discharge system	• Wetland construction • Seepage pond construction • Installation of linked discharge system	Low	Moderate	High	3	• Due to excavation of overburden at the foundation of the TMF, a storage pond at the toe of the embankment would have to be very large, and would need to be pumped to be discharged, which is in in contradiction of the stated objectives of the Yukon Government for non-active closure.
1.e. Discharge seepage and TMF overflow directly to Dip Creek via pipeline	Pipeline and pump maintenance	Construction of pipeline Installation of pumping system	Moderate	Moderate	Moderate	2	To avoid discharge to Casino Creek, discharge could be pumped directly to Dip Creek and meet water quality objectives through higher dilution availability. Pumping would be required, which is in in contradiction of the stated objectives of the Yukon Government for non-active closure.

*Option in **bold** is the chosen option

B.4.10.1.2 R2-70

R2-70. Discussion and, if necessary, an update to the conceptual closure plan to take into account the most recent Government of Yukon Reclamation and Closure Planning for Quartz Mining Projects, Plan Requirements and Closure Costing Guidance (Government of Yukon, 2013). Details should include:
a. additional closure methodology that demonstrates that the open pit water can passively flow to the TMF without continued intervention; and
b. identification of closure methodologies that have been demonstrated effective in northern environments, and that clearly meet the objectives described in Section 5 of the guidance document.

a. The North TMF Wetland, which receives discharge from the Open Pit, has been designed to accept uncontrolled flows from the Open Pit to the TMF. A review of the North TMF Wetland design has been conducted (Appendix B.4G), and includes a 12 ha wetland (previously a 7 ha wetland) which is sized to achieve CCME guidelines for all parameters at the 95th percentile concentration and 50th percentile flows, with added contingency. These calculations are based on no control of flow from the Open Pit.

   Therefore, while CMC believes that controlling discharge from the open pit is feasible, the design for closure has been evaluated to have that control as only a contingency measure, with a robust treatment wetland design to intercept that discharge at variable flow rates.

b. As detailed in the Conceptual Closure and Reclamation Plan (Appendix 4A), although "conceptual", the plan is based on numerous site characterization and engineering studies in support of the mine plan and closure. This plan will be expanded during the Quartz Mining License application to meet additional reporting requirements, such as costing, as detailed in the Yukon Mine Reclamation and Closure Policy.

   Consistent with the objectives described in Section 5 of the *Reclamation and Closure Planning for Quartz Mining Projects* (Government of Yukon, 2013), CMC outlined general closure objectives in Section 1.4 of Appendix 4A as well as the comprehensive and conservative approach to closure planning undertaken by CMC to ensure the objectives are met in Section 2 of that same plan. These were further detailed in the response to R110, and include:

   - Protect public health and safety;
   - Minimize, mitigate or prevent adverse environmental impacts;
   - Reclaim the site to a land use state consistent with surrounding conditions;
   - Ensure long-term stability of the spent ore and waste rock storage area and site water quality;
   - Restoration of the mine area, considering terrestrial restoration (vegetation) compatible with surrounding area;
   - Physical stability of residual structures (i.e. tailings dam, heap leach facility, etc.);
   - Protection of downstream receiving environment; and
   - Minimize requirements for post-closure activity (i.e. site presence).

   For comparison, Table B.4.10-2 outlines the objectives outlined in the Government of Yukon report (2013) and the components of the Casino Project closure plan that meet these objectives.

CMC considers all closure methodologies presented in the Conceptual Closure and Reclamation Plan to be applicable in northern environments. For reference, CMC has provided a list of “Northern” mines where comparable methodologies have been applied in Table B.4.10-3. This list is not exhaustive, but is meant to identify comparable locations, with the intent of demonstrating the applicability of those methodologies to the Project. Mines with the methodologies detailed in government approved closure plans, but not yet implemented, are identified with italics in Table B.4.10-3.

Table B.4.10-2 Closure Components to meet Government of Yukon Closure Objectives

Objective (Government of Yukon, 2013)	Conceptual Closure and Reclamation Plan Components (Appendix 4A)
Physical Stability • All mine-related structures and facilities are physically stable and performing in accordance with designs. • All mine-related structures, facilities and processes can withstand severe climatic and seismic events.	• Design and construction of the TMF dam for the 1 in 10,000 year earthquake and probable maximum flood (the highest standards recommended by the Canadian Dam Association). • Processing of all ore stockpiles or disposal in open pit (no material left on surface). • Filling of open pit with groundwater and surface water to minimize geochemical exposure. • Construct berm at access points around perimeter of open pit. • Detoxification of Heap Leach Facility and capture of infiltration discharge in the TMF. • Re-contouring of surface slopes to meet long-term stability objectives. • An active closure period of 3 years to remove mine infrastructure from the site and construct covers on the TMF embankment, HLF after detoxification, and stockpile footprints. • Decommissioning of the Freegold Access Road.
Chemical Stability • Release of contaminants from mine related waste materials occurs at rates that do not cause unacceptable exposure in the receiving environment.	• Mitigation “by design” of major infrastructure to: • Minimize project footprint; • Ensure all sources of uncontrolled discharge are captured by the TMF or open pit; • Dispose of geochemically reactive waste using best management practices; and • Maximize source control (e.g., segregation of non-PAG waste). • All sources of discharge post-closure may be intercepted by passive treatment systems to form a “treatment train” of redundant treatment systems to ensure ultimate protection of the receiving environment (e.g., North TMF wetland, HLF wetland, South TMF wetland, seepage wetland). See Appendix B.4G.
Health and Safety • Reclamation eliminates or minimizes existing hazards to the health and safety of the public, workers and area wildlife by achieving conditions similar to local area features. • Reclamation and closure implementation avoids or minimizes adverse health and safety effects on	• Dismantle buildings and infrastructure and salvage any material with value. Inert material without salvage value disposed of in on-site landfill. • Remove and properly dispose of any hazardous materials off-site. • Decommission power plant. • Reclaim roads not required for post-closure activities. • Clean up and dispose of any debris and garbage. • Decommission access road to prevent public access.

Objective (Government of Yukon, 2013)	Conceptual Closure and Reclamation Plan Components (Appendix 4A)
the public, workers and area wildlife.	• Remove and remediate any hydrocarbon contaminated soils. • Re-vegetate disturbed areas. • Construct berm at access points around perimeter of Open Pit. • Maintain site access roads for on-going monitoring access only. • Monitoring of the TMF and open pit lake will include determination of any wildlife attraction, an assessment of the risks if wildlife are using it, and the need for deterrence measures, if required (see SIR-A Section A.12).
Ecological Conditions and Sustainability • Reclamation and closure activities protect the aquatic, terrestrial and atmospheric environments from mine-related degradation and restore environments that have been degraded by mine-related activities. • The mine site supports a self-sustaining biological community that achieves land use objectives.	• Open pit will become a pit lake, with acceptable water chemistry for wildlife use. • Tailings Management Facility will become a shallow lake with treatment wetlands at key locations. Water chemistry will be acceptable for wildlife use. No accumulation of metals predicted in wetland plants. • Treatment wetland at toe of tailings embankment will maintain water quality objectives in the Casino Creek receiving environment (see Section B.4.10).
Land Use • Lands affected by mine-related activities (e.g., building sites, chemical and fuel storage sites, roads, sediment ponds, tailings storage facilities, waste rock storage areas, underground workings, etc.) are restored to conditions that enable and optimize productive long-term use of land. Conditions are typical of surrounding areas or provide for other land uses that meet community expectations. • Site access is consistent with community land use expectations.	• Dismantle buildings and infrastructure and salvage any material with value. Inert material without salvage value disposed of in on-site landfill. • Remove and properly dispose of any hazardous materials off-site. • Decommission power plant. • Reclaim roads not required for post-closure activities. • Clean up and dispose of any debris and garbage. • Decommission access road to prevent public access. • Remove and remediate any hydrocarbon contaminated soils. • Re-vegetate disturbed areas (including stockpile areas and heap leach facility). • Construct berm at access points around perimeter of Open Pit. • Maintain site access roads for on-going monitoring access only.
Aesthetics • Restoration outcomes are visually acceptable.	• Final landscape will consist of lakes, wetlands and hill-slopes vegetated with native plants. • Final landscape will appear similar to other comparable high alpine Yukon landforms.

Objective (Government of Yukon, 2013)	Conceptual Closure and Reclamation Plan Components (Appendix 4A)
Socio-economic expectations • Reclamation and closure implementation avoids or minimizes adverse socio-economic effects on local and Yukon communities, while maximizing socio-economic benefits. • Reclamation and closure activities achieve outcomes that meet community and regulatory expectations.	• Closure activities would be carried out concurrently with mine operations wherever possible. • Most of the mine site area will be available for a variety of land uses following reclamation. However, the area occupied by several reclaimed site facilities (i.e. TMF and open pit) will be unavailable for future land use activities. • Closure activities will comply with regulatory requirements. • Monitoring will continue to ensure continued compliance.
Long-term certainty • Minimize the need for long-term operations, maintenance and monitoring after reclamation activities are complete.	• Mitigation "by design" of major infrastructure to: • Minimize project footprint; • Ensure all sources of uncontrolled discharge are captured by the TMF or open pit (i.e., only one source of discharge); • Dispose of geochemically reactive waste using best management practices; and • Maximize source control (e.g., segregation of non-PAG waste). • Design and construction of the TMF dam for the 1 in 10,000 year earthquake and probable maximum flood (the highest standards recommended by the Canadian Dam Association). • Re-contouring of the heap leach facility to stable slope. • All sources of discharge post-closure may be intercepted by passive treatment systems to form a "treatment train" of redundant treatment systems to ensure ultimate protection of the receiving environment (e.g., North TMF wetland, HLF wetland, South TMF wetland, seepage wetland). See Appendix B.4G. • A long-term monitoring program consisting of active and passive phases will begin after the primary reclamation activities have been completed.
Financial considerations • Minimize outstanding liability and risks after reclamation activities are complete.	• Mitigation "by design" minimizes liability and risk in the design phase. • Passive treatment systems require minimal maintenance, and are self-sustaining in the long term. • Quality control and quality assurance during the construction phase ensures facilities will meet design standards post-closure.

Table B.4.10-3 Proposed Closure Methodologies and Demonstrated Use in Northern Environments

Proposed Closure Methodology	Demonstrated Use *(italics indicate Projects not yet in closure)*	Location	Average Annual Temperature (average range)	Reference
Disposal of remaining stockpiles in open pit	Owl Creek pit	Timmins, Ontario	2°C (-17°C to 17°C)	MEND, 1995
	Collins Bay B-Zone Pit, Rabbit Lake Operation	350 km north of La Ronge, Saskatchewan	-5°C (-17°C to 20°C)	MEND, 1995
	Udden pit	Northern Sweden	8°C (-2°C to 19°C)	MEND, 1995
	Kemess South	300 km northwest of Mackenzie, BC	2°C (-11°C to 15°C)	Lysay, et.al., 2011
	Minto Mine	Minto, YT	-2°C (-43°C to 30°C)	Capstone, 2014
	• Over 10 more sites in Canada			MEND, 1995
Filling of open pit with water	Owl Creek pit	Timmins, Ontario	2°C (-17°C to 17°C)	MEND, 1995
	Collins Bay B-Zone Pit, Rabbit Lake Operation	350 km north of La Ronge, Saskatchewan	-5°C (-17°C to 20°C)	MEND, 1995
	Sture pit	Northern Sweden	8°C (-2°C to 19°C)	Lu, 2002
	Udden pit	Northern Sweden	8°C (-2°C to 19°C)	Lu, 2002
	Cluff Lake	75 km south of Lake Athabasca, Saskatchewan	-4°C (-27°C to 16°C)	CNSC, 2003
	Fort Knox Mine	Fairbanks, Alaska	-2.9°C (-23°C to 17°C)	Schlumberger, 2013
	Mt.Milligan	155 km northwest of Prince George	3.5°C (-10°C to 15°C)	Terrane, 2008
	• Over 20 more sites in Canada, many with multiple open pits • All open pit mines result in pit lakes at closure			MEND, 1995 Gammons et al., 2009
Pit lake treatment (lime or biological treatment)	Collins Bay B-Zone Pit, Rabbit Lake Operation	350 km north of La Ronge, Saskatchewan	-5°C (-17°C to 20°C)	Cameco, 1999
	Highland Valley Copper	80 km southwest of Kamloops, BC	9°C (-5°C to 21°C)	Larratt et al., 2007
	Faro Mine	Faro, Yukon	-2.2°C	Laberge, 2010

Proposed Closure Methodology	Demonstrated Use *(italics indicate Projects not yet in closure)*	Location	Average Annual Temperature (average range)	Reference
			(-22°C to 15°C)	
	Colomac Mine	220 km northwest of Yellowknife, NWT	-5°C (-27°C to 17°C)	Laberge, 2010
	Island Copper	Port Hardy, BC	8°C (3°C to 14°C)	Laberge, 2010
	Equity Silver	Houston, BC	11°C (-5°C to 22°C)	Laberge, 2010
Rinsing of HLF	Brewery Creek	55 km east of Dawson City, YT	-4°C (-27°C to 16°C)	EBA, 2011
	Gilt Edge Mine	Lead, South Dakota	7°C (-7°C to 19°C)	US. EPA, 1994
	Fort Knox Mine	Fairbanks, Alaska	-2.9°C (-23°C to 17°C)	Fairbanks Gold Mining, 2013
	Eagle Gold Project	Mayo, YT	-3.6°C (-27°C to 16°C)	Victoria Gold Corp., 2012
Vegetated cover of HLF	Brewery Creek	55 km east of Dawson City, YT	-4°C (-27°C to 16°C)	EBA, 2011
	Key Lake Mine	570 km north of Saskatoon	-5°C (-17°C to 20°C)	MEND, 2009
	Fort Knox Mine	Fairbanks, Alaska	-2.9°C (-23°C to 17°C)	Fairbanks Gold Mining, 2013
	Eagle Gold Project	Mayo, YT	-3.6°C (-27°C to 16°C)	Victoria Gold Corp., 2012
	• Earthen or dry cover systems are the best available technology for spent heap leach piles			Ayres and O'Kane, 2013 MEND, 2009 MEND, 2010 MEND, 2013
INCO/SO_2 Cyanide destruction water treatment plant	Equity Silver	Houston, BC	4°C (-10°C to 15°C)	Price and Aziz, 2012
	Premier Gold Project	20 km north of Stewart, BC	6°C (-4°C to 15°C)	Zurkirchen and Mchaina, 1999
Co-disposal of tailings and waste rock in TMF	Eskay Creek Mine	50 km northwest of Stewart, BC	6°C (-4°C to 15°C)	Barrick, 2014
	Huckleberry	86 km southwest of Houston, BC	4°C (-10°C to 15°C)	Lighthall et al., 2007
	Mt.Milligan	155 km northwest of Prince George	3.5°C (-10°C to 15°C)	Borntraeger and Hamilton, 2011
NAG tailings and/or water cover of tailings and waste rock	Equity Silver	Houston, BC	4°C (-10°C to 15°C)	Price and Aziz, 2012
	Kemess South	300 km northwest of Mackenzie, BC	2°C	Lysay, et.al., 2011

Proposed Closure Methodology	Demonstrated Use *(italics indicate Projects not yet in closure)*	Location	Average Annual Temperature (average range)	Reference
			(-11°C to 15°C)	
	Eskay Creek Mine	50 km northwest of Stewart, BC	6°C (-4°C to 15°C)	Barrick, 2014
	Wolverine Mine	Frances Lake, YT	-3°C (-20°C to 13°C)	Yukon Zinc, 2015
	Mt.Milligan	155 km northwest of Prince George	3.5°C (-10°C to 15°C)	Borntraeger and Hamilton, 2011
	Huckleberry	86 km southwest of Houston, BC	4°C (-10°C to 15°C)	Lighthall et al., 2007
Treatment wetlands	Campbell	Red Lake, Ontario	0.9°C (-20°C to 18°C)	Terrane, 2008
	Musselwhite	North of Thunder Bay, Ontario	2.4°C (-15°C to 18°C)	Terrane, 2008
	United Keno Hill Mine	Elsa, YT	-3.6°C (-27°C to 16°C)	Sobelewski, 1996
	Mt.Milligan	155 km northwest of Prince George	3.5°C (-10°C to 15°C)	Terrane, 2008
	Eagle Gold Project	Mayo, YT	-3.6°C (-27°C to 16°C)	StrataGold, 2014
	Minto Mine	Minto, YT	-2°C (-43°C to 30°C)	Capstone, 2014
	Nico Project	160 km northwest of Yellowknife	-5°C (-27°C to 17°C)	Fortune Minerals, 2011
	• See Appendix A.4H for more examples of cold climate passive treatment systems			

B.4.10.2 Design and Operation of Wetland Water Treatment System

B.4.10.2.1 R2-71

R2-71. In relation to examples of successful similar treatment systems provided in Appendix A.4H (Cold Climate Passive Treatment Systems Literature Review), a discussion on flow rates relative to those for the proposed project.

Constructed wetlands are considered to be one of the most established passive treatment methods for remediating mine-impacted water and have been used by the mining industry since the mid-1980s (Eger and Wagner 2003, Gusek, 2000, ITRC 2003). In flow-controlled systems, the flow rate through the system can be controlled to provide the required retention (treatment) time to optimize the size of the treatment plant. In un-controlled systems, such as treatment wetlands and bioreactors, the systems themselves must be sized to meet the requirements for retention time to achieve the water quality objectives, using the following equations:

$$t = \frac{-\ln\left(\frac{C_f}{C_i}\right)}{k} \quad \& \quad t = \frac{V}{Q}$$

Where:

t = hydraulic retention time

k = first-order treatment rate coefficient for a given constituent/design

C_i = inflow concentration of the constituent

C_f = outflow concentration of the constituent

V = volume of water in the system

Q = flow rate

Retention time in constructed wetlands are often restricted by topography and available area; however, at the Casino Project, the tailings management facility forms the foundation for the treatment wetlands, and as such, the available area is effectively unlimited (i.e., available area is much greater than the retention time requirements to achieve the treatment objectives).

EcoMetrix specifically raised the concern of having an example of a successful, full scale wetland treatment at a flow rate of 220 L/s. The maximum predicted flow from the open pit, is 394 L/s (95th percentile – June of year 148), but the flow rate, on average, is only 21 L/s. To meet CCME guidelines for the protection of aquatic life (CCME, 2007), at the 95th percentile concentrations, a 70 ha wetland would be required at the North TMF, compared to the 7 ha wetland previously estimated in Appendix 4A with regulated flows. However, the sizing of the North TMF wetland is conducted to minimize the load to the South TMF wetland, and is not necessarily required to meet CCME guidelines. However, as described in Appendix B.4G, a 12 ha wetland at the North TMF is able to achieve CCME guidelines for all parameters in an average scenario.

In comparison, wetland treatment technology has been used at the Campbell and Musselwhite mines in Red Lake and north of Thunder Bay, Ontario, respectively, since 1998. The flow rates at those treatment wetlands is on average 85 L/s at the Campbell mine and 180 L/s at the Musselwhite mine for wetlands 22 ha and 42 ha, respectively (Terrane, 2008). A constructed wetland approved at the newly operational Mt.Milligan mine is proposed to be 14.5 ha, with average flows of 20 L/s, comparable to the 21 L/s predicted for the North TMF wetland (Terrane, 2008). The average annual temperatures at these three sites are provided in Table B.4.10-3, and are comparable to the Casino Project with temperatures getting to below -20°C in the winter months. Water quality results from the Campbell and Musselwhite mines are summarized in Table B.4.10-4. Data is summarized from the *Mt.Milligan Copper-Gold Project Environmental Assessment Report V.2.0* (Terrane, 2008).

Table B.4.10-4 Campbell and Musselwhite compared to predicted Casino Water Quality Results

	Casino Project (North TMF Wetland)				**Campbell Mine**		**Musselwhite Mine**	
Size	10 ha		10 ha		22 ha		42 ha	
Flow Rate	21 L/s		55 L/s		85 L/s		180 L/s	
	Concentration (mg/L)							
Parameter	**Inflow (50th/50th)**	**Predicted Outflow**	**Inflow (95th/95th)**	**Predicted Outflow**	**Inflow**	**Measured Outflow**	**Inflow**	**Measured Outflow**
Cd	0.0036	**0.00008**	0.0037	0.00023	n/a	n/a	n/a	n/a
Cu	4.9	**0.035**	5.0	**0.035**	0.057	**0.011**	0.02	**0.003**
Se	0.012	**0.001**	0.012	**0.001**	n/a	n/a	n/a	n/a
U	0.056	**0.015**	0.058	**0.015**	n/a	n/a	n/a	n/a

Bold values are less than CCME guidelines; Inflow (50th/50th) indicates that the model results represent predictions of 50th percentile water quality and 50th percentile flow.

B.4.10.2.2 R2-72

R2-72. In relation to plans on field studies to support and refine the effectiveness of the wetland water treatment system, details on:

a. what benchmarks (e.g. CCME WQO or SSWQO identified in proposal) will serve as the performance objectives for the overall passive treatment system;

b. what performance triggers (i.e. clear indication that the current strategy will not achieve treatment objectives) will be used during the development of the passive treatment system to identify when contingency treatment methods, such as development of bioreactors in the case of the HLF, will need to be investigated.

a. To clarify, as stated in the response to R238, CMC did not present site specific water quality objectives (SSWQO) in the Project Proposal. The purpose for presenting guidelines such as those outlined in the CCME water quality guidelines for the protection of aquatic life (CCME, 2007), or alternative guidelines such as BC MOE or US EPA guidelines was to determine the significance of effects of water quality parameters that have been predicted to exceed CCME guidelines. SSWQOs will be presented during the Type A Water Use Licence application, and will be used to determine appropriately protective limits for discharge to the environment.

   In relation to the wetland water treatment systems, performance objectives will be compared to CCME guidelines initially, until treatment objectives are derived from the approved discharge criteria issued by the Type A Water Use Licence. As detailed in Appendix B.4G, modeling indicates that CCME objectives can be met by the various wetlands, and the wetlands will be sized to accomplish this objective. However, the treatment rate coefficients will need to be refined through pilot-scale (off site), and demonstration-scale (on site) testing, as removal rate coefficients are highly specific and must be developed in a site-specific manner, for each element of interest. The treatment rate coefficients applied in the updated wetland modeling were based on pilot-scale testing conducted at another site in the Yukon and a mine in the Northwest Territories. The model assumed that the CCME concentrations are thermodynamically possible within this system, which will be confirmed in pilot-scale testing.

b. As detailed in the response to R116, a phased design and optimization program is being implemented for the site-specific development of the treatment wetlands. These phases are: 1) site assessment and information gathering including technology selection and conceptual design, 2) bench/laboratory-scale and pilot-scale testing and optimization (controlled environment), 3) on-site demonstration-scale confirmation and optimization, and 4) full-scale implementation. Performance triggers at each phase of development are outlined in Table B.4.10-5, and contingency options are provided. While CMC is confident in the robustness and effectiveness of the proposed treatment strategy, Table B.4.10-5 outlines possible alternatives should the results of the treatment system testwork prove drastically different than those modeled.

Table B.4.10-5 Performance Triggers for Wetland Treatment System Development

Activity	Objective	Performance Triggers for Consideration of Contingency Options	Possible reasons why	Timeline	Contingency options
Literature and water quality modeling	Determine conceptual feasibility of passive water treatment, in context of site-specific aspects.	Constituents requiring decrease in concentration to meet WQO are not deemed treatable based on scientific modeling.	Although the elements in the water are conceptually treatable, the overall water chemistry could negatively affect the treatability.	• First iteration has successfully been completed. All elements requiring treatment are theoretically treatable, with exception of sulphate. • Will need to be refined as water quality modeling is revised.	• Different water sources at site may require different wetland designs • Explore semi-passive treatment options (e.g., metered organics into wetland, addition of iron or manganese sources, vertical flow design, or bioreactor). • Re-evaluate site water management to enhance treatability (e.g., mixing contaminated waters before treatment, or treating before mixing in order to achieve best treatment).
Water periodicity modeling	Determine conceptual feasibility of passive water treatment, in context of seasonality of flows and site-specific aspects	Treatment needed in winter when wetlands frozen.	Seepage and overflow during winter months is sufficient to maintain flows throughout the year (rather than glaciating as happens at other mines in the Yukon).	On-going	• Explore options for water management (holding ponds) • Explore semi-passive treatment options for winter that do not freeze (e.g., vertical flow wetland, bioreactor).
Site assessment	Identify natural latent potential for treatment of water at site (e.g., plants growing in natural water sources with elevated metals concentrations or acidic water, sulphate and selenium-reducing bacteria at site, etc.)	No indications of passive treatment potential at site	• Plants/microbes at site are not conducive to treatment or not tolerant to elevated metals • There are no natural habitats at site with elevated metals that would also be suitable for wetland plant species (e.g., flow rates too high, intermittent drying, metals at site only associated with low pH, etc), but if topography/hydrology changed, would be possible.	August 2015	• Test local plants and microbes in laboratory-, bench-, and/or pilot-scale trials to determine actual treatment potential • Pursue semi-passive options such as bioreactor
Pilot-scale testing (off site)	Evaluate treatment feasibility and develop rate kinetics for passive water treatment in context of site-specific aspects.	• Treatment rates at pilot-scale suggest land area is insufficient to achieve required WQO's. • Constituents considered as theoretically treatable are not decreasing in concentration as expected. • Plants unable to withstand flow rates	• Hydrology of wetland requires adjustment • Soil substrate of wetland requires modification (organics, nutrients) to initiate cycling that will be performed by plants later on. • Flow rates or concentrations too great to achieve full removal extent needed.	Pilot-scale testing iteration 1 will take 12-18 months to complete. Can be initiated anytime after site visit report is complete.	• Second iteration of pilot-scale testing to optimize designs/soils/plants • Consideration of semi-passive water treatment options such as bioreactors or semi-passive wetland designs for enhanced treatment rates (e.g., dosing of organics, amendment additions, vertical flows)
	Evaluate fate and	• Unacceptable metals uptake into	Targeted ranges of explanatory parameters not		• Second iteration of pilot-scale testing to optimize

Activity	Objective	Performance Triggers for Consideration of Contingency Options	Possible reasons why	Timeline	Contingency options
	distribution of removed elements	plants • Load to sediments is elevated and bioavailable	achieved		designs/soils/plants
Demonstration-scale testing (on site)	Confirm rate kinetics for passive water treatment on site and refine timelines for implementation of full-scale system	• Constituents considered as theoretically treatable are not decreasing in concentration as expected. • Plant survival is low	• Longer time for plants to establish • Insufficient rooting depth • Wetland dries out during winter • Materials used on site for construction are outside of specification • Water chemistry is significantly different than modeled/predicted	As soon as pilot-scale testing is complete and water similar to that of closure is available on site (e.g., at water storage pond)	• Revisit pilot scale to test other water chemistries or soil • Consideration of semi-passive water treatment options such as bioreactors or semi-passive wetland designs for enhanced treatment rates (e.g., dosing of organics, amendment additions, vertical flows)

B.4.10.2.3 R2-73

R2-73. Contingency, alternative, or additional treatment options that could achieve water quality objectives should the passive treatment system not be viable or perform as required. Details should include:
a. identification of alternative treatment methodologies that can be employed at the site with best practicable technologies that is supported by comprehensive technical information;
b. a conventional water treatment option within the framework of the water treatment plan for temporary and final closure. This should include the circumstances and triggers under which this treatment option would be developed; and
c. a full alternatives assessment to demonstrate how alternative treatment technologies (that do not include wetland systems) were considered.

As detailed in Table B.4.10-3, CMC has included multiple treatment methodologies in the Conceptual Closure and Reclamation Plan (Appendix 4A) that have demonstrated effective use at mine sites comparable to the Casino Project. These are supported by the closure options analysis provided in Table B.4.10-1. Contingency options during the planning and design phase for the wetland treatment systems are provided in Table B.4.10-5.

a. Alternative treatment methodologies that may be employed to improve source water quality include:

Pit lake treatment

- **Chemical Treatment**: In the treatment of acidic pit lake waters, lime is frequently added as a dilute lime solution, to neutralize the acidity (Jensen et al., 2014). However, the impact of lime dosing is only effective if there is an initial acidic load that can be neutralized by lime treatment, and the net input is alkaline (Jensen et al., 2014). However, with excess addition of carbon and lime, the treatment may be permanently effective (ITRC, 2010a). An example of proposed lime treatment of a pit lake is at Lorado site (Nero Lake subaqueous disposal) in Northern Saskatchewan (Jensen et al., 2014), the Barite Hill mine is South Carolina (ITRC, 2010a) and the Copper Basin site in Tennessee (ITRC, 2010a).
- **Biological Treatment:** Enhanced metal removal through biological growth stimulation. This treatment involves the addition of fertilizers and/or carbon sources such as sugar or ethyl alcohol to stimulate algal bloOM&S. The biogenic particles in the algae scavenges metals from the water column and as the plankton dies, settles to the bottom of the pit lake, where, under the highly reducing conditions at the bottom of deep pit lakes, sulphate reducing bacteria precipitate metals as metal sulphides (Laberge, 2010). This treatment was conducted at the Faro Mine Complex in 2002, and reduced zinc from 58 mg/L to 3 mg/L (Laberge, 2010).

Heap Leach Facility

- **Rinsing of Heap Leach Pad:** Upon cessation of supplemental gold recovery at the end of mine life, heaps can be detoxified by rinsing with treated solution and/or freshwater using the solution irrigation system. The water accumulated in the heap is then allowed to draindown until the ore on the heap reaches the long-term estimated moisture content. The heap is then re-contoured and covered to minimize further precipitation infiltration.
- **Biological Destruction:** Bacterial destruction enhances cyanide destruction through the promotion of cyanide-degrading bacteria commonly found already existing in spent heaps. Through the addition of nutrients such as sugars, alcohol and fats, existing bacteria in the heap use the nutrients to transform

cyanide and other metals to stable forms (EBA, 2011). This treatment was successfully used at the Brewery Creek mine in Yukon (EBA, 2011).

- **Capping and Covers:** Various capping and covering techniques are available to amend infiltration characteristics of mine waste piles, such as:
    - Simple soil caps
    - Drainage layers
    - Geotextiles
    - Evapotranspiration covers
    - Impermeable caps
    - Hardened cover
    - Vegetative cover
    - Phytostabilization (ITRC, 2010d)

  The selection of which technique to use depends on the physical parameters of the available borrow materials, annual precipitation, current and future use, and water quality predictions and discharge objectives (ITRC, 2010d).

  Effluent Treatment

- **Conventional Treatment:** Conventional water treatment can incorporate chemicals such as lime, sulphides, and/or coagulants to introduce alkalinity, induce precipitation of contaminants and coagulate metal precipitants (ITRC, 2010b). This approach is the most common method for addressing elevated metal concentration in mine waters and is in use all over the world. There are many variations available to adapt the technology to specific conditions of a particular site. At the Casino Project, conventional treatment would most likely incorporate lime-based pH adjustment followed by precipitate settling and metal removal. The main components of the system would be: lime storage, lime conditioning, lime mixing with effluent, settling and precipitate removal in a clarification tank and sludge disposal. A conventional treatment system would require chemical reagents and fuel to be trucked to the site, ongoing power production, operators for the plant, and all associated site infrastructure and logistics support for ongoing site presence. Perpetual treatment has very high capital and on-going maintenance costs.

- **Bioreactors:** Bioreactors utilize the ability of microbes to transform contaminants and to increase pH, typically under anaerobic conditions (ITRC, 2010c). Bioreactors can be designed as open ponds, buried ponds, within tanks, or trenches and are filled with an organic substrate with a mixture of organic materials, and, if neutralization is required, limestone (ITRC, 2010c). Passive bioreactors have low operation and maintenance costs, however, are limited by flow rates, extended periods of severe cold, and pH range (ITRC, 2010c). Bioreactors may also be executed in active treatment systems, which can more readily accommodate high flow rates and pH adjustment, however, as with conventional treatment discussed above, would have ongoing power production, operators for the plant, and all associated site infrastructure and logistics support for ongoing site presence.

- **Constructed Wetlands:** Constructed wetlands are engineered wetlands with drain, anaerobic and aerobic layers with transplanted water loving plants in constructed impoundments rich in organic carbon substrate (Laberge, 2010). Constructed wetlands can decrease of total suspended solids, remove total and dissolved metals, and neutralize acidic waters. Constructed wetlands can be designed for seasonal or year round water treatment, requiring varying degrees of maintenance ranging from passive care to semi-active management. Constructed wetlands can also be built into a treatment train with active treatment systems to reduce overall costs. These options must take into account the water chemistry and flows, but also the overall site objectives and goals of the constructed wetland (Haakensen et al., 2015).

Hundreds of constructed wetlands have been used to treat mine waste water for many years (Laberge, 2010). In the Yukon, experimentation with passive wetlands began in 1995 at the former United Keno Hill Mine (Laberge, 2010), and constructed wetlands are currently approved for implementation at closure in the Yukon at the Minto Mine (Capstone, 2014) and Eagle Gold Mine (StrataGold Corp, 2014) and in the Northwest Territories at the Nico Project (Fortune, 2011).

b. *Conventional water treatment options within the framework of the water treatment plan for temporary and final closure.*

In the event that no other technology could be developed to an adequate reliability level, then conventional water treatment could be used on a temporary or long-term basis. Such a situation is not acceptable to Yukon Government or CMC, therefore, it is the expectation of both organizations that there would be significant research and optimization of the proposed water treatment method. The proposed constructed wetland treatment systems have been modeled to remove contaminants of concern down to acceptable concentrations in the various site waters. However, there remains outstanding questions as to tolerable range of influent chemistry, range of conditions under which good treatment can be achieved (temperature and flow), and achievable water quality. Determining the limits of the wetland system will define the conditions/thresholds under which it could be necessary to use conventional water treatment for part of the year or for a period of years until conditions exist that are suitable for wetland treatment.

There are four time periods where it is conceivable that water quality could be outside the range for which wetland treatment is viable. These are:

i. In the initial closure period (just after end of operations when the pit is filing) when TMF pond water is impacted by contact with waste rock;

ii. When the pit overflows, and the pit pond has not stratified or water quality is worse than expected due to PAG rock on the pit walls;

iii. Early post-closure of HLF as final drain-down occurs; and

iv. If a plume of significantly different quality seepage emerges below the dam.

Scenarios 3 and 4 above may be mitigated through the HLF wetland and WMP wetland contingencies discussed in Appendix B.4G. However, for any of the above scenarios, a supplement to wetland treatment could be required. This could involve a broad range of treatment activities using conventional water treatment. The main aspect of this would be collection of select contaminated water, treating it with chemical reagents in a mixing/conditioning system and then removal of precipitate. Sludge disposal would likely be in the open pit bottom, although construction of a dedicated sludge facility or deep injection into the void space of PAG rock in the TMF are viable alternatives. A conventional treatment system would require chemical reagents and fuel to be trucked to the site, ongoing power production, operators for the plant, and all associated site infrastructure and logistics support for ongoing site presence.

At this stage of the Casino Project, all water quality predictions have been made with conservative or first-flush chemistry values, and the need for conventional water treatment is not expected. The water quality that might necessitate conventional water treatment is outside the range of predictions, and consequently it is not feasible to provide details on plant capacity, chemical requirements or effluent quality. Site water quality will be monitored during operations, and if poorer than expected water quality occurs such that conventional treatment is required, then the plant can be designed at that time, with the commitment to temporary operation, with long-term solutions complying with the objectives of the Yukon Government's *Reclamation and Closure Planning for Quartz Mining Projects* (Government of Yukon, 2013).

c. Assessment and consideration of alternative treatment technologies

A rigorous assessment of alternative water treatment technologies was not conducted during the design phase of the Casino Project, as all alternatives which required continuous site presence were rejected as unacceptable. The project team was strongly guided by the objective of the Yukon Government to avoid long-term site presence.

All aspects of the project were designed to avoid or minimize the risk of adverse water quality (see Section 2 of the Conceptual Closure Plan (Appendix 4A) for the list of 16 major design considerations to achieve this objective). However, the notion of zero or negligible impact was identified as unrealistic for the Casino Project. Therefore, some modest level of treatment was expected to mitigate potential downstream impacts. Only passive treatment technologies were considered.

A well-respected and commonly used tool used in the evaluation of passive treatment technologies is the Interstate Technology Research Council (ITRC) Mining Waste Treatment Technology Selection Guidance Document (http://www.itrcweb.org/miningwaste-guidance/). The ITRC Mining Waste Treatment Technology Selection Guidance Document provides an efficient process for identifying appropriate treatment technologies through use of a formal decision matrix and technical backup. These are in the form of technical guidance documents that facilitate more detailed evaluation, design, and implementation of the identified preferred treatment technologies. This process was particularly well suited for incorporation in the assessment of conventional treatment technologies for the reclamation and closure plan. CMC and its consultants also made use of applicable northern climate guidance documents in the decision process, such as those produced by Mine Environment Neutral Drainage (MEND).

The conventional treatment methods of constructed wetlands and bioreactors were selected for the Casino site based on a thorough review of literature for available technologies, as well as application of the ITRC web decision making tools and guidance documents produced by MEND. These have been selected as proven and conventional treatments, but with the realization that they need to be applied in a site-specific manner, through a phased program for design and optimization. Casino Mining Corporation has committed to undertake such a program. Aside from the conventional and proven treatment methods that were selected as primary means of water treatment in closure for this project, several contingency methods of passive water treatment were also identified through the technology review process (Appendix A.4H Cold Climate Passive Treatment Literature Review). In addition to the selection of conventional treatment technologies, contingency passive treatment methods, and a phased research program for the site-specific design, optimization, and implementation of these technologies, the current state of knowledge will be regularly reassessed through CMCs reclamation research program to ensure the technologies being applied are appropriate to the closure objectives of the site.

B.4.10.2.4 R2-74

R2-74. In order to evaluate the potential effects related to the worst case scenario of an ineffective passive treatment, prediction of a worst case scenario of downstream water quality assuming no treatment system. Predictions should extend as far downstream as necessary to demonstrate no further exceedances of the CCME surface water quality objectives attributed to the mine (or 90th percentile of background for those constituents that naturally exceed CCME).

CMC re-iterates that occurrence of zero treatment is not an acceptable outcome for the passive treatment systems, and as such, cannot predict the downstream water quality in this scenario. However, CMC understands the need to assess accidents and malfunctions, and the possible mitigations that may be needed to avoid such

occurrences. Evaluation of the variability model, which examined a 52 year dataset, with varying hydrologic conditions (i.e., wet and dry periods) through the water quality model (Appendix A.7B) enables CMC to evaluate the impacts of high flow (i.e., upset) conditions on the passive treatment system. While the flows in Casino Creek can vary from 0.5 m^3/s summer flows in dry years to 1.7 m^3/s in wet years (Figure B.4.10-1), the effect on the downstream water quality (e.g., for copper in Figure B.4.10-2) is muted, due to the system of controlled storage in the water management pond, and a controlled discharge from the TMF spillway. In fact, water quality concentrations are higher in the receiving environment during the low flow periods, when impacts from seepage (which is a constant rate) are greater (Figure B.4.10-2). As such, CMC is considering a supplemental passive treatment system downstream of the water management pond, as described by Contango in Appendix B.4G.

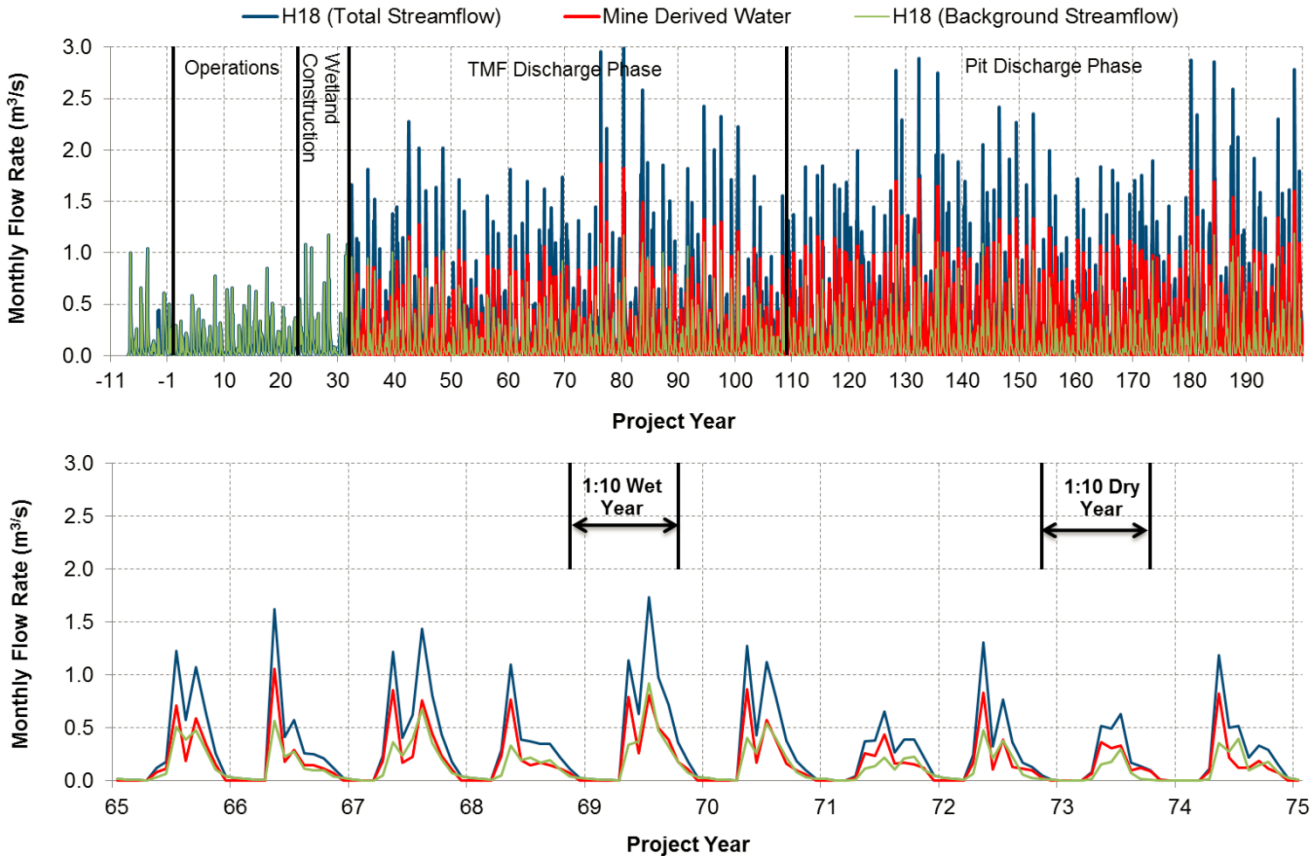

Figure B.4.10-1 Monthly Flow Rate in Casino Creek at H18 (Realization #1)

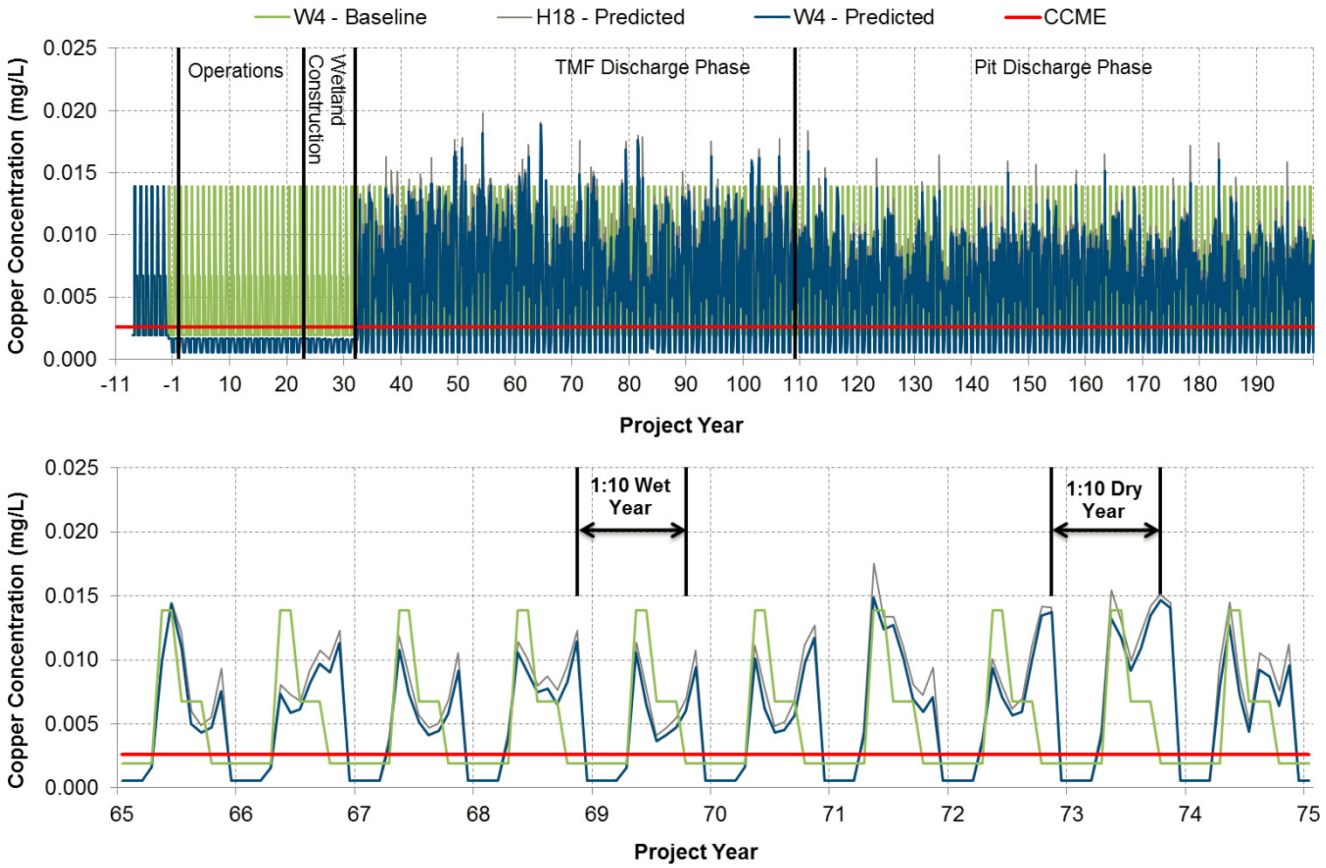

Figure B.4.10-2 Modelled Copper Concentration at H18 and W4 (Realization #1)

To prevent malfunctioning of the passive treatment systems, CMC has included the following mitigation measures in the Closure and Reclamation Plan (Appendix 4A):

- Construct the treatment wetland systems during the active closure phase;
- Continue to pump back TMF seepage to the TMF pond during active closure;
- Validate wetland performance for as many years as is required to produce acceptable discharge water quality. Continue to pump back seepage until wetland performance is validated; and
- Once discharge has commenced from the South TMF wetland, continue to monitor downstream water quality and monitor wetland systems during annual inspections.

Further, as summarized in the response to R121, while there is a high level of confidence that the proposed systems will address the water treatment goals of this project, as an added measure of conservatism the phased program of testwork is being developed in the context of additional passive contingency, alternative, or additional treatment options that could be implemented should it be deemed necessary, and may include:

- Allocation of greater area for treatment wetlands than expected to be needed, providing for additional wetland treatment areas if needed.
- Testing of multiple wetland designs at pilot-scale to refine optimal site-specific design and operation strategy.
- Control of flow from Open Pit with solar powered valve.

- Treatment of HLF draindown by bioreactor prior to pumping to Open Pit.
- In-pit treatment prior to discharge of Open Pit to TMF.
- Added treatment wetland for HLF seepage to TMF.
- Construction of demonstration-scale treatment wetland at WMP early in operations, with retention of this treatment capacity in closure.
- Enhancing wetland treatment by periodic dosing of electron donors (e.g., ethanol, methanol, straw, wood chips).
- Incorporation of materials with iron in conveyance channels and wetland construction materials to promote targeted cation-anion balances.
- Strategic co-management of water sources and treatment locations (e.g., HLF, Open Pit, TMF, WMP).
- Strategic incorporation of spillways/conveyance channels to promote glaciation in winter months.
- Sizing of North TMF wetland assuming no regulation of flows coming from open pit and also no application of a bioreactor during draindown period.
- Evaluation of possibility of designing South TMF wetland to treat for water, assuming North TMF wetland not constructed.
- Evaluation of timing for when to build the North TMF wetland.

Further, an assessment of the current wetland treatment design has been conducted by Contango Strategies (Appendix B.4G), which outlines some contingency measures available to CMC should the North and South treatment wetlands do not perform as designed. These include:

- Construction of a wetland downstream of the Water Management Pond;
- Construction of a wetland at the toe of the HLF;
- Amended sizing of the wetlands based on the updated variability water quality model (Appendix A.7B); and
- A plan for laboratory and field work to verify the assumptions in the conceptual plan.

As such, due to the multiple approaches available to CMC to prevent impacts to the downstream receiving environment, CMC is confident in the ability of the passive treatment systems to meet the downstream water quality objectives.

B.4.10.2.5 R2-75

R2-75. A discussion and rationale on how the design of the north end of the tailings management facility wetlands will accommodate a range of possible flows from the pit lake. Identify how residence time can be controlled when flows are expected to be so highly variable, and how the proposed control valves could be relied upon in such a remote area.

A technical memo has been provided by Contango Strategies, which describes the analysis undertaken to develop conceptual sizing for the constructed wetland treatment systems. This memo includes an assumption of no flow control from the Open Pit and also conservatively assumed no freezing of the open pit lake water overflow in winter (i.e., winter operation of the wetland systems). This memo is provided in Appendix B.4G.

B.4.10.2.6 R2-76

R2-76. Details and design considerations for the remotely operated solar powered decant valves. Details should include:
a. contingency planning related to malfunctions, inappropriate feedback and interaction; and
b. examples where such systems are effectively used in similar northern or cold climate conditions.

Contango Strategies has conducted an evaluation of the conceptual treatment wetland system design (Appendix B.4G) and identified that the North TMF wetland is sufficiently robust to receive flows from the Open Pit without any control of the discharge. However, in response to request R2-76, details of a remotely operated solar powered decant valve system are provided below.

A system which has the capacity to control, power and communicate (monitor) remotely a valve actuator that will in turn regulate the outflow from the open pit is currently available technology. This system could involve solar panels to provide the required energy, with supporting automated generators and fuel cell, and satellite communications to transmit data and operating signals. In addition, the system would report water level and valve position through satellite communication. It is assumed that the equipment will be serviced annually, but otherwise the system will be able to operate unattended.

An electronic control system will be required to open and close the valve. It will consist of several sub-components, including: solar panels to collect energy, bank of batteries to store the energy, motor control system to run the electric motor which opens and closes the valve on the pipe, an instrumentation system to record data on water level, water temperature, and flow rate in the pipe, and finally, a communications element to allow remote operation of the whole system. The communication system will use existing satellite phone technology.

a. Contingency aspects of the design are:

- Valve type will default to “closed” if there is a power failure or upset in the control system.
- Any power failure or system interruption would lead to an alert at the off-site control center. Personnel would be sent, likely by helicopter, to make repairs as necessary.
- In the event of an extreme upset, where the intake structure is damaged or somehow the pipeline becomes blocked, it would be possible to install a temporary siphon or barge system (depending on freeboard to pit invert) to remove pit water until repairs could be made. This would require equipment and possibly a small generator to be mobilized to the site.

b. The remotely controlled system for gravity discharge from the pit to the TMF is the option which best meets the principles and approaches for reclamation and closure planning outlined by the Yukon Government in the Reclamation and Closure Planning guidance (Yukon Government, 2013). This approach may be considered “new” as the electronic capacity for such a system did not exist a decade ago (except for satellite operations), and only recently have mine closure objectives modified so as to avoid long-term site presence. CMC is unaware of any other site that has a similar in active use. At a high level, the proposed system is akin to the currently available technologies for remote operation of household items using a cell phone. The system will require solar energy capture and storage for remote operation. The recently approved Fortune – Nico Project in NWT has envisioned a similar concept for the post-closure management of seepage from the TMF (Fortune Minerals, 2013).

B.4.10.3 Open Pit Stability

B.4.10.3.1 R2-77

R2-77. Details regarding potential impacts to pit water quality, and demonstrate water treatment capabilities in the TMF are sufficient, if a pit wall fails and there is a spike in metals and/or acidity in pit water.

To evaluate the impacts of pit wall failure on pit lake water quality, the GoldSim water quality model (Appendix A.7B) was run simulating a 2.1 Mt slide of the pit walls into the pit shortly after initial pit discharge (i.e., Year 120). The following steps were carried out to evaluate water quality impacts using the GoldSim water quality model:

Determine time during the post-closure model simulation when the event occurs: In general, pit lake water quality improves over the simulation after initial discharge from the pit. Therefore, the model assumed the pit wall failure occurs shortly after initial discharge, or Year 120, a few years after initial discharge.

Calculate mass of rock failure from the highwall: The 2.1 Mt slide was modelled after the 2.1 Mt landslide that occurred in the Berkley pit in Montana, resulting in a landslide generated wave. A 2.1 Mt slide would be a very large event (~20% of the total 1 km^2 of highwall) so this is considered a conservative evaluation. While the 2.1 Mt is somewhat arbitrary it allows a presentation of scale. A 2.1 Mt block would require a large section of either the north or south high wall to fail to the 4 m depth of the blast influenced zone, which while not completely impossible (since something similar occurred in Montana), a series of smaller failures would be much more likely. The impact to water quality and flood wave would be significantly reduced for smaller failures. The response to R128 in SIR-A addressed pit wall failure and the resulting landslide generated wave.

Determine the composition of rock (geochemical rock units) in the failure: Two polygons with planar areas equal to 0.21 km^2 were superimposed on the pit wall lithology (Figure B.4.10-3). Composition of the slide material was assumed to equal 50% SUP / 30% HYP / 20% CAP, based on the proportion of the total amount of each type of wall rock in the highwall.

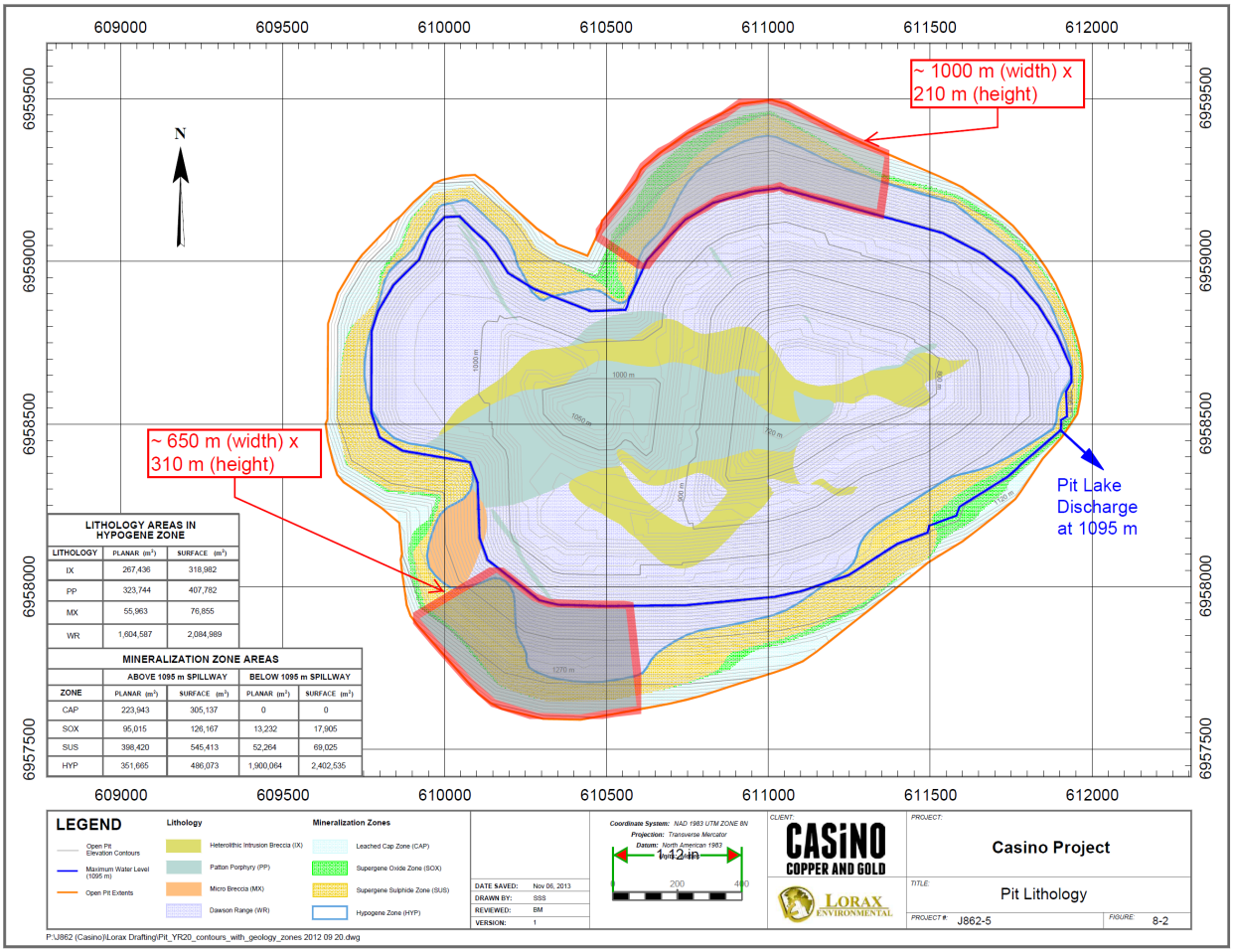

Figure B.4.10-3 Modeled Pit Wall Failure Areas

Calculate the proportion of neutral and acidic rock based on exposure time: The amount of build-up of oxidation by-products on the wall rock prior to the failure event was calculated from the values in Table 8-10 from the Lorax (2013) source term report (Appendix 7D), provided in Table B.4.10-6.

Table B.4.10-6 Available Load from Sub-Aqueous Casino Pit Wall per Year of Sub-Aerial Exposure (Table 8-10 from Lorax, 2013, Proposal Appendix 7D)

Parameter	Unit	HYP Neutral	SUP Neutral	CAP -	HYP Acidic	SUP Acidic
Sulphate	$mg/m^2/yr$	102000	109000	24500	360000	131000
Acidity	$mg/m^2/yr$	78.3	257	1930	274000	75300
Cl	$mg/m^2/yr$	1040	1020	203	2440	491
F	$mg/m^2/yr$	406	971	66	677	515
Br	$mg/m^2/yr$	1560	1530	162	731	673
Ag	$mg/m^2/yr$	0.00417	0.0104	0.0276	0.0895	0.0443
Al	$mg/m^2/yr$	1.04	1.46	285	36100	8110
As	$mg/m^2/yr$	2.54	3.31	0.221	3.36	0.72

Parameter	Unit	HYP Neutral	SUP Neutral	CAP -	HYP Acidic	SUP Acidic
Sb	mg/m^2/yr	2.51	5.78	0.196	0.911	0.449
Ba	mg/m^2/yr	42.7	91.8	24.3	11.2	1.89
Cd	mg/m^2/yr	0.0893	0.0478	0.138	4.05	6.52
Ca	mg/m^2/yr	40600	42600	6990	14400	17700
Cr	mg/m^2/yr	0.208	0.583	0.324	10.6	1.23
Co	mg/m^2/yr	0.516	1.51	4.55	83.9	19.6
Cu	mg/m^2/yr	7.15	25.3	370	9390	9830
Fe	mg/m^2/yr	6.25	24.2	14.2	24800	8800
Pb	mg/m^2/yr	0.19	0.185	0.124	0.63	0.266
Mg	mg/m^2/yr	4250	3820	1190	15000	2400
Mn	mg/m^2/yr	30.6	101	57.9	317	37.8
Hg	mg/m^2/yr	0.00625	0.0104	0.00545	0.0244	0.0224
Mo	mg/m^2/yr	66.7	24.6	0.265	0.654	0.0665
Ni	mg/m^2/yr	0.78	1.11	1.46	47	7.09
K	mg/m^2/yr	3170	3160	1780	580	276
Se	mg/m^2/yr	0.964	1.12	0.405	2.21	3.19
Na	mg/m^2/yr	298	307	573	145	98.2
Tl	mg/m^2/yr	0.0208	0.104	0.0493	0.102	0.0449
U	mg/m^2/yr	11.6	13.4	0.453	102	74.3
Zn	mg/m^2/yr	9.4	17	13.4	788	634

Calculate loading into pit based on loading rates and exposure time: The wall rock flushing loading rates are in terms of m^2 of wall rock submerged (Table B.4.10-6). To convert mass to planar area of wall rock the 3.8 m thick blast zone was assumed to slide (0.9 m + 2.9 m thick layers), equal to 14,000 kg/m^2 (Table B.4.10-7), or ~0.07 m^2/t. This was rounded up to 0.1 m^2/t for conservativeness. Therefore 2.1 Mt corresponds to about 0.21 km^2 of planar area of failure in this assessment.

Table B.4.10-7 Physical Scaling Factors (Table 8-5 from Lorax, 2013, Proposal Appendix 7D)

Scaling Factors	Unit	Blast Damaged	Blast Fractured
Thickness	M	0.9	2.9
Average Wall Slope	Degree	45	45
Mass (CAP)	kg/m^2	3,207	10,335
Mass (SUP)	kg/m^2	3,309	10,663
Mass (HYP)	kg/m^2	3,373	10,868
% of reactive material – ¼”	-	20%	5%
% of material flushed	-	75%	50%

Apply loading rates to simulate the flush of built-up oxidation by-products to calculate mass load into the pit lake: The amount of hypogene and supergene that had gone acidic by the time of the failure event was calculated using the relationships provided in Figure B.4.10-4 and Figure B.4.10-5.

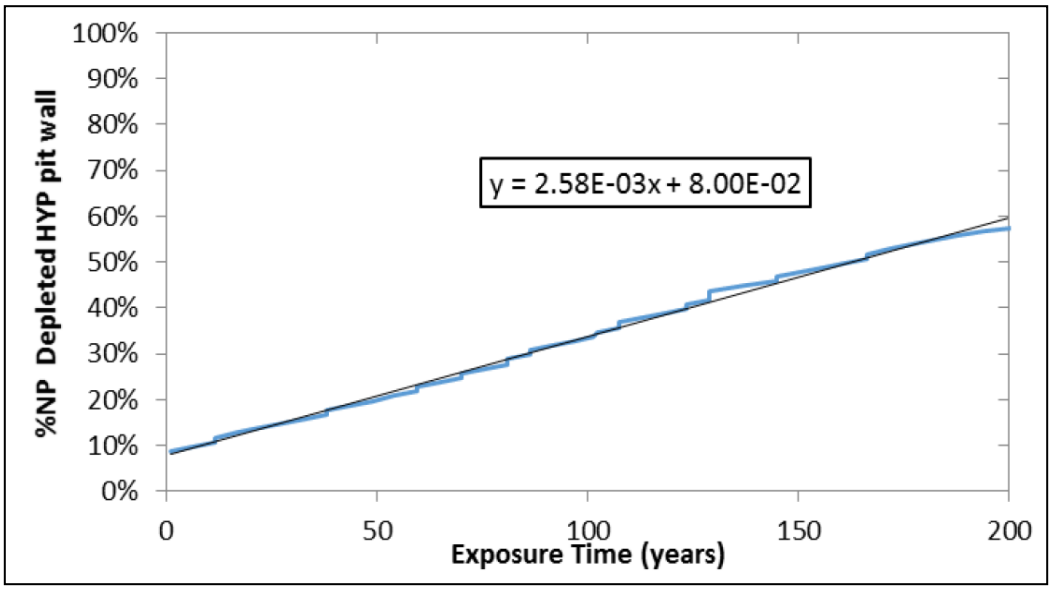

Figure B.4.10-4 Rate that HYP wall rock becomes depleted in NP as a function of exposure time (Figure 8-7 from Lorax, 2013, Proposal Appendix 7D)

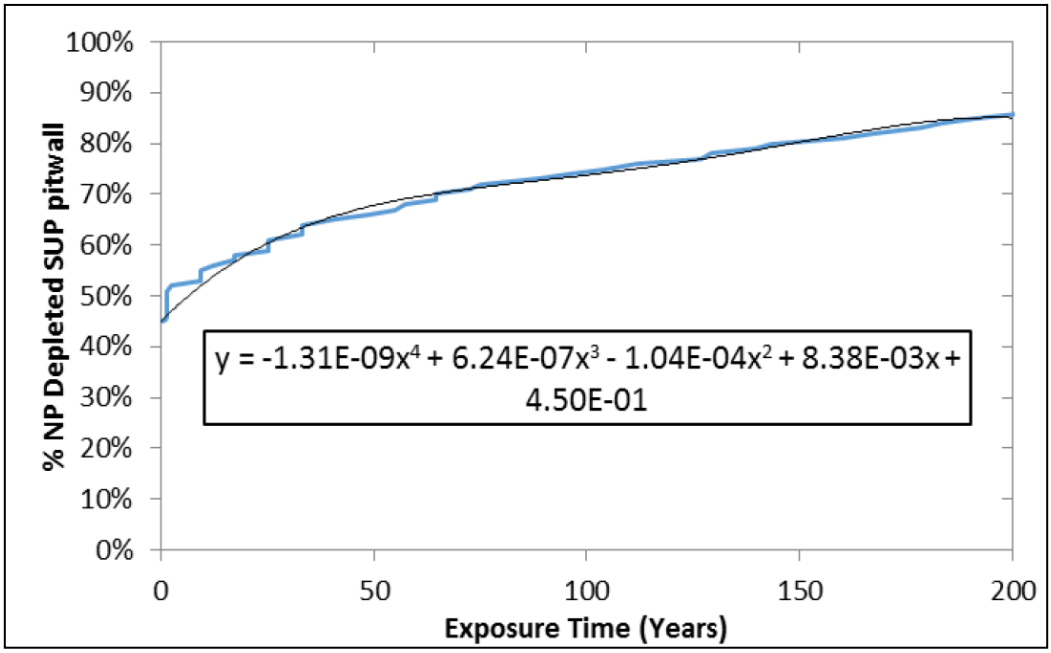

Figure B.4.10-5 Rate that SUP wall rock becomes depleted in NP as a function of exposure time (Figure 8-8 from Lorax, 2013, Proposal Appendix 7D)

Run the model, and compare with base case scenario: The results of the wall failure on pit wall water quality pH and sulphate, cadmium, copper and selenium concentrations are provided in Figure B.4.10-6 through Figure B.4.10-10. The pit wall failure scenario (orange line) is compared to the pit water quality provided in the Water

Quality Model (Appendix A.7B). Note the zoomed in y-axis to enable examination of the wall failure impact. The pit wall failure results in minor increases in the concentrations of sulphate, and metals, and would increase the long-term concentrations in the pit lake. The pH in the pit lake dips to 6.08 immediately after the failure (Figure B.4.10-6), but increases back to the value before the failure (6.20) within 4 years.

The incremental loading flushed in to the lake is mostly diluted by the pit lake and the spike in concentrations will be relatively small. The modeled pH and metal concentration ranges are well within the concentrations treatable by the North TMF treatment wetland.

The failure would also result in a temporary increase in water level of about 0.4 m. This will be well within the range of flows acceptable to the North TMF wetland. A discussion on the North TMF wetland management of variable flows is provided in the response to R2-75 above.

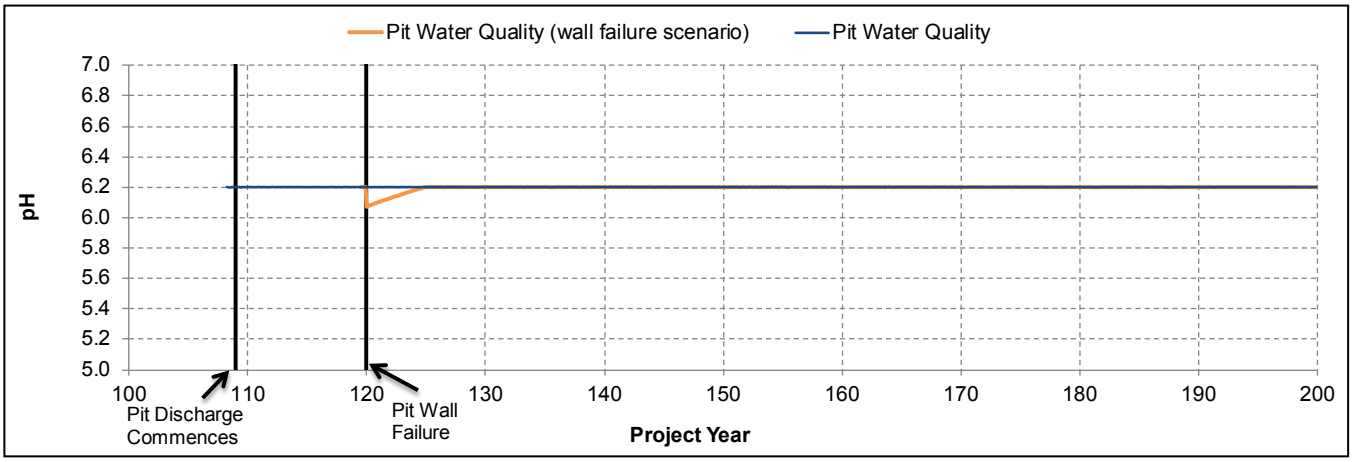

Figure B.4.10-6 Effect of Pit Wall Failure on pH

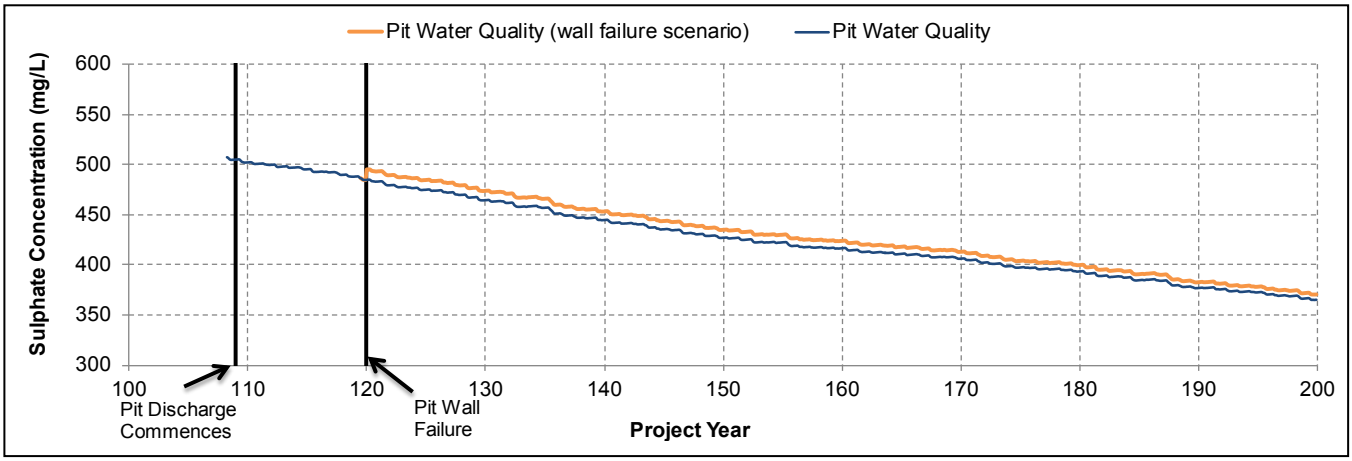

Figure B.4.10-7 Effect of Pit Wall Failure on Sulphate Concentration

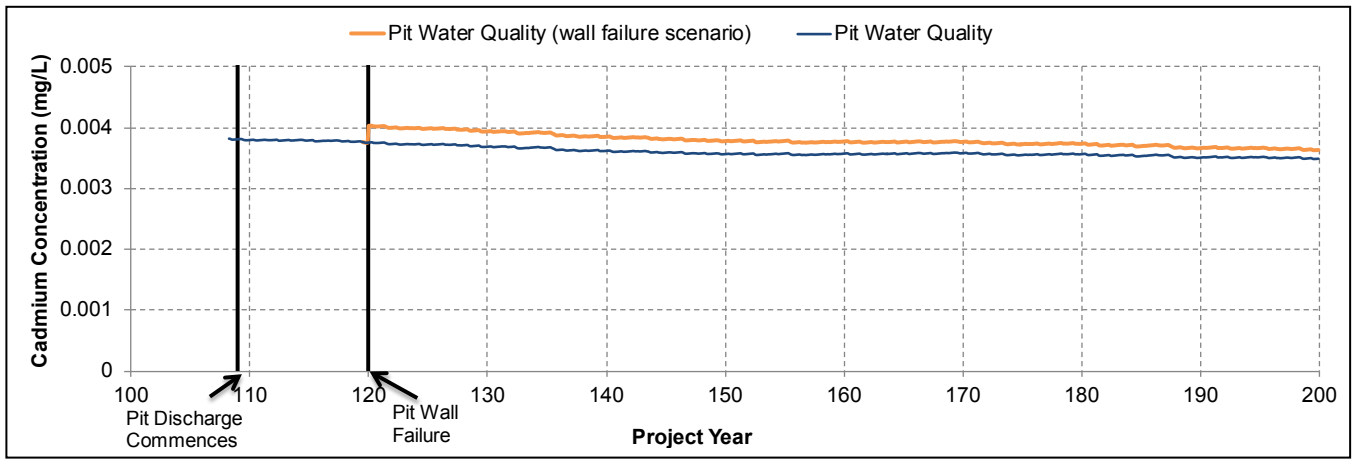

Figure B.4.10-8 Effect of Pit Wall Failure on Cadmium Concentration

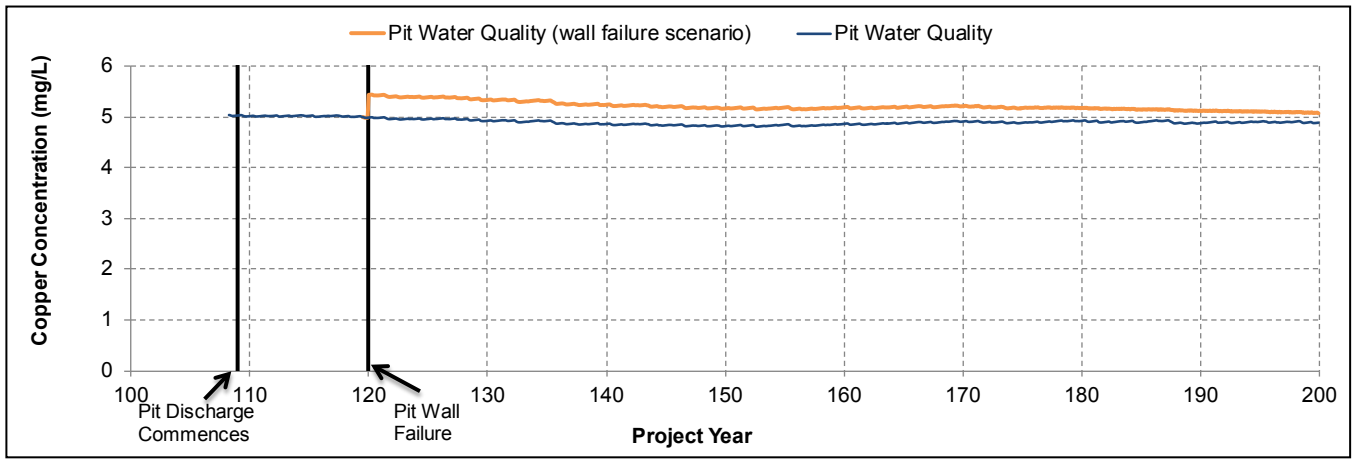

Figure B.4.10-9 Effect of Pit Wall Failure on Copper Concentration

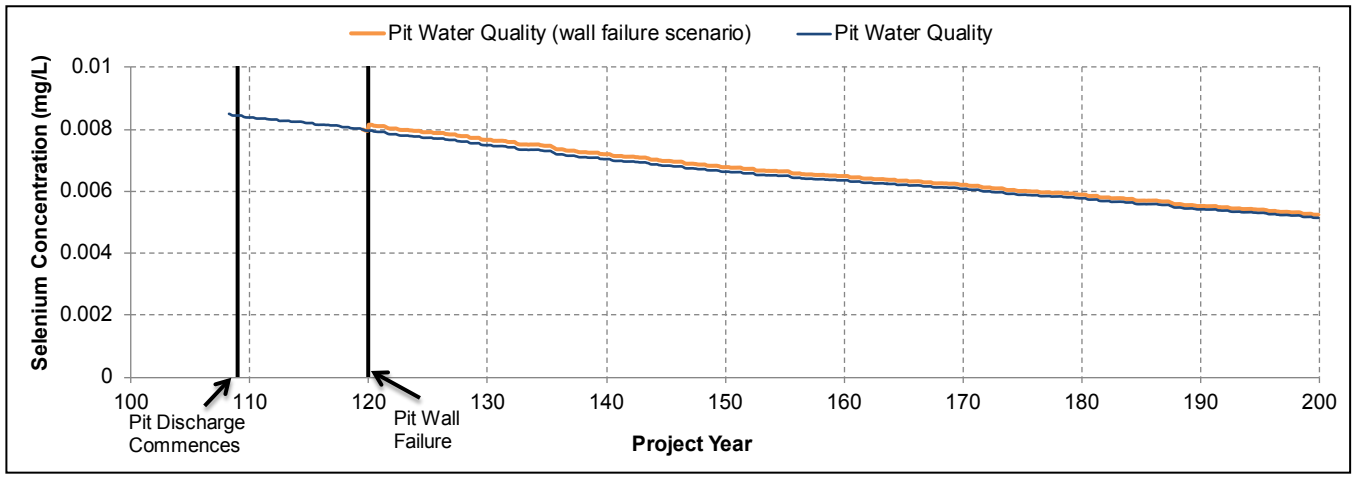

Figure B.4.10-10 Effect of Pit Wall Failure on Selenium Concentration

B.4.10.4 HLF Closure and Cyanide

B.4.10.4.1 R2-78

R2-78. Examples of successful heap rinsing at comparable sites where materials of a similar nature, mass and northern location have been encountered.

Key comparable heap leaching sites are the Brewery Creek Mine, which operated and was closed in the Yukon, and the Fort Knox Mine in Alaska, which is still operating. However, there are many heap leach facilities that have been operated and successfully closed at sizes comparable to the Casino Project in other locations (Table B.4.10-8). Of note are the large number of heap leach operations located in northern Nevada that have been operated and closed in an environment that experiences freezing temperatures every year.

Table B.4.10-8 Examples of Gold Heap Leach Operations where Heap Rinsing has been Successfully Implemented

Mine	Location	Heap Size	Rinsate	Reference
Casino Project	Yukon	157.5 Mt 8 m lifts 150 ha surface area	Freshwater followed by Inco/SO_2 treatment	
Fort Knox	Alaska	150 Mt	Freshwater with discharge to TSF. Possible treatment options being investigated include engineered wetlands reverse osmosis, oxide scavenging, chemical reduction, and biologically remediated reduction.	Fairbanks Gold Mining, 2013
Mesquite Mine	California	• 1985 – 2001: 140 Mt • 2007 – 2014: 74 Mt • 7 Leach Pads • 23 m high (6 m lifts) • 37 ha	Freshwater	US EPA, 1994 RPA, 2014b
Goldstrike Mine	Nevada	• 50 Mt • 100 ha surface area	Water followed by hydrogen peroxide and sodium hypochlorite treatment	Sengupta, 1993 Zhan, et. al., 2013
Gold Quarry	Nevada	• 44.5 Mt • 81 ha • 245 m centres	Solution recirculation with treatment by carbon adsorption columns	NDEP, 2012
Castle Mountain	California	• 31 Mt • 1.8 Mt processed through mill • Tails agglomerated into the leach pad	Freshwater	RPA, 2014a

Mine	Location	Heap Size	Rinsate	Reference
Brewery Creek	Yukon	• 10.4 Mt • Three 10 m lifts	Freshwater rinsing with nutrient addition	EBA, 2011 Tetra Tech EBA, 2014
Borealis Mine	Nevada	• 726,000 t • 100,000 m pad • 37 m stack height	Freshwater	Sengupta, 1993
Kendall Mine	Montana	• 82,000 t • 1 ha • Compacted clay liner • 2 lifts	Freshwater followed by alkaline chlorination using calcium hypochlorite	Poell, 1994
Others: **Nevada** • Relief Canyon • Pinson • Pebble • Alligator Ridge • Round Mountain • Northumberland • Round Mountain • Illapah		California • Carson Hill • Standard Hill	New Mexico • Ortiz	Leong and Majumdar, 2009

Italics indicate mines not yet in closure

B.4.10.4.2 R2-79

R2-79. A description how the liner in the HLF will be perforated following completion of the rinsing stage. Include a description of how drainage flowing from the HLF through the perforated liner will be captured by the TMF.

The HLF liner will be perforated by drilling from the top of the heap leach until the liner has been perforated. All drainage from the valley the HLF is located in drains to the TMF, there are no other routes for drainage.

B.4.10.5 HLF and Cover Material

B.4.10.5.1 R2-80

R2-80. Details on the design of the HLF cover. Details should include:
a. details of construction materials and methods being proposed (e.g. on-site borrow material and/or geosynthetic liner) and supported by on-site characterization;
b. consideration of other mine-site facility requirements for low-permeability material; and

c. stability and long-term maintenance requirements if incorporating a geosynthetic liner.

a. Details of Heap Cover Materials and Methods

The HLF cover is expected to be composed of local soils with modest capacity to reduce infiltration. The establishment of vegetation will reduce the long-term infiltration and also improve erosion resistance. Based on the expectation of relatively poor cover material, the infiltration prediction for the HLF is has been selected (for modeling) at a relatively high value of 20% of MAP.

It is expected that through additional investigation, sufficient local soils will be available for the HLF cover. As a contingency, a low permeability cover, such as LLDPE, may be placed on parts of the HLF where slopes are flat enough that long-term stability can be achieved. This is likely to be slopes flatter than 5:1 (ref: Faro – Grum Sulphide Cell), and therefore limited to only the top and select benches of the HLF.

Final design of the cover will depend upon water quality, available cover materials, and integration of HLF effluent into the site water quality prediction. In the event that the post-closure impacts from the HLF are predicted to be unacceptable, then one or more of several contingencies will be used. These include:

- Extended rinsing;
- Expanded anaerobic treatment cell; and
- Discharge of HLF seepage to the pit for dilution and/or containment if the pit stratifies. This would be conducted until loading decreases to acceptable levels.

b. Other Mine Components Potentially Needing Low Permeability Cover

In the mine plan as proposed by CMC, no mine site facilities are expected to require a low permeability cover requiring borrowed material other than the HLF.

c. Stability and Long-Term Performance of Geosynthetic Covers

Geosynthetic materials are not part of the long-term closure plan for Casino. They are considered as a contingency option if operational monitoring indicates that the proposed soil covers will not be adequate. If they are needed to provide long-term environmental protection, then only highly durable materials such as LLDPE and HDPE will be used. While there is no certainty as to the long-term service life of these materials a range of 500 plus years seems to be generally accepted.

B.4.10.6 TMF Winter Seepage Mitigation Pond

B.4.10.6.1 R2-81

R2-81. Feasibility level design details for the water management pond cut-off wall and cut-off trench/barrier. Include a discussion of how the structures are to be constructed. Details should include:
a. details on how CMC will ensure that all groundwater seepage is collected in the water management pond as designed and modelled;
b. what monitoring will be set up to ensure that the water management pond is performing as predicted, including groundwater and seepage monitoring; and
c. contingencies for all project phases, in case the water management pond does not perform as expected, including if groundwater/seepage is found to by-pass the water management pond.

The water management pond (WMP) is well situated in the valley to collect seepage that naturally drains to the area below the TMF embankment. The WMP cut-off wall will consist of a grout curtain keyed into bedrock to intercept all seepage from the upstream area and force it to surface where it will drain by gravity into the storage pond. Cut off walls are typically made from grouted curtains injected into the ground substructure. The installation of grout curtains for seepage reduction and seepage control is a common practice (Powers et al., 2007). The grout mix is typically comprised of high sulphate-resistant cement with bentonite (to minimize bleed), silica fume (to fill small voids and thus reduce permeability), superplasticizer (to reduce water content, reduce bleed, and increase strength while providing desired viscosity), Whelan gum (to bind excess water and reduce washout of cement and fines), and clean water. The dimensions of the cut-off wall will depend on the distance to the confining layer of low hydraulic conductivity, based on site investigations.

In general, grouting is conducted using a phased approach with the need for secondary and tertiary injection holes dependent on the results of primary injection. Grout curtains may be constructed via boreholes initially drilled to the full wall depth, or in a borehole which is drilled in stages to the desired wall depth. Between stages the borehole is injected with grout. Grout quality is evaluated by Marsh cone viscosity or viscometer and American Petroleum Institute (API) pressure filter bleed resistance and testing by Lugeon water pressure tests in verification drill holes.

a. *Details on process to ensure groundwater seepage to WMP:* The flows from the cut-off wall to the WMP will be monitored via continuous flow meters to verify the water quantity predictions. Downstream monitoring will be compared to the baseline aquatic environment to evaluate the magnitude of effects on the receiving environment, and provide feedback for optimizations of the system. As the WMP and cut-off wall will be constructed during the construction phase of the project, and operated throughout the operations phase, ample time will be available to verify the performance of the groundwater seepage collection system prior to closure of the site.

b. *WMP monitoring:* On-going water quantity and quality monitoring will be required to assess the effectiveness of the Water Management System. Seepage quantity and quality will be monitored throughout the construction and operations phases to understand time influenced changes to the sub-surface flow. Groundwater will be monitored in wells situated downstream of the Main Embankment and West Saddle Embankment and downstream of the WMP. Surface water monitoring will also be conducted downstream of the WMP. Collected water quality will be compared to the aggregated baseline chemistry and to water quality predictions to determine if actual water chemistry has deviated from that predicted.

   Downstream seepage beyond the water management pond will be monitored through visual observation of upwelling flow and through water quality monitoring at station W28 (confluence of Brynelson and Casino Creek, same station at hydrology station H18 – see details in the response to R242). If upwelling water is identified downstream of the water management pond, and upstream of Brynelson, it will be assumed to be seepage, and monitoring and effects analysis under the Metal Mine Effluent Regulations (MMER) will be applied.

c. *Contingencies:* Contingencies may include:

   - **Groundwater monitoring wells:** A network of monitoring wells will be situated along the downgradient boundary of the TMF and groundwater will be sampled to monitor the groundwater quality. If the results of groundwater monitoring indicate that additional mitigation measures are required, groundwater pumping wells can be installed so that groundwater is pumped back into the TMF while secondary mitigation measures are implemented.

- **Secondary and tertiary injection holes in cut-off wall:** The cut-off wall may be re-enforced by additional grouting phases on either the upstream or downstream sides or further into the valley walls.
- **Seepage interception tunnels:** The tunnels act to intercept flow paths and direct seepage into the water management pond instead of allowing these flows to bypass the WMP and grout curtain. This interception will be achieved by drawdown of the phreatic surface within the cut-off wall by a network of drain holes drilled upward and downward from the collection tunnels. The tunnels will be graded at 2% and will have portals just above the normal pond level of the WMP.

B.4.10.6.2 R2-82

R2-82. Additional details about the water management pond dam should include:
a. cross-sections;
b. construction materials;
c. consequence of failure classification;
d. detailed foundation characterization; and
e. monitoring and maintenance requirements.

During operations, seepage water from the TMF will be collected by a Water Management System, which consists of an under-drain system and a surface ditch system, both of which discharge into a water management pond located downstream of the Main Embankment. Seepage collected in the pond will be pumped back into the TMF. The Water Management System has been designed to accommodate seepage originating from the TMF, water recovered from cyclone sand embankment construction and surface runoff.

During operations, the water management pond (WMP) will operate as a dry-pond and is sized to manage the 1 in 10 year 24-hour storm event. Any storm events greater than the 1 in 10 year will discharge through the spillway channel, which will be sized to safely pass flood flows up to and including the 200 year flood. The pump station to return the water stored in the pond back to the TMF will be controlled through level controls. Supplemental booster pump stations will be required as the TMF embankment height increases.

During the closure phase, the WMP will transition to a storage and discharge system that collects seepage during the winter, and discharges to Casino Creek in the spring and summer (in relation to the flows in Brynelson Creek and the discharge from the TMF spillway)..

a. A typical cross-section for the water management pond (WMP) is provided on Figure B.4.10-11. The final design of the water management pond will depend on the verified geotechnical conditions in the area (i.e., depth of ice-rich soil), and on the ultimate configuration of the TMF (i.e., may also have changes to slope angle, affecting the location of the WMP). Verification of the design will be conducted during the detailed design phase of the Project, following the site investigation phase and verification of the groundwater recharge rates.

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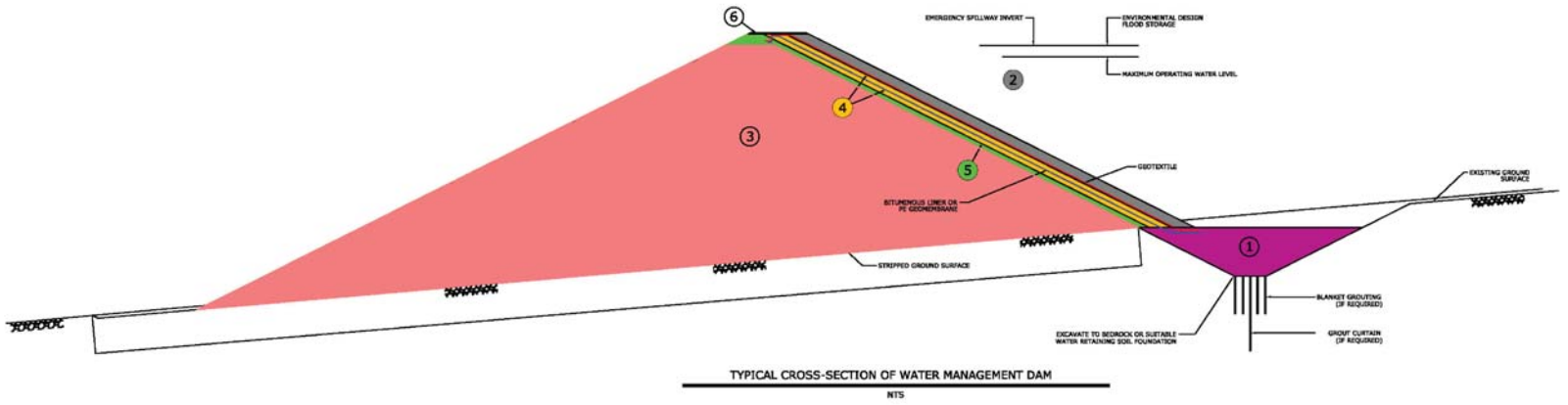

TYPICAL CROSS-SECTION OF WATER MANAGEMENT DAM

NTS

Figure B.4.10-11: Seepage Dam for TMF

NON-WOVEN GEOTEXTILE

BITUMINOUS LINER OR PE GEOMEMBRANE

GROUTING (if required)

DAM ZONES

1. KEY TRENCH
2. UPSTREAM (U/S) SHELL
3. DOWNSTREAM (D/S) SHELL
4. FILTER / BEDDING
5. TRANSITION
6. ROAD SURFACE

Authors: H.Brown and J.Corman

Date: 14/12/2015

b. *WMP construction materials:* Preliminary design for the water management pond indicates that the dam will be approximately 10 m high, made of similar material to the starter tailings dam, i.e., Suitable rockfill from local borrow sources, supplemented by available non-reactive (leach cap) waste rock material from pre-production stripping. The core may be supplemented with compacted material and asphalt, if required. A drainage blanket will be constructed below the downstream portion of the dam to maintain a low phreatic surface for stability. The foundation and abutments may be grouted along the centreline to reduce seepage under the dam.

   Construction of the WMP dam will consist of:

   - Excavation of unsuitable material (average 20 m depth);
   - Backfilling/pond slope construction;
   - Installation of the liner system: bedding layer, leak detection layer/drainage gravel layer and primary geomembrane (60 mil LLDPE);
   - Installation of the pipeline from the WMP to the TMF (HDPE DR9 700 mm);
   - Construction of the pond spillway and discharge channel (approximately 472 m) including placement of excavation and erosion protection;
   - Installation of the pump station; and
   - Construction of drainage ditching (construction and engineered lining/energy dissipation 2.5 – 6 m wide).

c. The WMP dam is designed based on criteria specified for a dam classified as “low” in accordance with the CDA Dam Safety Guidelines (2007). The dam will be designed to meet the seismic and inflow design flood criteria for this dam classification.

d. There are four geotechnical drill holes in the area of the WMP as well as several test pits dug in 1993, 1994, 2011 and 2012 (Figure B.4.10-12 and Figure B.4.10-13). A thermistor was installed in the 2012 drillhole.

   The depth to bedrock is considerably larger near the valley bottom where slopes are gentler in the area of the WMP. Drillhole HD12-03 was drilled near the valley bottom and has an overburden thickness of approximately 21 m. This material is classified as colluvial apron, which has a higher fines and organic content than the colluvial veneer, and is mostly frozen and ice rich. The colluvial apron is underlain by alluvium closer to Casino Creek. The alluvium is coarse grained and comprised of interbedded sands and gravelly sands with cobbles. It is typically overlain by frozen, organic-rich colluvial apron, except near the creek where the alluvium is non-frozen and at surface. The alluvium is generally at surface in tributary valleys, where it consists of highly saturated, ice rich, fine grained sands and clayey silts. Ice-rich silty frozen soils were found in the top six meters in DH12-03.

   Further details can be found in Appendix 7C Hydrogeology Baseline Report and results of monitoring conducted in 2013 and 2014 are provided in Appendix A.7M, including the results of thermistor monitoring in DH12-03.

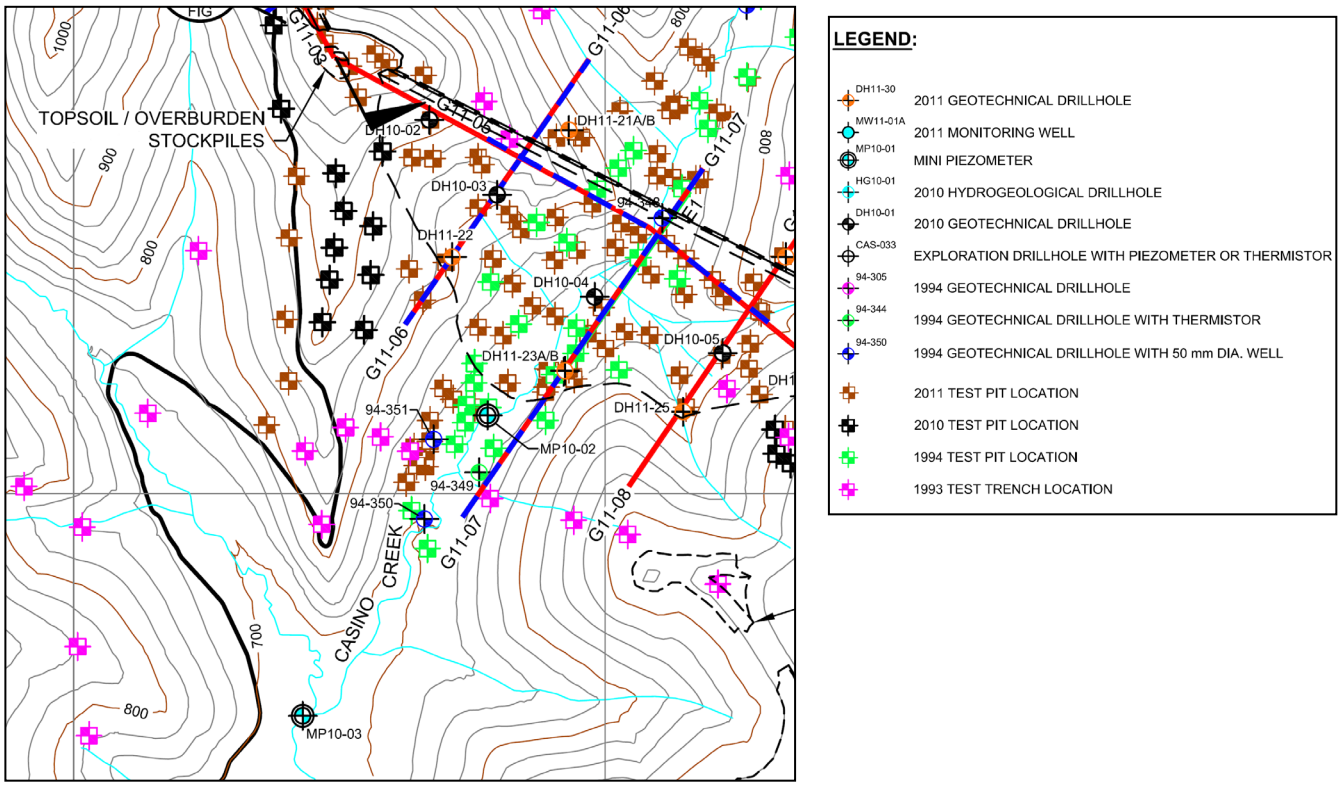

Figure B.4.10-12 Geotechnical Investigations in the WMP area (1994 – 2011)

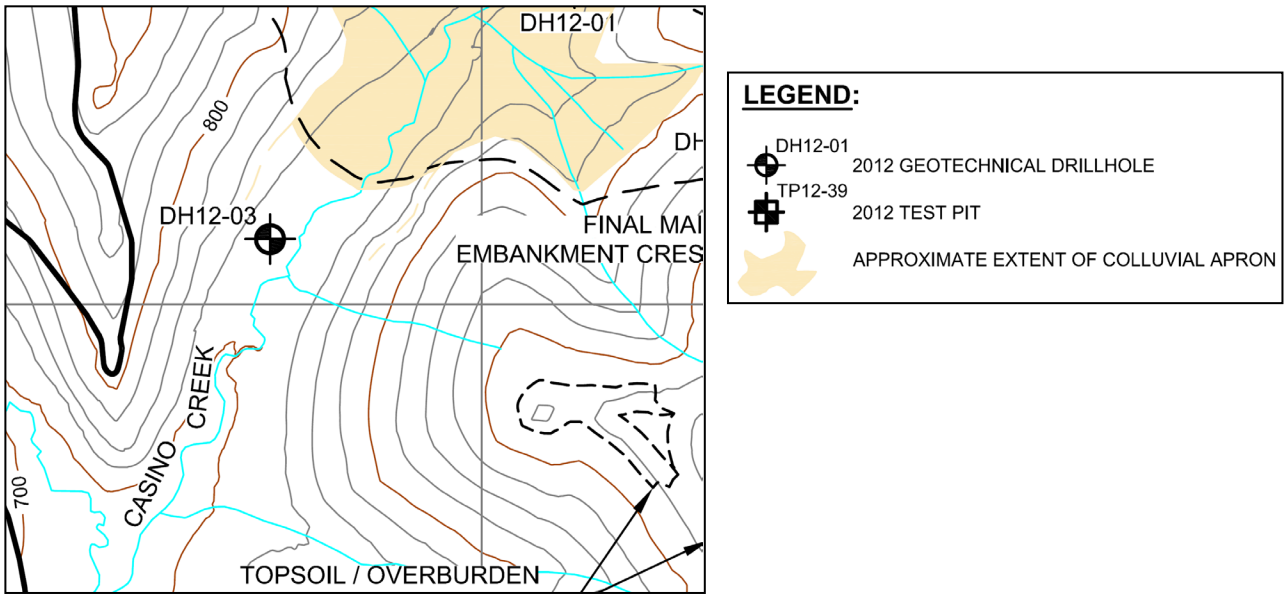

Figure B.4.10-13 Geotechnical Investigations in the WMP area (2012)

e. *Monitoring and maintenance requirements*:

On-going water quantity and quality monitoring will be required to assess the effectiveness of the Water Management System. Seepage quantity and quality will be monitored throughout the construction and operations phase to understand time influenced changes to the sub-surface flow. Groundwater will be monitored in wells situated downstream of the Main Embankment and West Saddle Embankment and downstream of the WMP. Surface water monitoring will also be conducted downstream of the WMP. Collected water quality will be compared to the aggregated baseline chemistry and to water quality predictions to determine if actual water chemistry has deviated from that predicted.

Downstream seepage beyond the water management pond will be monitored through visual observation of upwelling flow and through water quality monitoring at station W28 (confluence of Brynelson and Casino Creek, same station at hydrology station H18 – see details in the response to R242). If upwelling water is identified downstream of the water management pond, and upstream of Brynelson, it will be assumed to be seepage, and monitoring and effects analysis under the Metal Mine Effluent Regulations (MMER) will be applied.

Monitoring of the structural integrity of the dam will be in accordance with the Canadian Dam Association guidelines.

B.4.10.7 Temporary or Early Closure

B.4.10.7.1 R2-83

R2-83. Contingency measures or alternatives that may be required in the event of early closure if passive treatment system field trials have not been completed or are shown to be unsuccessful. Details should include:
a. identification of alternative treatment methodologies that can be employed at the site with best practicable technologies that is supported by comprehensive technical information;
b. a conventional water treatment option within the framework of the water treatment plan for temporary and final closure. This should include the circumstances and triggers under which this treatment option would be developed.

In the event of early closure, the closure plan as described in the Conceptual Closure and Reclamation Plan (Appendix 4A - CCRP) will be implemented, along with the following early closure specific activities:

- Pit dewatering will cease and water allowed to accumulate in the pit, all pit infrastructure will be removed, and the closure decant system will be installed;
- Canadian Creek will re-directed to the Open Pit (assuming early closure occurs at a time when the pit outline has intercepted Canadian Creek);
- All LGO stockpiles will be processed as needed for TMF reclamation (minimum 1 m cover on all PAG waste rock) or relocated to the Open Pit for sub-aqueous disposal;
- A spillway invert elevation, consistent the requirements for dam freeboard, will be determined. Any PAG tailings higher than 1 m below the invert elevation will be relocated such that a final cover of minimum 1 m of water is provided;
- Erosion protection will be placed on exposed sand areas of the dam;

- Water in the TMF will be temporarily pumped to the pit to lower the pond level for construction of the wetlands;
- Heap operations will continue with ongoing circulation of water onto the heap and processing of water in the recovery plant. Cyanide addition to the circulating water will be stopped. Once gold recovery ceases, water will be processed in the cyanide destruction plant and used to rinse the heap. Drain-down water will be processed in the cyanide destruction plant, through the bio-reactor for selenium removal and then pumped the pit; and
- All infrastructure will be removed as per the closure plan.

a. *Alternative treatment methodology:* In the event that the wetland treatment systems are not yet fully developed, then conventional water treatment could be used on a temporary basis. Conventional (i.e., active) water treatment is not a viable long-term solution, as it is in contravention of the stated policy of the Yukon Government that "reliance on long term active treatment is not considered acceptable for reclamation and closure planning" (Yukon Government, 2006). This applies for any closure scenario, be it planned closure for final mine footprint, or early closure. A robust schedule of testwork will be conducted to establish criteria for the passive treatment systems, such as sizing and composition, and long-term field trials will be conducted to verify these criteria prior to installation. CMC has already initiated the design of the wetland treatment system (see Appendix B.4G), the treatment system will be designed well in advance of any closure scenario. Additionally, comprehensive monitoring following installation will be conducted to ensure that the systems are functioning appropriately, and are sufficiently protective of the receiving environment. CMC will be required to achieve closure objectives, regardless of the timing of closure.

   All aspects of the project were designed to avoid or minimize the risk of adverse water quality (see Section 2 of the Conceptual Closure Plan (Appendix 4A) for the list of 16 major design considerations to achieve this objective). However, the notion of zero or negligible impact was identified as unrealistic for the Casino Project. Therefore, some modest level of treatment was expected to mitigate potential downstream impacts. Only passive treatment technologies were considered.

   The proposed constructed wetland treatment systems have been modeled to remove contaminants of concern down to acceptable concentrations in the various site waters. However, there remains outstanding questions as to tolerable range of influent chemistry, range of conditions under which good treatment can be achieved (temperature and flow), and achievable water quality. Determining the limits of the wetland system will define the conditions/thresholds under which it could be necessary to use conventional water treatment for part of the year or for a period of years until conditions exist that are suitable for wetland treatment.

b. *Use of conventional water treatment:* As discussed in (a), conventional water treatment could be used on a temporary basis only. Should temporary active treatment be required, the sulfur dioxide-air cyanide destruction plant that will be on-site to treat effluent solutions from the HLF may be modified to treat for parameters of concern should discharge be required prior to refinement of the wetland treatment systems.

B.4.10.8 Mine Reclamation and Security

B.4.10.8.1 R2-84

R2-84. Update the CCRP and security estimates based on the Government of Yukon's updated guidance document: Reclamation and Closure Planning for Quartz Mining Projects, Plan Requirements and Closure Costing Guidance (Government of Yukon, 2013).

CMC has developed the Conceptual Closure and Reclamation Plan (CCRP) in accordance with the Yukon Mine Reclamation and Closure Policy (Yukon Government, 2006), as is the Reclamation and Closure Planning for Quartz Mining Projects (Yukon Government, 2013). However, the Reclamation and Closure Planning for Quartz Mining Projects Guide, states that it "focuses on RCPs [Reclamation and Closure Plans] that will be provided in accordance with QML [Quartz Mining Licence] and WL [Water Licence] processes". The CCRP provided in Appendix 4A has *not* been submitted in support of a QML and/or WL application, and hence is not required to meet the guidelines outlined in the Reclamation and Closure Planning for Quartz Mining Projects Guide.

Additionally, the Proponents Guide to Information Requirements for Executive Committee Project Submission (YESAB, 2005), requires that the Proponent:

> Present and describe financial security requirements for closure. Decommissioning plans at a conceptual level should be costed for an estimation of mine reclamation bonding requirements. The proponent should submit a security proposal to address the liability at the site (Section H.18, page 58).

The information on costs, as it relates to financial security for closure was provided in the response to R144 in SIR-A (Section A.4.11.13.2).

CMC re-iterates that the CCRP provided in Appendix 4A is appropriate for the level of assessment at the YESAB assessment phase, and that the plan will continue to be refined as the Project progresses through the YESAB assessment through consultation with stakeholders, and as such should not be expected to meet the requirements for Projects that have already completed that process. A complete Reclamation and Closure Plan will be submitted as required by the Yukon Government and Yukon Water Board, once the fully assessed Project has been confirmed through the YESAA process.

B.4.10.8.2 R2-85

R2-85. Additional justification and discussion on security estimates based on new information generated by questions throughout this report. Details should include:
a. all major mine components;
b. all reclamation and closure stages;
c. consideration of temporary or early closure;
d. consideration of accidents and malfunctions, including the implications of structural and non-structural failures of the TMF dam; and
e. consideration of effects of the environment.

A discussion on security estimates can be found below.

a. *Cost estimate per major mine component:* CSP2 has noted that the building closure total does not account for all estimates under decommissioning of buildings – which is correct. Additionally, Table A.4.11-11 did not include the values for project management (5% of the total), engineering (5% of the total) or contingency (20% of the total), which made up the initial estimate of $145M. Table A.4.11-11 has been updated for the correct total for decommissioning of buildings and the missing project management, engineering and contingency values added for transparency in Table B.4.10-9, as well as to reflect updates in the post-closure monitoring, as per the response to R2-28.

Table B.4.10-9 Feasibility Reclamation and Closure Cost Estimate (Updated)

Component	Cost Estimate
Open Pit	
Access control	$108,307
Spillway construction	$52,906
Pit flooding (assumes lime addition)	$1,670,000
Open Pit Closure Total	**$1,831,213**
Tailings Management Facility	
Rip rap for stabilization	$344,463
Wetland development; vegetation of beach	$13,340,674
Pump TMF water to pit to establish wetlands	$4,500,000
Spillway construction	$688,496
Removal of operations phase infrastructure	$70,731
Instrumentation installation	$200,000
Tailings Management Facility Closure Total	**$19,144,364**
Ore and Overburden Stockpiles and Cover for HLF	
Topsoil and vegetation of stockpiles	$3,119,179
Low grade ore stockpile relocation to open pit, re-contouring and vegetation	$30,675,491
Stockpile Closure Total	**$33,794,669**
Decommissioning of Buildings	
Building decontamination and hazardous materials removal	$73,920
Demolition of buildings and piping	$4,780,604
Grade and contour	$4,651,275
Reclamation of roads (site roads, airstrip access road, pipeline road, Freegold Road Extension)	$878,006
Buildings Closure Total	**$10,383,805**
Hazardous Materials	
Hazardous materials audit (Phase I & Phase II)	$300,000
Disposal of hazardous materials	$500,000
Contaminated soil removal	$270,458
Hazardous Materials Closure Total	**$1,070,458**
Landfill Closure	
Place soil cover	$23,958
Vegetate	$2,169
Landfill Closure Total	**$26,127**
Mobilization of Equipment	
Mobilization of equipment from Edmonton	$283,829

Component	Cost Estimate
Mobilization of workers	$696,000
Mobilize miscellaneous supplies	$1,500,000
Worker accommodations	$4,680,000
Pump TMF seepage to pit	$622,200
Care and maintenance for 5 year closure period	$3,072,192
Mobilization Total	**$10,854,221**
Post-closure Monitoring and Maintenance	
Bi-annual water quality sampling	$100,000
Compile data on flows, runoff, water quality for reporting and ongoing management of water control system	$50,000
Tailings Management Facility	
Dam and spillway geotechnical inspections: Annual Inspection	$9,000
Dam and spillway geotechnical inspections: Dam Safety Review	$2,000
Event driven inspection	$10,000
Event driven repairs (e.g., repair rip rap in spillway, repair erosion on face of dam after major rain event, repair dam crest to correct settlement from an earthquake, repair berms in wetland due to settlement or high flow damage)	$200,000
Wetland maintenance and monitoring	$50,000
Open Pit	
Operation of water control system (remote control of valves)	$2,000
Inspection of energy system (solar cells, batteries, etc.)	$2,000
Replacement of energy system components	$200
Inspection of piping/valves, repair/replacement as needed	$2,000
Passive treatment of pit water	$500,000
Heap Leach Facility	
Inspect/repair erosion on face of dam after major rain event	$50,000
Provide nutrients for bio-reactor	$2,000
Other Requirements	
Transportation	$40,000
Power and heat	$25,000
General administrative expenses	$10,000
Post-Closure Monitoring and Maintenance Total	**$1,054,200**
Discount rate	3.50%
Number of year for post-closure activity	200 years
Present Value	**$30,089,041**
Project Management (5%)	**$5,359,695**

Component	Cost Estimate
Engineering (5%)	**$5,359,695**
Contingency (25%)	**$26,798,475**
Total	**$144,711,763**

The Executive Committee has noted that the cost estimate seems general in nature and excludes the following components, which CMC has clarified below each bullet.

- Reclamation of the heap leach facility including detoxification, draindown, and closure.
  - Detoxification and draindown of the heap leach facility is planned to occur following the cessation of leaching in Year 18 and take a total of 10 years (5 years for rinsing and 5 years for drain down). The detoxification is included in the operational costs of the mine and hence is excluded from the closure cost estimate. There are no additional costs associated with the draindown as the heap is simply allowed to drain naturally.
  - Cover and removal of the liner in the events pond and breaching of the HLF liner was included in the costs for the Ore and Overburden Stockpiles (i.e., $3,119,179). This has been corrected in Table B.4.10-9.
- Decommissioning of the Freegold Road Extension.
  - Decommissioning (i.e., scarify and install water breaks and vegetate) of the Freegold Road Extension was incorporated into the "Decommissioning of Buildings" cost estimate under "Reclaim Roads"; however, was missing a portion of the road. This has been clarified and updated in Table B.4.10-9.
- Topsoil and vegetation for the tailings beach, embankment, building sites.
  - The vegetation of the beach for erosion control was included in the cost under "Tailings Management Facility: Wetland development", and was estimated at $125,454. This has been clarified in Table B.4.10-9.
  - The closure cost included $344,463 for rip rap to stabilize the TMF embankment. As described in the CCRP, the embankment cover was to be either topsoil (approximately 0.5 Mm3) and vegetation; or a 0.3 m deep cover of rip-rap. The closure cost estimate considered the rip-rap cover. This cost is considered to be sufficient to consider either the topsoil or rip-rap cover.
- Removal of contaminated material from all stockpile areas.
  - The closure cost considered the "Ore and Overburden Stockpiles and Cover for HLF: Low grade ore stockpile relocation to open pit, re-contouring and vegetation" for a cost of $30,675,491. This included removal of 5% of LGO piles to the open pit of $24,283,261. The remaining $6,392,230 considered contouring the reclaimed area and placing topsoil on the ore stockpile footprints.
- Landfill and waste disposal.
  - Hazardous material disposal is included in the "Hazardous Materials" section in the closure estimate and totals $1,070,458.
  - Cover and revegetation of the landfill was missing from the closure cost estimate, and has been updated in Table B.4.10-9.

EMR and HSS have requested updates to the post-closure care and maintenance values. This has been conducted in the response to R2-28, and the updated values of $1M per year provided in Table B.4.10-9 has been assigned to post-closure care (i.e., annual geo-technical inspections, surface water sampling, groundwater sampling, receiving environment sampling, transportation to site and annual passive treatment of pit water). This is comparable to the estimate that EMR provided for the Minto Mine (i.e., $800,000). In comparison to the Wolverine Mine, the most recent Reclamation and Closure Plan (V2015-06) has a requirement for $655,800 for compliance monitoring and reporting and $100,000 for closure maintenance, which totals $755,800.

While not mentioned in ARR No.2, the closure cost estimate in Table A.4.11-11 also included the construction of the Winter Mitigation Storage Pond and groundwater collection system, originally proposed to be installed at closure. As CMC has now committed to constructing these systems during the construction phase, these items have been removed from the closure cost in Table B.4.10-9.

The updated Closure cost estimate is updated to $144M.

b. *Reclamation and closure stages:* All reclamation and closure stages (i.e., active closure and post-closure) have been included in the preliminary estimate provided in Table B.4.10-9. However, CMC re-iterates that this estimate is a feasibility level estimate only, and will be refined as the Project develops.

c. *Temporary or early closure considerations:* Temporary or early closure may be conducted in instances where economic conditions are not conducive to the continuation of mineral extraction activities. The economics of the Casino Project are such that the Project is viable at a very low copper and gold price, and hence has robust economics with minimal risk of shut-down due to changing prices. However, as part of the Reclamation and Closure Plan to be submitted as part of the QML and WL applications, temporary closure plans will be described. These plans will include the following items, as per the Reclamation and Closure Planning for Quartz Mining Projects (Yukon Government, 2013), to ensure public health and safety and protect the environment and manage risks:

- The cost to maintain facilities substantially intact and in good working order.
- Continuation of site maintenance, monitoring, and reporting.
- Interim water and solution management plan.

Costs associated with early closure are considered to be comparable to the costs for final closure.

d. *Consideration of malfunction and related implications:* The Reclamation and Closure Planning for Quartz Mining Projects guide (Yukon Government, 2013) requires the assessment of costs to permanently monitor and maintain water conveyance and/or containment facilities. These costs have been provided in Table B.4.10-9. The Reclamation and Closure Planning for Quartz Mining Projects guide does not require costing of accidents and malfunctions, including structural and non-structural failures, but does require an assessment of uncertainty and risk management, with adaptive management plans to outline processes for comparing performance to thresholds, and descriptions of specific actions to be taken in response to threshold exceedances. CMC will provide adaptive management plans as required in the applications for the Quartz Mining and Water Use licences.

e. *Consideration of effects on the environment:* Effects on the environment are considered in the closure cost estimate through the on-going monitoring and maintenance of the site, which will include event-driven maintenance of site facilities following large environmental events such as large storms, earthquake, and forest fire.

B.4.11 WASTE MANAGEMENT

B.4.11.1 R2-86

R2-86. Location, size, volume, and hydrology of the landfill site

The responses relating to the proposed landfill site are as follows:

Location and Hydrology

The proposed location for the landfill and waste management area is provided in Figure B.4.11-1, north of the TMF. The location is on a ridge above the heap leach facility, in an area dominated by hillslope colluvium and weathered bedrock (see Figure 2.1 in Appendix 7C Hydrogeology Baseline Report). The underlying structure is the Whitehorse Suite, granodiorite, granite, quartz diorite and diorite (Figure 2.2 in Appendix 7C). There are no creeks or streams in the area, as it is on a hillslope, and the inferred groundwater table is approximately 125 m below the ground surface and flows down towards the tailings management facility (Figure 4.1 in Appendix 7C).

Size and Volume

The size of the landfill has been estimated using an estimate of waste production per person of 0.0146 m^3/day during construction and 0.0097 m^3/day during operations. Additionally, the amount of waste sent to incineration (e.g., combustible and putrescible waste) was estimated at 2.24 kg/person/day during construction and 3.01 kg/person/day during operations. These estimates result in storage requirement of ~100,000 m^3 of waste (Table B.4.11-1), plus ~20,000 m^3 of soil cover required at intervals to prevent dispersal by wind or interactions with birds. This estimate results in a 120,000 m^3 landfill, 10 m high, and 110 m long by 110 m wide for storage of non-incinerated waste over the life of the Project.

Table B.4.11-1 Landfill Requirements through Construction, Operations and Closure Phases

Waste	Construction	Operations	Closure	Total
Project Year	**4 Years**	**22 Years**	**3 Years**	
Waste to landfill (m^3/year)	5,400	2,500	5,400	92,800 m^3
Waste to Incinerator (tonnes/year)	820	770	820	22,680 tonnes

CASiNO

Figure B.4.11-1: Proposed Landfill

Legend

- proposed line facilities
- proposed polygon facilites
- proposed landfill
- proposed landfill (20m fence)

Date: 14/12/2015
Author: hbrown
Coordinate System: NAD 1983 UTM Zone 7N
Projection: Transverse Mercator
Datum: North American 1983

B.4.11.2 R2-87

R2-87. Anticipated volume of landfill space required for different waste streams.

As per CMC Waste Management Plan (Appendix A.22A), the landfill at the Casino Project will be rated a "Class 2" facility, which is a waste disposal site where waste is buried and/or incinerated and which serves a population of less than 13,000 people (Yukon Environment, 2014). Non-putrescible, non-hazardous waste not incinerated or recycled will be disposed of in the on-site landfill.

The composition of materials in the landfill is expected to be a mix of the following materials:

- Ash;
- Incinerator residue;
- Construction waste;
- Plastics or synthetics;
- Rubber and rubber coated products; and
- Siding, and inert wastes arising from mine related operations.

The following materials are not accepted in the landfill:

- Hazardous waste;
- Putrescible waste;
- Food waste or waste containing food residues;
- Oily waste including oil filters or used absorbent pads;
- Used oil, fuels, lubricants or solvents;
- Grease and sludge;
- Asbestos;
- Aerosol cans;
- Paint products;
- Chemical waste; and
- Lead acid batteries and salvageable or recyclable materials such as drums, vehicles and tanks.

Incineration will be utilized to reduce the volume of burnable waste by 80- 90%; this reduces the waste streams and reduces wildlife attractants. CMC intends to use a two stage design incinerator, designed and engineered to suit the mines specific needs. Operators will be trained by the manufacturer in aspects of operation, maintenance and safety. Ash will be generated from the incineration of the following materials:

- Food waste;
- Food contaminated packaging;
- Putrescible waste;
- Paper waste;

- Cardboard; and
- Wood waste (skids, pallets, crates).

Please refer to the Waste and Hazardous Materials Management Plan (Appendix A.22A) for more details.

B.4.11.3 R2-88

R2-88. A description of the liner and/or leachate collection system proposed, including details for maintenance, operation, and closure.

The landfill at the Casino Project will be rated a "Class 2" facility, which is a waste disposal site where waste is buried and/or incinerated and which serves a population of less than 13,000 people (Environment Yukon, 2014). Therefore, the landfill must be constructed to one of the two following specifications:

1. The facility must be constructed on a natural or constructed substrate that will support natural attenuation of landfill leachate. Modeling must be conducted to demonstrate that leachate will attenuate to the extent that all contaminants will be below the applicable standards in the Contaminated Sites Regulation at the points of contact with all relevant receptors.
2. If a natural or constructed substrate to support natural attenuation of landfill leachate is not available, the facility must be constructed with a leachate collection system that must have a minimum permeability of 1 x 10^{-3} cm/s and must be of an appropriate thickness and design, with piping as needed to facilitate the movement of leachate to a collection point.

Waste disposal facilities are required to develop a 10-year solid waste management plan describing in detail their design, construction, operation, upgrading, closure and post-closure plans. During operation and renewal, environmental protection officers have the ability to conduct inspections and will be provided any requested information.

CMC will conduct further investigations in the detailed design phase and will provide exact details regarding liner and leachate collections systems during the application process for the required permits. Engineering services will be contracted from a qualified landfill design provider, during the course of this engineering process issues such as attenuation, hydrology, final size and volume and management/maintenance of the facility will be determined. The designed liner system will conform to applicable regulations.

All non-hazardous waste materials will be decommissioned according to the Solid Waste Regulations of the *Environment Act*. Once landfilling is complete, waste will be buried beneath leached heap rock and covered by 0.5 m of topsoil and revegetated.

B.4.12 CLIMATE CHANGE REPORT

B.4.12.1 R2-121

R2-121. Clarification on how the design for the TMF accounts for climate variation in perpetuity, beyond the construction and operation phases of the mine.

Periodic assessment of the facilities will include the impact of the effects of climate change, as described in the responses to R2-2, R2-27, R2-61 and others. This is typical practice, as prescribed by the Mining Association of Canada. The assessments would include realized and projected climate change to address climate variability.

CMC has stated that monitoring of the TMF will need to continue well past the closure period, and has projected monitoring for 200 years post-closure.

The design of the TMF is robust and is adaptable to uncertainties in a number of ways, for example:

- Increases in IDF can be accommodated by increased freeboard during operating phase;
- Increase in IDF during post-closure can be accommodated by increased freeboard or incremental increase in spillway width;
- Increase in annual inflow to TMF during operations can be accommodated by reduction in the fresh water make-up from the Yukon river;
- Decrease in annual inflow to the TMF can be mitigated by increasing pumped water from the Yukon river;
- Please also refer to the responses to R-259 & R-261 for discussion on uplift factors to be applied to peak design flows, consistent with APEGBC;
- Refer to R2-04 for discussion on variability of climate and its effect on water balance.

Please see response to R2–2 to understand how climate change is addressed under “change management”.

B.4.12.2 R2-122

R2-122. After the application of a maximum 25 percent increase in flow to all relevant baseline information, a comprehensive description of resulting changes to the tailings management facility, open pit, water management pond, heap leach facility, and diversion ditches. This should include consideration of project effects, and mitigations.

Please refer to response R2 -121 and R2 - 02