CUMBERLAND
RESOURCES LTD.

MEADOWBANK GOLD PROJECT

PHYSICAL ENVIRONMENT IMPACT ASSESSMENT REPORT

2004

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LIST OF ABBREVIATIONS

2PL .... Second Portage Lake
3PL .... Third Portage Lake
Ag .... Silver
Al .... Aluminum
ANFO .... Ammonium nitrate/ fuel oil
ARD .... Acid Rock Drainage
As .... Arsenic
BGC .... BGC Engineering Inc.
CCME .... Canadian Council of Ministers for the Environment
Cd .... Cadmium
CN .... Cyanide
Cr .... Chromium
CRL .... Cumberland Resources Ltd.
Cu .... Copper
CWQG .... Canadian Water Quality Guidelines
CWQG(FAL) .... Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life
F .... Fluorine
Fe .... Iron
Hg .... Mercury
HDPE .... High Density Poly Ethylene
IF .... Iron formation rock
IV .... Intermediate volcanic
LSA .... Local Study Area
m.A.S.L.: .... Metres Above Sea Level
ML .... Metal leaching
MMER .... Canadian Metal Mining Effluent Regulations
Mo .... Molybdenum
Ni .... Nickel
NTU .... Nephelometric Turbidity Units
NO2 .... Nitrite
PAG .... Potential for Acid Generation
Pb .... Lead
QTZ .... Quartzite
Se .... Selenium
Tl .... Thallium
TSS .... Total suspended solids
V3 .... Vault Lake (Drilltail Lake)
VEC .... Valued Ecosystem Component
Zn .... Zinc

Acidic – Any substance with a pH below 7.

Active layer – The zone above the permafrost that thaws in the summer and freezes in the winter.

Aggrade – To build up the level of (any land surface) by the deposition of sediment.

Alkaline – A substance with a pH greater than 7

Berm – a narrow path or ledge at the edge of a slope, road, or canal.

Borrow pit – an excavation dug to provide fill to make up ground elsewhere

Cryoturbation – Churning and heaving of the ground and subsoil by frost action.

Degrade – to reduce or be reduced by erosion or down-cutting, as a land surface or bed of a river.

Dike – an embankment constructed to prevent flooding.

Effluent – liquid discharged as waste, as from an industrial plant or sewage works.

Fault – A Fracture zone in which there has been movement or displacement of rocks, relative to each other, on either side.

Frost mound – Any mound-shaped landform produced by ground freezing combined with groundwater movement or the mitigation of soil moisture.

Geotextile – any strong synthetic fabric used in civil engineering, as to retain an embankment.

Glaciomarine – The processes, sediments and landforms associated with meltwater streams in contact with the sea.

Ground ice – A term used to describe all bodies of ice in the ground surface of the permafrost layer.

Hydraulic conductivity – A measure of the ability of a fluid to flow through the ground, determined by the size and shape of the pore spaces of the various rocks and soils.

Hydraulic Gradient – The slope of the groundwater level or water table.

Hydraulic head – The pressure exerted by a liquid as a result if the difference in its surface level between two points

Ice lense – Horizontal accumulation of permanently frozen ground ice.

Ice wedges – Wedge-shaped, ice body composed of vertically oriented ground ice that extends into the top of a permafrost layer.

Leachate – water that carries salts dissolved out of materials through which it has percolated.

Limnology – the study of bodies of fresh water with reference to their plant and animal life, physical properties, geographical features, etc.

Lithology – the physical characteristics of a rock, including colour, composition, and texture

Oligotrophic – poor in nutrients and plant life and rich in oxygen.

Overburden – Earth overlying a useful deposit of rock or other useful material.

Oxidation – Chemical attachment of free oxygen to other elements and compounds. One of the types of chemical weathering.

Patterned ground – Term used to describe a number of surface features found in periglacial environments. These features can resemble circles, polygons, nets, steps, and stripes. The development of some of these shapes is thought to be the result of freeze-thaw action.

Permeability – The ease of which liquids can pass through a rock or soil.

pH – A numerical measure of the acidity or alkalinity of water ranging from 0 to 14. Neutral waters have pH near 7. Acidic waters have pH less than 7 and alkaline waters have pH greater than 7

Protalus rampart – Unsorted, non-stratified, coarse angular rock debris forming arcuate low ridges. Associated with former persistent snowbanks in shaded sites, commonly at base of corrie headwalls

Recharge area – an area of land where the groundwater moves downward and water infiltrates from the surface into the geological formations below.

Salinity – Concentration of dissolved salts found in a sample of water. Measured as the total amount of dissolved salts in parts per thousand. Seawater has an average salinity of about 34 parts per thousand.

Seismicity – seismic activity; the phenomenon of earthquake activity

Subaerial – Beneath the sky; in the open air, specifically (Geol) taking place on the earth's surface.

Subaqueous – occurring, appearing, formed, or used under water.

Sublimation – The process where ice changes into water vapor without first becoming liquid.

Subsidence – The lowering or sinking of the Earth's surface.

Tailings – waste left over after certain processes, such as from an ore-crushing plant.

Talik – An area of permanently unfrozen ground in regions of permafrost.

Thalweg – Line of deepest water in a stream channel as seen from above. Normally associated with the zone of greatest velocity in the stream.

Thermistor – (thermal resistor) It is a semiconductor whose resistance varies sharply in a known manner with temperature.

Thermokarst – A landscape dominated by depressions, pits, and caves that is created by the thawing of ground ice in high latitude locations.

Till – Unsorted sediment deposited by a glacier.

Total Dissolved Solids (TDS) – TDS are made up of inorganic salts such as calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates and small amounts of organic matter that are dissolved in water.

Turbidity – muddy or opaque, as a liquid clouded with a suspension of particles.

PROJECT LOCATION MAP

EIA DOCUMENTATION ORGANIZATION CHART

Project Description Report
Main Contributor: Cumberland Resources
Reviewer: All Consultants

ENVIRONMENTAL IMPACT STATEMENT

Project Alternatives
Main Contributor: Lynton Gormley, AMEC Americas
Reviewer: Brad Thiele, Cumberland Resources; Golder Associates Ltd.

Baseline Reports

- **Aquatic Ecosystem** — *Main Contributor: Randy Baker, Azimuth Consulting; Reviewer: Mike Lawrence, North-South Consulting*
- **Fish Habitat** — *Main Contributor: Randy Baker, Azimuth Consulting; Reviewer: Mike Lawrence, North-South Consulting*
- **Terrestrial Ecosystem** — *Main Contributor: Martin Gebauer, Gebauer & Associates; Reviewer: Ben Hubert , Hubert & Associates*
- **Physical Ecosystem** — *Main Contributor: BGC Engineering; Reviewer: Golder Associates Ltd.*
- **Socioeconomic** — *Main Contributor: Robert Hornal; Reviewer: Susan Ross, Golder Associates Ltd.*
- **Archaeology** — *Main Contributor: Deborah Webster; Reviewer: Gloria Fedirchuk, FMA Heritage Resource Consultants*
- **Traditional Knowledge (TK)** — *Main Contributor: Darlene Hughes, IBIS Group, Inc.; Reviewer: Tom & Hattie Mannik*

Impact Assessments

- **Aquatic Ecosystem/Fish Habitat** — *Main Contributor: Randy Baker, Azimuth Consulting; Reviewer: Mike Lawrence, North-South Consulting*
- **Cumulative Effects (CEA)** — *Main Contributor: Ly-Shu Ramos, AMEC Americas; Reviewer: Robert Hornal, Hornal & Associates*
- **Terrestrial Ecosystem** — *Main Contributor: Martin Gebauer, Gebauer & Associates; Reviewer: Ben Hubert, Hubert & Associates*
- **Physical Ecosystem** — *Main Contributor: BGC Engineering Ltd.; Reviewer: Golder, Azimuth, AMEC*
- **Socioeconomic & Archaeology** — *Main Contributor: Susan Ross, Golder Associates Ltd.; Reviewer: George Hegmann, AXYS Environmental Consulting*
- **Noise** — *Main Contributor: Richard Palczynski, AMEC Americas; Reviewer: Bob Humphries, Levelton Engineering*
- **Air Quality** — *Main Contributor: Richard Palczynski, AMEC Americas; Reviewer: Levelton Engineering*

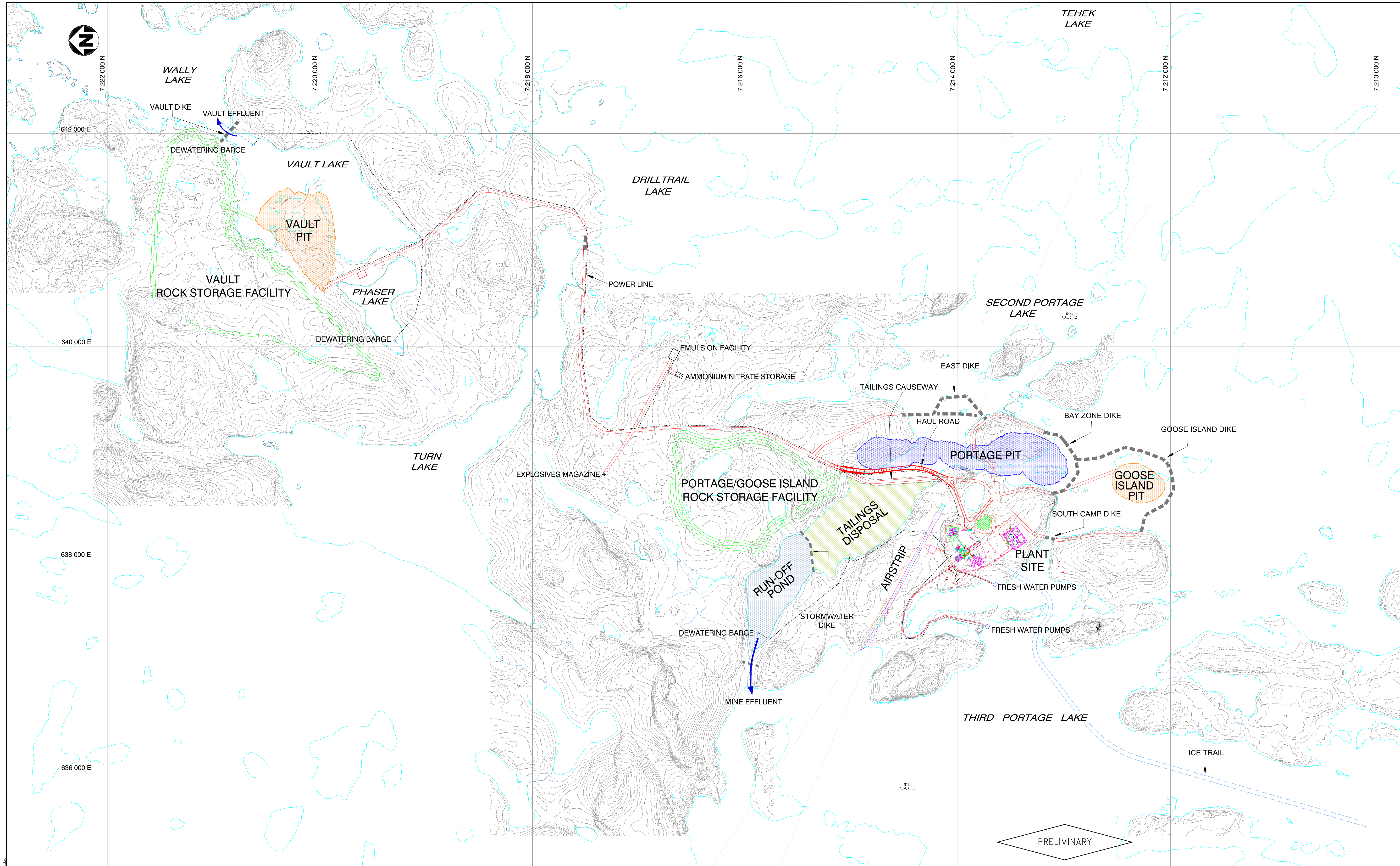
Management & Monitoring Plans

- **Aquatic Effects Management Program (AEMP)** — *Main Contributor: Randy Baker, Azimuth Consulting; Reviewer: Mike Lawrence, North-South Consulting*
- **Metal Mining Effluent Regulations (MMER)** — *Main Contributor: Randy Baker, Azimuth Consulting; Reviewer: Mike Lawrence, North-South Consulting*
- **Terrestrial Ecosystem** — *Main Contributor: Martin Gebauer, Gebauer & Associates; Reviewer: Ben Hubert , Hubert & Associates*
- **No-Net-Loss of Habitat (NNL)** — *Main Contributor: Randy Baker, Azimuth; Reviewer: Mike Lawrence, North-South Consulting*
- **Socioeconomic & Archaeology** — *Main Contributor: Susan Ross, Golder Associates Ltd.; Reviewer: Robert Hornal, Hornal & Associates*
- **Mine Waste & Water** — *Main Contributor: Golder Associates Ltd..; Reviewer: BGC Engineering Ltd.*
- **Air Quality & Noise** — *Main Contributor: Richard Palczynski, AMEC Americas; Reviewer: Bob Humphries, Levelton*
- **Access & Air Traffic** — *Main Contributor: Raj Anand, Cumberland Resources; Reviewer: Alistair Kent, Gartner Lee*
- **Reclamation & Closure** — *Main Contributor: Golder Associates Ltd..; Reviewer: BGC Engineering Ltd.*
- **Emergency Response** — *Main Contributor: Darlene Hughes, IBIS Group, Inc.; Reviewer: Cumberland Resources*
- **Hazardous Materials** — *Main Contributor: Darlene Hughes, IBIS Group, Inc.; Reviewer: Cumberland Resources*
- **Spill Contingency** — *Main Contributor: Darlene Hughes, IBIS Group, Inc.; Reviewer: Cumberland Resources*
- **Occupational Health & Safety** — *Main Contributor: Darlene Hughes, IBIS Group, Inc.; Reviewer: Ted Rutherglen, Cumberland Resources*
- **Human Resources** — *Main Contributor: Ted Rutherglen, Cumberland Resources; Reviewer: Cumberland Resources*

SECTION 1 • INTRODUCTION

Valued Ecosystem Components (VECs) are defined as: "those environmental attributes or components, identified as a result of an ecological and social scoping exercise, which were determined on the basis of perceived public concerns related to social, cultural, economic and aesthetic values. They also reflect scientific concerns of the professional community as expressed through the social scoping procedures (i.e., hearings, questionnaires, interviews, workshops, media reports, etc.), and through technical studies."

This document deals with three VECs, surface water quantity, water quality, and permafrost. The surface water quantity, water quality and permafrost VEC impact assessments matrices can be found in Appendices A, B and C, respectively. The mine site plan referred to throughout this document is as shown on Figure 1-1.



0 250 500 750 1000 1250 1500 1750 2000m

Datum: UTM NAD83 Zone 14

Figure 1.1

Facilities Location Map for the Meadowbank Project Area

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Meadowbank Gold Project

1.1 PROJECT COMPONENTS

Major project components and activities assessed in the matrices are outlined along the left hand column of the matrices and described below.

1.1.1 Dikes

The construction, operation and closure of the dikes are considered, not what is captured within or isolated behind them. Dikes considered include the East Dike, Tailings Dike and Bay Zone Dike, which are to be built during the construction phase of the project. The remaining dikes, Goose Island Dike, South Camp Dike and Vault Dike will be built during the operational phase of the project.

1.1.2 Dewatering

Dewatering of the Portage Pit will occur during the construction phase of the project. Impacts on the dewatered basin and the receiving environments of Second and Third Portage lakes are assessed. Dewatering impacts of the Goose Island Pit and Vault Lake are considered under the operational phase of the project.

1.1.3 Open Pits

The Meadowbank project involves mining of approximately 20 million tonnes of ore, which will produce approximately 160 million tonnes of waste rock. Development of the Portage Pit is considered during construction, and the Goose Island and Vault pits are assessed during the operational phase of the project. Impacts are also assessed during re-watering of the dewatered basins during closure, which includes flooding of the depleted pits.

1.1.4 Rock Storage Facilities

Storage of waste rock in the Portage and Vault rock storage facilities is assessed. The Portage rock storage facility, which will hold 97 million tonnes, begins during the construction phase. The 54 million tonnes planned for the Vault facility will be placed during the operational phase. Both are also assessed after being capped at closure.

1.1.5 Borrow Pits & Quarries

Borrow pits and quarries are all within the ultimate pit and waste rock pile footprints. They are given limited consideration.

1.1.6 Tailings Disposal Facilities

An estimated 20 million tonnes of tailings occupying between 12 and 14 million cubic metres will be deposited in a portion of the dewatered arm of Second Portage Lake. Dike construction and dewatering activities are considered separately (see Sections 3.2.1 and 3.2.2, respectively). Tailings placement is assessed during operations. It is also assessed at closure after capping.

1.1.7 Roads, Airstrip & Related Traffic

A network of haul roads will connect the ore bodies to the rock storage facilities and the plant site. A 1,000 m long airstrip will be provided initially, due to a shortage of available materials. This airstrip is suitable for medium sized turboprop commuter aircraft, such as the HS748 that is commonly in use in the north. In the future, CRL intend to extend the airstrip to at least 1,500 m long, to accommodate Hercules aircraft, thus providing the ability to bring in unanticipated heavy spare parts and other operating supplies. It is also possible and feasible that the airstrip could be further extended to approximately 1900m length, and widened, to accommodate jet aircraft such as the Boeing 737. The airstrip will be located on the peninsula separating Second Portage Lake and Third Portage Lake to the immediate north of the plant site. The airstrip is orientated so as to minimize the effect of prevailing winds on landing craft. The airstrip and roads will be elevated to reduce problems with snow drifting, and a compactor and grader will be used to maintain the surface year round. Impacts of road and airstrip construction and their utilization are assessed at all temporal phases of the project.

1.1.8 Ditches & Contact Water Diversion Structures

Ditches are assessed during all temporal phases of the project. Ditches along roads, the airstrip, and those needed to manage contact water are not differentiated. Contact water is defined as any water that may have been physically or chemically affected by mining activities.

1.1.9 Mine Plant & Associated Facilities

Development of the plant site area is assessed during construction. Its utilization during mine operations and closure conditions are assessed separately.

1.1.10 Freshwater Intake & Pipeline

Construction of the freshwater intake facilities on the shore of Third Portage Lake and the pipeline are assessed during construction. Utilization during mine operations and closure conditions are assessed separately.

1.1.11 Discharge Facilities, Pipeline & Effluent Discharge

Construction of the discharge pipeline is assessed during construction. The impact on water quality from effluent discharges is evaluated during operations and over the closure transition period until conditions stabilize.

1.1.12 Non-Contact Diversion Facilities

Non-contact water is limited to runoff originating from areas unaffected by mining activity and that does not come into contact with developed areas. Non-contact water will be intercepted and directed away from developed areas by means of natural or man-made diversion channels and allowed to flow to neighbouring lakes untreated. The diversion ditches are assessed during all temporal phases of the project.

1.1.13 Laydown Storage (at Plant Site)

The laydown storage pad and fuel storage facility are assessed during all temporal phases of the project.

1.1.14 AN/Explosives Storage & Emulsion Plant

Ammonium nitrate/fuel oil (ANFO) will be used 70% of the time and an emulsion will be used for the remaining 30%. The explosives storage and emulsion plant is assessed during all temporal phases of the project.

1.1.15 Site Accommodations

An accommodation facility for approximately 350 personnel during construction and 250 personnel during operation will be located in the plant site area. It will consist of ATCO-style rigid wall modules connected to the process plant, offices, service and warehouse buildings by Arctic corridors. Rooms will be single occupancy with centrally located separate washrooms and showers for male and female personnel. The facilities will include lounge, television, recreation and games rooms. They are assessed during all phases of the project.

1.1.16 Sewage & Waste Disposal

Sewage will be collected from the accommodations complex and change room facilities and pumped to a sewage treatment plant. A rotating biological contractor treatment system will be installed with the effluent meeting Nunavut guidelines for wastewater discharge into the tailings pond. Solid waste will be burned in a waste incinerator. This will be diesel-fired and located downwind of the facilities. Sewage treatment and waste disposal facilities are assessed during all temporal phases of the project.

1.1.17 Road & Traffic

Annual operation of a 92 km long haul road between Baker Lake and the mine site is assessed. A winter route to the Meadowbank property is deployed at the present for the exploration activities.

1.1.18 Baker Lake Access Road & Traffic

Construction and operation of short sections of new roads as well as utilization of existing roads in Baker Lake is assessed during all phases of the project.

1.1.19 Baker Lake Marine Barge Landing Facility

Construction and operation of a barge landing facility on the shores of Baker Lake is evaluated during all phases of the project.

1.1.20 Marine Barge Traffic

The impacts of increased shipping traffic and routine operation of marine transport vessels in Hudson Bay between Churchill and Baker Lake are evaluated during all phases of the project. .

1.1.21 Baker Lake Staging Facility

Construction and operation of a Baker Lake staging facility is evaluated during all phases of the project.

1.1.22 Baker Lake Explosives Magazine

Construction and operation of explosives magazines in Baker Lake are evaluated during all phases of the project.

1.1.23 Baker Lake Tank Farm

Diesel fuel will be delivered by barge to a 25 million litre vertical tank storage facility in Baker Lake consisting of several steel tanks and fuel transfer pumps. The tanks and pumps will be located within bermed containment areas lined with High Density Poly Ethylene (HDPE). The main fuel tanks will be un-insulated and designed to meet American Petroleum Institute specifications. From these tanks, fuel will be trucked via the winter road from Baker Lake to a nearly identical facility on site.

SECTION 2 • SURFACE WATER QUANTITY EIA

2.1 BACKGROUND

Water Quantity has been identified as a Valued Ecosystem Component (VEC) because of the importance of water quantity in supporting fish habitat, navigable waters, and water balance for wildlife and human health values. Impacts of activities related to construction and operation of the Meadowbank Gold Project on water quantity and movement within project lakes are identified, quantified and their significance assessed in this chapter.

The Meadowbank Project will affect surface water quantities and movements during mine construction, operation, and closure phases. Some residual impacts will persist after mine closure because lake areas and volumes will have changed as a result of pit development. Examples of water quantity impacts include activities that involve consumption of lake water, diversion of water from roads via ditches to attenuation ponds, and severe, but short-term impacts such as dewatering of lakes in areas where pits are planned.

2.2 DATA SOURCES

Local climate data (wind, precipitation, snow depth, etc.) have been collected at Meadowbank since September 1997, a period of six years. These data have been put into perspective with regional Environment Canada data for the community of Baker Lake, dating back to 1949. Meadowbank annual and seasonal rainfall data correlate well with regional data. On average, between 1997 and 2003 rainfall at Meadowbank averaged 85% of rainfall at Baker Lake. The same ratio was assumed for snowfall data. Thus, long-term data at Meadowbank were assumed to be 85% of totals reported at Baker Lake since data collection began in 1949.

The surface water hydrology program at Meadowbank was initiated in June 2002 and consists of empirical lake elevation and outlet discharge data at key stations during as much of the open water period as ice conditions permitted. Although empirical data exist from only two years, precipitation data collected during these two years were put in perspective with long-term, historic data. For example, 2002 was a wetter than average year (350 mm precipitation), so lake level and discharge rates in project lakes were higher than average. 2003 was a dry year (234 mm precipitation), so lake level and discharge were lower than is typical. Interestingly, mean precipitation measured during 2002 and 2003 (292 mm) was nearly identical to long-term precipitation (292 mm), pro-rated based on Baker Lake data. Thus mean seasonal lake elevation changes and stream discharge data during 2002 and 2003 will approximate long-term, typical mean hydrology data for Meadowbank.

Mean seasonal lake level changes (e.g., spring high and fall/winter low) and elevations and stream discharge estimates from 2002 and 2003 and averaged over these two years were used to put project-related changes in water balance in perspective with observed data. The average precipitation data during 2002 and 2003 was similar to historic data. When estimating impacts, average data was used to put potential change in discharge or lake elevation change in perspective. Of course, if dewatering of pits took place during a high precipitation year, potential impacts might be greater. The converse would be true if it was a dry year.

SECTION 3 • IMPACT ASSESSMENT METHODOLOGY

3.1 GENERAL SCOPE AND APPROACH OF ASSESSMENT

Water Quantity was identified as a Valued Ecosystem Component (VEC) based on extensive discussions with government regulators, Baker Lake residents and other stakeholders, public meetings, traditional knowledge and the experience of other mines in the north. Information from these consultations has been described and summarized in the Traditional Knowledge and Community Consultation report included with this EIA submission.

The general approach of this assessment is described below.

3.1.1 Spatial and Temporal Boundaries

The Local Study Area (LSA) encompasses the watersheds and lake areas of Third Portage, Second Portage, Vault and Wally lakes, extending up to the small receiving basin/bay of Tehek Lake. The Regional Study Area (RSA) includes the remainder of Tehek Lake, downstream lakes and the Quioch River to Chesterfield Inlet. These definitions are consistent with spatial boundaries for water quality and fish and fish habitat VECs.

Temporal boundaries were defined by the various stages of the mine life. Temporal boundaries should be related to reasonable return periods (see below). The Construction phase of the project is the period from Year –2 to Year -1, a period when the majority of lake dewatering, and facility development activities are undertaken. The Operation phase is from Year 1 to Year 10. The primary activities during this period include ongoing development of pits, dewatering of the Goose Island area of Third Portage Lake, and continued expansion of waste rock and tailings piles. The closure and post-closure phase is from Year 10 to the end of the mine monitoring period (~Year 25). Closure activities such as facility removal, deactivation of roads, rewatering of pits and basins, as well as monitoring activities that extend well past the operational life of the mine, are part of this phase. A temporary closure is a cessation of mining and processing operations for three to 12 months where the intention is that the mine will resume operations as soon as possible after the cause of the temporary shutdown has been removed. An indefinite or long-term shutdown is a cessation of mining and processing operations for an indefinite period of time greater than 12 months. The exploration phase occurs both prior to and during the life of the mine.

Habitat components and fish populations are intimately related to changes in water level and movement. The frequency and duration of changes in water movement during construction, operation and post-closure have the capacity to affect overall productivity and biomass in the project lakes. Therefore, the durations of changes in water movement has been related to the average life span of food resources and fish populations as follows:

- Short-term impacts are defined as being 2 years or less, which is the average life span of most aquatic invertebrate species and the number of years between spawning events by mature fish species.

- Medium-term impacts are defined as being 12 years or less, which is approximately half the life span of important fish species, such as whitefish and lake trout.

- Long-term impacts are defined as being more than 25 years, which is equivalent to the average life span of important fish species.

- Permanent impacts persist well beyond mine life, over several generations of fish (at least 100 years).

3.1.2 Summarize Existing Conditions

Baseline information was used to better understand how widespread project effects on the Surface Water Quantity VEC might be. Hydrometric monitoring has taken place within the Meadowbank LSA since 2002.

3.1.3 Key Potential Project Interactions

Potential impacts, proposed mitigation and monitoring measures, and identified residual effects to water quantity during construction, operations, and closure / post-closure stages of the mine life are described below. The discussion is based on a system of matrices (see Appendices), which tabulate Project Components cross-referenced with Potential Effects, Assessment of Unmitigated Effects, Proposed Mitigation, Assessment of Residual Effects, and Monitoring and Management. Separate matrices have been prepared for each of the three primary project phases (i.e., Construction, Operations, and Closure & Post-Closure).

One of the purposes of developing detailed impact matrices was to identify the most critical issues that could adversely affect water movement during the various project phases and to determine if prevention or mitigation is possible. Discussions have been developed around these issues, whereas less attention has been given to generic issues or effects that are not considered to be significant (i.e., acceptable) and/or are easily mitigated or are clearly inconsequential.

3.1.4 Identify Mitigation Strategies for Key Potential Interactions

A preliminary mitigation and monitoring plan has been prepared (see Mine Waste and Water Management Plan). A summary of these mitigation strategies is provided in this report.

3.1.5 Summarize Residual Impacts of the Project

Ultimately, the effects remaining after all mitigation effort has been applied (i.e., residual effects) are of greatest concern. Therefore, considerable attention has been given to identifying, quantifying and describing these residual effects so that determination of potential significant/unacceptable and/or cumulative effects is facilitated. It is these residual effects that will provide the basis for the cumulative effects assessment (see Cumulative Effects Assessment report) and the determination of the significance of effects (i.e., Acceptable [No], Unacceptable [Yes]) by regulators (see NIRB EIA Terms of Reference).

3.1.6 Assessment Criteria

Criteria for evaluating the significance of impacts have been developed for this project based on best practice, professional judgement and experience on other impact assessments for similar northern projects. The intent of this process is to be transparent and to document decision pathways so that others can review the process that was used to determine the likelihood of predicted impacts, how mitigation has avoided or reduced an impact, and the significance of impacts, particularly residual impacts. This section presents the definition for each criterion used to determine significance.

To determine whether or not an impact may have a significant adverse effect on the Surface Water VEC component, the magnitude, spatial extent, duration, frequency and timing of effects for each project-related activity have been assessed. (see Appendices). How each of these criteria influence significance is discussed below and summarized in Table 3.1.

Magnitude is a measure of the intensity or severity of the effect of a mine-related activity relative to a change from background conditions. Magnitude is somewhat subjective and takes into consideration such factors as ecological relevance, degree of change from baseline conditions, certainty of occurrence, and ecological resilience (defined as the ability of an ecosystem recovery to a stable state, following disturbance or stress). The certainty with which the magnitude of an effect can be quantified has a strong influence on whether magnitude is ranked as high, medium, or low. The magnitude of change in water quantity as a result of project-related activities must be considered relative to the natural magnitude of change in water quantity and movement over time. Water levels naturally change from one year to the next, depending primarily on differences in annual precipitation levels. The magnitude of impacts is therefore related to fish, the most important aquatic VEC affected by water level changes.

- 0 – 10 year return period in average annual water level or discharge = low magnitude. This is equivalent to less than half the life span of important VEC fish species.
- 10 – 25 year return period in average water level or discharge = moderate magnitude. This is equivalent to the average life span of important VEC fish species.
- >25 year return period in average water level or discharge = high magnitude. This exceeds the average life span of VEC fish.

Spatial Extent is a measure of the geographic boundary for a given impact related to water quantity. ***Frequency*** is a measure of how frequently effects on Water Quantity will be felt using standard measures (e.g., weeks, months, years). ***Duration*** is defined by the main temporal phases of the project (i.e., construction, operation, and closure/ post-closure) within which impacts on water quantity are evident. ***Timing***, in the context of this VEC assessment, refers to the seasonality of a given effect on water quantity.

Table 3.1: Evaluation criteria to determine project effects.

Criteria	Levels/Ranks of Criteria	Definition of Levels/Ranks of Criteria
Magnitude	High	Effect is >25 year return period from average water level or discharge within the LSA and has a high certainty of occurring.
	Medium	Effect is 10 – 25 year return period from average water level or discharge within the LSA and has a moderate to high certainty of occurring.
	Low	Effect is <10 year return period from average water level or discharge within LSA and has a low to moderate certainty of occurring.
Spatial Extent	Regional	Area outside the first receiving basin of Tehek Lake downstream to other lakes and the Quioch River to Chesterfield Inlet
	Local	Area encompassing the watershed of Second Portage (includes Third Portage, Turn, Vault, Phaser, Wally and Drilltrail lakes) up to the first receiving basin of Tehek Lake.
Frequency	Continuous	Effect occurs continuously.
	Frequent	Effect occurs very regularly (i.e., daily or weekly).
	Infrequent	Effects occurs infrequently (i.e., (monthly to yearly).
	Rare	Effect occurs rarely (i.e., yearly or less frequently).
Duration	Permanent	Effect continues well beyond mine life, at least 100 years.
	Long-term	Effect occurs over a period exceeding 25 years.
	Medium-term	Effect occurs over a 25 year period.

	Short-term	Effect occurs during a two year period.
Timing	All Year	The effect can occur at any month of the year.
	Winter	The effect occurs during the time that waterways are frozen (i.e., Oct to May)
	Summer	The effect occurs during the time waterways are free-flowing (i.e., Jun to Sep)

3.1.7 Determination of Significance

Measures of magnitude, spatial extent, duration, frequency and timing are individually evaluated and ranked for each project-related activity to assess whether the impact is predicted to be significant or not. To determine significance, a transparent, step-wise process combining the outcome of individual criteria has been established to arrive at an overall conclusion. Therefore, significance is determined depending on a particular combination of previously defined criteria (see Table 3.2).

A summary of the distinction between significant (i.e., potentially unacceptable) and non-significant (i.e., likely acceptable) impacts include:

- All high magnitude impacts, regardless of spatial extent, duration and frequency, with the exception of short-term rare events within the local study area are considered significant.
- All medium magnitude impacts within the regional study area are also considered significant, regardless of duration or frequency.
- Low magnitude impacts within the regional study area of a long-term to permanent nature that occur frequently are significant.
- Medium magnitude impacts within the local study area of any duration are significant if frequency is continuous
- Low magnitude impacts within the local study area are not significant regardless of duration, frequency or timing.

Table 3.2: Significance evaluation matrix for project impacts.

Magnitude	Spatial Extent	Frequency	Duration	Timing	Conclusion About Significance
High	Regional	Any	Any	Any	Yes
High	Local	Any	Permanent	Any	Yes
High	Local	Any	Medium-term	Any	Yes
High	Local	Frequent to Continuous	Short-term	Any	Yes
High	Local	Rare to Continuous	Short-term to Medium-term	Any	No
Medium	Regional	Any	Medium to Permanent	Any	Yes
Medium	Regional	Frequent to Continuous	Short-term	Any	Yes
Medium	Local	Frequent to Continuous	Medium-term to Permanent	Any	Yes
Medium	Local	Rare to Infrequent	Long-term to Permanent	Any	No
Medium	Local	Continuous	Short-term to Medium-term	Any	Yes
Medium	Local	Rare to Frequent	Short-term to Medium-term	Any	No
Low	Regional	Frequent to Continuous	Medium-term to Permanent	Any	Yes
Low	Regional	Rare to Infrequent	Medium-term to Permanent	Any	No
Low	Regional	Any	Short-term to Medium-term	Any	No
Low	Local	Any	Any	Any	No

3.2 APPROACH TO IMPACT ASSESSMENT

Impacts associated with construction, operation and closure are assessed independently for each major project activity, creating a temporal phased approach to the impact assessment. The magnitude, duration and frequency of project activities differ among temporal phases and the significance of these are determined separately.

The Meadowbank Project has three distinct spatial components: the Portage development; Vault development; and Baker Lake development. The Portage and Vault developments share similar activities, dominated by dike installation, dewatering of impoundments, dike operation, and effluent discharge. Developments at Baker Lake are entirely different from those of the project lakes and consist of a barge unloading and storage facility, winter road, tank farm and a staging facility. These are assessed independent from the Vault and Portage developments.

3.2.1 Impact Matrices

The primary means by which impacts of construction, operation and closure on water quantity were assessed was through the use of impact matrices (Appendices). Potential impacts on water quantity were assessed for each major development activity during construction, operation and closure in the absence of and with mitigation (i.e., residual impacts). The purpose of comparing unmitigated and residual impacts was to satisfy the TOR and to highlight the effectiveness of planned mitigation efforts to avoid or reduce the magnitude, extent and duration of impacts. By taking this approach, consideration is given to every possible combination of activity during the life of mine development to ensure that nothing was missed and that the assessment procedure is thorough and our decision pathway, transparent.

3.2.2 Mine Components

Major project components and activities assessed in the matrices (Appendices) were divided among construction, operation and closure scenarios. These are outlined along the left hand column of the matrices.

3.2.3 Effects Assessment and Significance

The structure of the remaining columns of the matrices is focused on evaluating the unmitigated and residual impacts of each major development component or activity during construction, operation and closure. Major headings and their content are as follows:

Potential Effects – This column outlines the physical activity (e.g., dewatering) and physical effect (e.g., increase in lake levels of receiving waters)

Assessment of Unmitigated Effects – The magnitude, spatial extent, duration, frequency and timing of impacts to water quantity are assessed in the absence of mitigation to arrive at an overall significance based on the combination of assessment results (see Table 3.2).

Proposed Mitigation – This column describes the mitigation proposed for each project component during construction, operation and closure phases. Mitigation may include avoidance of sensitive periods, dewatering over an extended period and/or other measures to reduce the magnitude, spatial extent and frequency of impacts.

Residual Effect and Influence of Mitigation – This column assesses the likely residual effects after mitigation has been applied and summarizes the consequences of mitigation and its influence on reducing the magnitude, extent, duration, frequency and/or timing of the activity. In some cases, significant impacts in the absence of mitigation can be reduced to insignificant after mitigation is applied. In other cases, although mitigation may reduce the relative magnitude or spatial extent of significant impacts, mitigation may not be sufficiently effective to reduce significance to negligible levels.

Consistent with the assessment methodology described here and as promulgated by the CEAA, impact assessment is focused on residual effects, after mitigation has been applied.

Significance of Residual Effects – The overall ecological significance of residual impacts (i.e., after mitigation is applied) on water quantity (significant [Yes] or insignificant [No]) is assessed based on the combination of magnitude, extent, duration, frequency and timing as outlined in Table 3.2).

Certainty of Prediction – This column assesses the probability or certainty that the proposed mitigation will be successful in reducing impacts and achieving the predicted residual assessment of significance stated in the previous column.

Management and Monitoring Plan – This column describes whether or not a monitoring program exists to monitor residual effects and confirm/refute our assessment of the magnitude, extent, duration, frequency and timing of impacts. The Mine Waste and Water Management Plan outlines these strategies.

3.3 KEY QUESTIONS DURING CONSTRUCTION AND OPERATION

To reduce the complexity of addressing all of the impacts to water balance from each of the development activities during construction and operation, this assessment has focused on critical issues, as identified in the impact matrices (Appendices). These have been posed as ***key questions***. Ancillary activities and facilities that are generic in nature and for which there are proven mitigation measures or engineered solutions to minimize impacts (e.g., road construction, winter road utilization) are assessed with less rigor or scrutiny than more important issues warrant. Activities that have no or negligible potential impact on water balance have been addressed within the matrices and not within the text. Therefore, all possible combinations of mine-related impacts and their potential significance, with and without mitigation during construction and operation are considered.

The key questions posed during ***construction*** of the Portage Pit, Bay Zone and Vault Pit and by mine infrastructure on water balance are:

- What is the impact of construction on water balance in East, Bay Zone and Vault Dike within project lakes?
- What is the impact of dewatering of Second Portage, Bay Zone, and Vault Lake pits within the LSA?
- What is the impact of dike construction on water flow between lakes?
- What is the impact of installation of the Turn Lake crossing on water balance?

These dikes and pits are considered part of the construction phase because these activities occur within Cumberland's construction window during the first two years.

The key questions posed during ***operation*** regard Goose Island Dike and Pit development and mine infrastructure on water balance are:

- What is the impact of dewatering Goose Island Pit within the LSA?
- What is the impact of directing water from Phaser Lake to Turn Lake?
- What is the impact of operation of the Turn Lake crossing on water levels and flows?
- What is the impact of freshwater consumption on water level in Third Portage Lake?
- What is the impact of effluent discharge on water level in Third Portage Lake?
- What is the impact of alteration of lake morphometry on water balance during operation?
- What are the impacts on water balance in receiving waters as a result of collection and direction of contact and non-contact water over the plant site (roads, ditches, buildings, Rock Storage Facilities, etc.)?

Construction of the Goose Island Dike and Pit are considered under operation because they are forecast to take place at least five years into mine operation.

The key questions posed during ***closure*** of the Portage, Goose Island and Vault pits on water quantity or surface water are:

- What is the impact of rewatering of pits and associated basins on lake levels and discharge patterns of contributing water bodies?
- What is the impact of permanent alteration of lake morphometry on water balance?

SECTION 4 • IMPACT ASSESSMENT – WATER BALANCE

4.1 APPROACH

Changes to water balance (i.e., water volume, circulation and discharge pattern) within project lakes as a result of mine-related activities are important to how physical features or biological components are affected. That is, it is not the change in water level or discharge itself that is important, but whether the magnitude or temporal duration of the change is great enough to adversely affect water chemistry, erosion of habitat by ice, or fish passage, for example.

The construction and operation of dikes and pits have greater potential to affect water level, flow and circulation in the project lakes than other activities. Therefore, an important distinction has been made between the act of dike construction and pit development with respect to how water level, circulation and flow are affected within the project lakes. Dike construction occurs over a relatively very short time frame, on the order of weeks or months for each dike. This, combined with the very small volume of each dike relative to lake volume, means that no significant displacement of water occurs and no immediate effects on water level or circulation within the lakes will be realized during the brief construction period. However, construction of dikes to impound lake areas for open pit mining in Second and Third Portage lakes and Vault Lake will immediately and permanently alter water movement patterns between Third Portage and Second Portage lakes and disrupt flow from Vault Lake during mine operation.

Although dikes impound and separate water volumes within lakes, significant changes to water balance will not occur until water volumes are displaced during pit development. This is particularly true during dewatering of Portage Pit, where a large volume of water is displaced from Second Portage Lake to Third Portage Lake during construction. Much smaller water volumes are displaced during construction of Bay Zone and Vault Pits. Construction and dewatering of Goose Island Pit occurs during mine operation.

4.2 CONSTRUCTION

The key issues during construction involve potential impacts associated with dewatering of impoundments and discharge to adjacent lakes, especially Third Portage Lake. It is noteworthy that changes in water balance as a result of dewatering are restricted to the first one to three years of mine construction/operation, until lake levels stabilize. Beyond this, water elevation changes and discharge as a result of mine activities will be relatively small until mine closure. For example, components with the potential to affect water movement in the project lakes, such as effluent discharge or freshwater intake are relatively very minor despite the fact these activities occur throughout mine life. These are addressed under Operation, Section 4.3.

4.2.1 What is the Impact of Dike Construction on Water Level?

Activity

Dikes will isolate and impound water bodies within Second Portage Lake (East Dike), Third Portage Lake (Bay Zone, followed by Goose Island Dikes) and Vault Lake (isolated from Wally Lake).

Construction of the East Dike in Year –1 will impound approximately 135 ha (35% of surface area) and 58% of the water volume in Second Portage. Construction of the Bay Zone Dike in Year –1 will impound approximately 19.9 ha of Third Portage Lake (0.5% of Third Portage Lake surface area). The impounded volume is 0.4 Mm^3 or ~0.2% of lake volume. In Year 5 of operation, the Goose Island Dike will expand the affected area to allow development of Goose Island Pit. Lake area impounded by Goose Island is approximately 73 ha. Combined with the Bay Zone pit area (total 93 ha), this is 2.6% of the total surface area and < 1% (2.0 Mm^3) of lake volume of Third Portage Lake. The Vault Dike will isolate Vault Lake (2.0 Mm^3) from Wally and Drilltrail lakes.

Dike construction will not alter water levels within project lakes because of the short construction period and the very small surface area and volume of the dikes themselves. The vast majority of changes to water level, discharge and circulation within affected lakes will occur as a result of dewatering and discharge of impoundments to adjacent lakes.

Mitigation

Water level within project lakes will not be affected by dike construction or the presence of dikes and no mitigation is required.

Residual Effects of Dike Construction

Construction of East, Bay Zone and Vault dikes will have no impact on water volume within the project lakes because of the very small footprint area and volume of the dikes relative to the lakes. Thus, residual impact on water volume is low in magnitude, local in extent, of short duration, and occur infrequently, over one or two months for all dikes.

Summary of Residual Effects on Water Volume – Dike Construction

	Magnitude	Spatial Extent	Duration	Frequency/Timing	Significance
East Dike	Low	Local	Short-term	Infrequent	NO
Bay Zone	Low	Local	Short-term	Infrequent	NO
Vault Dike	Low	Local	Short-term	Infrequent	NO

4.2.2 What is the Impact of Dike Construction on Water Flow?

Activity

Construction of the East Dike and Bay Zone Dike will isolate and eliminate the westernmost connecting channel between Third Portage and Second Portage lakes. This is the main outlet channel between the lakes, handling at least 50% of the flow. Without mitigation, the natural flow outlet from Third Portage Lake would be constrained, causing higher water levels in Third Portage Lake and increased discharge through the remaining two channels. Increased discharge, especially during spring freshet could cause water to overtop the channels and cause erosion. Dewatering of Second Portage Pit would exacerbate this problem. The short- to medium-term consequence of this would be a rise in lake level in Third Portage Lake that might cause erosion of shorelines due to higher than normal water and ice levels.

Impairment of fish passage from Second Portage Lake to Third Portage Lake may also occur. Impacts of this are discussed in the Fish Habitat and Population Impact Assessment. However, given that very few fish move between Second Portage and Third Portage lakes, the implications of further minimizing fish passage, in the absence of mitigation, are minor.

Construction of Vault Dike will isolate Vault Lake from Wally Lake and eliminate discharge from Vault into Wally Lake during mine operation. Implications of this are discussed under dewatering.

Mitigation

Loss of the westernmost connecting channel between Third Portage and Second Portage lakes will require that an existing channel be modified, or a new channel be constructed. Cumberland Resources proposes that the existing, easternmost channel, which currently handles about 30% of the flow from Third Portage, be modified to allow the majority of flow (at least 90%) to pass into Second Portage Lake. Widening and slightly deepening the existing channel will be undertaken in Year-2 so that water level change within Third Portage Lake is minimized during dike construction and pit dewatering (Year –1).

The easternmost channel is short (50 m) and shallow. The bottom consists of boulders and cobble over which lake water moves around or under. Fish passage through this channel is difficult or impossible at all times except possibly during spring freshet. The new, engineered channel will be constructed to allow more efficient discharge of water from Third Portage Lake to Second Portage Lake. Bottom elevation of the new channel will be engineered to ensure that discharge will not be constrained and will function much the same as the existing three channels and ensure that the 1 m elevation difference between Third Portage and Second Portage Lake is maintained.

The new channel will also be designed to enable fish passage during the majority of the open water season, permitting fish from Second Portage Lake, especially Arctic char, to access Third Portage Lake, thereby increasing fisheries values. A full description of this is provided within the No Net Loss report.

Residual Impact

Re-engineering of the easternmost connecting channel between Third Portage and Second Portage lakes will ensure that discharge capacity is not diminished below current conditions and will have the further benefit of providing for more assured fish passage between the lakes.

The residual effect of the remediated channel on water flow from Third Portage Lake is expected to be *low* in magnitude, *local* in extent, of *permanent* duration, and is a *permanent* change. Residual effects are not significant. Certainty of this prediction is moderately high. The residual effect is not significant and will enable reciprocal movement by fish between the two lakes.

Summary of Residual Effects of Dike Construction – Water Flow

	Magnitude	Spatial Extent	Duration	Frequency/Timing	Significance
Discharge and Fish Passage	Low	Local	Permanent	Permanent	NO

4.2.3 What is the Impact of Dewatering Impoundments on Water Balance?

Activity

Lake areas impounded behind dikes during construction will be dewatered prior to pit development. Water will be withdrawn from each impoundment using pumps situated on a barge that is moored near the deepest portion of the impoundment to optimize withdrawal rate and minimize the risk of entraining sediment. Prior to dewatering, fish will be harvested or salvaged from the impoundments. Pits will not function as fish habitat during the mine life and will be re-flooded during mine closure (see Section 4.4). Water withdrawn from impoundments will be discharged to adjacent lakes from pipes suspended near the water surface. The dewatering volume and discharge relative to volume and discharge in the receiving environment lakes specific to Second Portage East Dike, Bay Zone Dike, Goose Island Dike (implications are discussed under Operation, Section 4.3) and Vault Dike to allow pit development are as follows:

Table 4.1: Increase in Lake Volume (Million m^3) and Discharge from Dewatering of Meadowbank Project Lake Impoundments.

Impoundment	Dewatering Volume (M m^3)[1]	Receiving Lake[2]	Receiving Lake Volume (M m^3)[3]	Percent Volume Increase[4]	Annual Average Discharge (Mm^3)[5]	Potential Maximum % Increase in Discharge[6]
Second Portage	12.2	Third Portage	228	5.3	11.6	105
Bay Zone	0.4	Third Portage	228	0.17	11.6	3.4
Goose Island	2.2	Third Portage	228	<1.0	11.6	19
Vault	1.5	Wally/Drilltrail	(28.1 + 15^)	3.5	21.9	6.9
[7]Project Lakes (1 Year maximum)	12.2	Tehek Lake*	2626*	~0.6	32.3	38

Notes: ^ Estimated based on precipitation/surface area relative to Wally Lake. ***** Estimated based on comparison of drainage area/volume of project lakes extrapolated from surface area of Tehek Lake (455 km^2).

[1] The maximum dewatering volume from the impoundment; [2] The receiving environment; [3] The volume of the receiving environment lake; [4] The maximum percent volume increase of the receiving lake; [5] Total annual discharge of the receiving lake, prior to mining; [6] The maximum increase in annual discharge as a percent of baseline, conservatively assuming that all water is discharged the same year that it is added to the receiving lake. [7] Maximum volume added to Tehek Lake conservatively assuming all water discharged to Third Portage Lake is discharged to Tehek.

Second Portage East Dike – The area of Second Portage Lake behind the East Dike will be drawn down by 28 m to allow construction of Portage Pit. The water volume pumped from Second Portage Lake into the north basin of Third Portage Lake during Year –1 is 12.2 M m^3. Assuming the water volume of Third Portage Lake is 228 M m^3, this is equivalent to an increase in volume of 5.4% and lake level by 20 – 30 cm.

Mean discharge from Third Portage Lake into Second Portage Lake in 2002 and 2003 was 11.6 M m^3. As discussed at the outset, the long-term mean rainfall depth of 292.8 mm at Meadowbank (prorated from Baker Lake data) is virtually identical to mean rainfall measured at Meadowbank in 2002-2003 (292.7 mm). Thus, average discharge volume in 2002 – 2003 should closely approximate the long-term mean discharge volume from Third Portage Lake. Adding an additional 12.2 M m^3 to Third Portage Lake will approximately double the total annual average discharge from the lake (11.6 M m^3). Therefore, the maximum potential increase in "typical" discharge is greater than 100%. However, because of constraints at Third Portage Lake outlet channels, not all of the dewatering volume pumped to Third Portage Lake will be discharged into the residual area of Second Portage Lake during the same year that dewatering occurs.

Assuming that the main discharge channel between the lakes is eliminated by construction of East Dike and Bay Zone Dike and if no mitigation is undertaken to replace this channel or enhance an existing channel, hydrodynamic modeling suggests that discharge of excess water may take place over several years. Water level in Third Portage Lake is also predicted to rise accordingly. Preliminary modeling indicates that approximately 7.1 M m^3 of the 12.2 M m^3 of water discharged to Third Portage Lake will be discharged in Year-1. The difference (5.1 M m^3) will remain in Third Portage over the winter. Lake elevation is predicted to rise in Year –1 by about 0.27 m, which is roughly equivalent to the normal seasonal rise in water level (0.24 – 0.52 m), based on extrapolation of historic precipitation data from Baker Lake.

During the following summer (Year 1), of the additional 5.1 M m^3 remaining in Third Portage, 1.1 M m^3 will be discharged while 4.0 M m^3 will remain in Third Portage. Thus, in the absence of any mitigation or channel enhancement, it may take a few years for a return to "typical" lake levels and discharge volumes.

The potential for adverse impacts to occur within Third Portage Lake as a result of an increase in water level by about 20 cm above the typical normal is unlikely to result in significant adverse impacts to fish habitat. Lake shorelines consist of large boulders or bedrock and are ice scoured and very resistant to wave energy. Adverse changes to fish habitat along shorelines from erosion or melting of permafrost is also unlikely, given the short duration of high water level. No impacts to habitat situated in deeper water (> 2 m), away from shore such as nursery, shelter, foraging or spawning habitat of fish is anticipated. There is uncertainty associated with this assessment. If dewatering occurred during a wet year, when lake levels are naturally high, there may be some erosion of vulnerable shorelines that could result in sediment deposition to fish habitat. Therefore, although no significant impacts to fish habitats are expected to occur (i.e., a measurable decline or loss of habitat in the order of 10%; see Fish Habitat/Populations EIA section), the potential for impacts depends on hydrological conditions during the year that dewatering actually occurs.

In the absence of mitigation, increased discharge volume and velocity from Third Portage Lake via the remaining two connecting channels could impair fish passage. However, fish passage is not normally possible via these channels, thus the likelihood and magnitude of this impact is very small. Also, depending on discharge velocity, some erosion of the two connecting channels between the Portage lakes might occur.

Water discharged to Second Portage Lake in Year-1 must also pass into Tehek Lake. Because of the considerably reduced volume and area of Second Portage after Year –1, much of the water discharged to Second Portage Lake will also be discharged to Tehek Lake. Average annual discharge volume from Second Portage/Drilltrail to Tehek ranged from 25.9 M m^3 to 38.6 M m^3 in 2003 and 2002 respectively. The projected discharge from Second Portage into Tehek Lake (7.1 M m^3) in Year –1 could increase discharge from between 18% to 27%. This percentage is less than the percent difference in flow between 2002 and 2003 (45%) and is within the observed inter-annual range. In the "worst-case", assuming that the largest dewatering volume (12.2 M m^3) is discharged, the increase in annual discharge is about 38%. Thus, adverse impacts to stream channel integrity or fish movement into Second Portage Lake is expected to be negligible, based on the predicted increased in discharge of this magnitude.

Third Portage Bay Zone Dike – Dewatering of the impoundment behind Bay Zone Dike is also scheduled for Year 2, two to three years after construction of East Dike. Approximately 0.4 M m^3 will be pumped from the impoundment and over the dike to Third Portage Lake, increasing lake volume by an about 0.2%. Given that dewatering takes place at least two years after dewatering of Second Portage Pit, there are negligible cumulative effects on water volume in Third Portage Lake. Changes in water level are not sufficient to cause adverse impacts on water quality, fish habitat or fish populations, even in the absence of mitigation, because of the small water volume.

Vault Dike – Development of Vault Pit will require that approximately 1.5 M m^3 of water will be discharged over the dike into Wally Lake, just upstream of its entry point into Drilltrail Lake. The approximate volume of Wally/Drilltrail Lake is 43.1 M m^3, so volume will be increased at most by 3.4%

during dewatering. This volume is relatively small and is not expected to adversely affect water quality, fish habitat or populations in receiving environment lakes.

Discharge volume from Drilltrail Lake into Second Portage Lake near its mouth at Tehek was 28.2 M m^3 in 2003 and 15.8 M m^3 in 2004. Average discharge volume is 21.9 M m^3. The volume of water discharged from Vault to Wally/Drilltrail represents an increase in average annual discharge of about 7%. This is well within normal inter-annual variation and the existing discharge channel can easily pass this additional flow. Upstream fish migration will not be adversely affected by an increase in discharge of 7%.

Phaser Lake normally drains into Vault Lake before entering Wally/Drilltrail. During operation of Vault Pit (> Year 1), water will directed away from Phaser Lake and into Turn Lake, which discharges into Drilltrail Lake, 4 km downstream of the mouth of Vault Lake. Although net water flow into Drilltrail Lake will not be altered during mine life, the location that this water enters the system will be altered. Thus there is no net change in water balance with respect to water level or flow. No adverse impacts on water quality or fish habitat and fish populations are anticipated.

Mitigation

Construction of the East Dike will eliminate the westernmost of the three channels connecting Second Portage and Third Portage lakes. To mitigate for the loss of this connecting channel, the easternmost channel will be modified and widened to facilitate greater flow. This channel is furthest from mine operations and is less likely to be affected by noise (e.g., blasting) or disturbance. Care will be taken to ensure that bottom elevation of the enhanced channel will be similar to the existing bottom depth to maintain the 1 m elevation difference between Third Portage and Second Portage lakes. Detailed design drawings of the enhanced connecting channel will be prepared in the near future.

The easternmost channel is approximately 25 m long and 10 m wide with shallow water depth and boulder/cobble substrate. Water flows between or beneath the large substrate at all times except freshet. Normally, fish passage via this channel is difficult or impossible during the open water season except possibly during the peak of spring freshet. Enhancing discharge capacity of the channel such that it is able to pass as much water as the former channel will ensure that water balance during operation of the Meadowbank project is not altered. Furthermore, the channel will be designed such that fish passage will be possible during all open water months.

Residual Impact and Significance of Pit Development and Dewatering

The magnitude and significance of residual impacts related to moving water from an impoundment to an adjacent lake depends on whether the magnitude of change in water volume or discharge velocity in the recipient lake is sufficient to cause adverse effects on water quality and/or fish habitat and populations. The difference in water level will also depend on hydrological conditions during the year of dewatering, so there is uncertainty with respect to actual magnitude of change. Residual impacts related to Portage, Goose Island and Vault pits are as follows:

Second Portage Lake – The total volume of water discharged from Second Portage Lake behind the East dike is 12.2 M m^3. This will increase water volume of Third Portage Lake by 5.3 % with a corresponding increase in lake level by about 20 cm. Operation of the enhanced channel will facilitate discharge of the additional volume to Second Portage Lake, reducing water level change within Third

Portage Lake during Year-1. Preliminary modeling suggests that at least half of the dewatering volume added to Third Portage Lake will be discharged to Second Portage in Year-1, increasing discharge by at least 50%. The remaining water will remain within Third Portage Lake over the next winter to be discharged over the next two to three years, depending on current hydrologic conditions.

Dewatering of Second Portage Lake will cause water level to increase in Third Portage Lake during the first two to three years of mine operation. Water quality is not expected to be significantly impaired given the rocky nature of the shorelines around the lake. However, even if some shoreline erosion were to occur, the impact on water quality would be small.

Increased lake area and depth will increase available fish habitat and no adverse impacts to spawning, nursery or overwintering habitat are expected. Although fish populations would not be affected by increased suspended sediment, there is a small risk to fish habitat. For this reason, this has been assigned a moderate magnitude of impact to fish habitat from possible sediment introduction to Third Portage Lake for one to two years.

With respect to water flow, discharge velocity within the connecting channel between the lakes will increase, especially during Year-1. However, the enhanced channel will be designed to accommodate this additional flow and fish passage between the two lakes will be significantly improved.

In summary, potential residual impacts of water balance change on water quality, fish habitat and fish populations in Third Portage Lake are *low* to *moderate* in magnitude, *local* in extent, of *short* duration (less than 2 years), and *infrequent*. Residual adverse effects are not significant. Certainty of this prediction is moderate to high.

Summary of Residual Effects on Third Portage Lake – Second Portage Lake Dewatering

	Magnitude	Spatial Extent	Duration	Frequency/Timing	Significance
Water Quality	Low	Local	Short-term	Infrequent	NO
Fish Habitat	Moderate	Local	Short-term	Infrequent	NO
Fish Population	Low	Local	Short-term	Infrequent	NO

Bay Zone – Approximately 0.4 M m^3 of water will be discharged from the Bay Zone to Third Portage Lake. This represents a negligible increase in volume (0.17%) and level (<1 cm) of Third Portage Lake. The approximate timing of dewatering is in Year 2, two to three years after dewatering of Second Portage Lake, so there is no cumulative impact associated with this activity. Changes in water level and discharge within Third Portage Lake would be negligible and would not be of sufficient magnitude to affect water quality, fish or fish habitat. The potential residual impact of dewatering the Bay Zone in Third Portage Lake is *low* in magnitude, *local* in extent, of *short* duration, and *infrequent*. Residual adverse effects are not significant. Certainty of this prediction is high.

Summary of Residual Effects on Third Portage Lake – Bay Zone Dewatering					
	Magnitude	**Spatial Extent**	**Duration**	**Frequency/Timing**	**Significance**
Water Quality	Low	Local	Short-term	Infrequent	NO
Fish Habitat	Low	Local	Short-term	Infrequent	NO
Fish Population	Low	Local	Short-term	Infrequent	NO

Vault Lake – The total volume of water contained within the Vault Lake, behind the dike, is 2.0 M m^3. Approximately 1.5 M m^3 will be discharged to Wally and Drilltrail lakes, increasing water volume by approximately 3.5%. The maximum incremental increase in discharge from Drilltrail to Second Portage and Tehek Lake, assuming that all of the dewatered volume is discharged the same year as dewatering, is approximately 6.9%. An increase in lake level by one or two centimetres will not be sufficient to adversely affect shorelines, water quality or fish habitat.

Residual adverse impact of water balance change on water quality, fish habitat and fish populations from dewatering Vault Pit is *low* in magnitude, *local* in extent, of *short* duration and *infrequent*. Residual adverse effects are not significant. Certainty of this prediction is high.

Summary of Residual Effects on Wally/Drilltrail Lakes – Vault Lake Dewatering					
	Magnitude	**Spatial Extent**	**Duration**	**Frequency/Timing**	**Significance**
Water Quality	Low	Local	Short-term	Infrequent	NO
Fish Habitat	Low	Local	Short-term	Infrequent	NO
Fish Population	Low	Local	Short-term	Infrequent	NO

4.2.4 What is the Impact of Turn Lake Culvert Installation?

Activity

The access road between the plant site and the Vault development requires that a culvert be installed at Turn Lake. The crossing will be approximately 70 m wide and pass over the constriction in the lake (i.e., outlet) between Turn and Drilltrail lakes, approximately 100 m from the discharge point to Drilltrail Lake. The crossing will require two 2.5 m diameter round culverts, each 75 m long (to allow side slope ratio of 3H:1V for protection of habitat), connecting the upstream and downstream sides. Culverts will be installed in the dry during winter and sunk 0.8 m (1/3 embedded) into the existing lake bottom to provide lateral structural stability.

Mitigation

Culverts are a common and frequently used means of crossing streams. There are established mitigation measures to ensure that stream flow is not impeded, or forced to overflow existing stream banks during construction and operation. To ensure that there is no impact on stream flow, culverts will be installed during winter when the outlet from Turn Lake into Drilltrail Lake is frozen to the bottom, ensuring no disruption of flow. The size of the culverts are sufficient to pass 1:100 year flood events, increased discharge due to dewatering of Phaser Lake into Turn Lake, and will not impair water movement out of Turn Lake, nor upstream fish movement.

Residual Impact of Turn Lake Culvert Installation

Culvert installation will occur during the winter, in the dry when there is no discharge or water movement out of Turn Lake. The residual effect of culvert installation across Turn Lake is expected to be *low* in magnitude, *local* in extent, of *short* duration, and will occur *infrequently*. Residual effects are not significant. Certainty of this prediction is high.

Summary of Residual Effects – Turn Lake Crossing Construction					
	Magnitude	**Spatial Extent**	**Duration**	**Frequency/Timing**	**Significance**
Water Movement	Low	Local	Short-term	Infrequent	NO

4.3 OPERATION

Key operational activities with the potential to affect water balance in the project lakes include construction and dewatering of Goose Island Zone, and effluent discharge and freshwater intake from Third Portage Lake. Changes in water balance due to diversion of contact and non-contact water is also considered. Other mine-related activities during construction with no or negligible potential to affect water balance are addressed by the impact matrices (Appendices).

4.3.1 What is the Impact of Dewatering Goose Island Zone on Water Balance?

Activity

Water will be pumped from within the Goose Island impoundment in the same fashion as the other impoundments, using barges and pipes. Fish will be harvested or salvaged prior to dewatering. Dewatering of Goose Island Zone will occur in Year 4 or 5. Approximately 2.2 M m^3 of water will be discharged over the dike into Third Portage Lake, increasing lake volume by <1%. Timing of dewatering is such that there should be no cumulative impact on water level or balance within Third Portage Lake because sufficient time will have passed since dewatering of Second Portage Lake.

The estimated maximum increase in lake elevation from dewatering is approximately 4 – 5 cm, prorated based on annual precipitation inputs and seasonal water level changes, and assuming that this entire volume is retained within the lake during the same year the pit is dewatered. This rise in elevation is well within typical annual changes in lake elevation (20 cm – 50 cm) and no adverse impacts to fish habitat or fish populations are expected from this change in water balance. However, given the proximity of Goose Island Zone to the outlet channels between Third Portage and Second Portage Lake, it is highly likely that most if not all of this volume will pass into Second Portage Lake and out of the system during the same year that dewatering occurs. If this were true, annual discharge volume from Third Portage Lake would increase by approximately 19%. This value is well within typical inter-annual differences in discharge observed between 2002 and 2003 (45%). Thus, changes in water balance within the project lakes are predicted to be relatively small and adverse impacts on fish habitat or populations are expected to be negligible.

Construction and operation of Goose Island Dike will alter water circulation pattern within Third Portage Lake. Water entering the East Basin from the North and South basins will be forced further east. This is also directly in line with the predominant wind direction. This may increase mixing of water between the North and South basins and the East Basin. Without the presence of Goose Island Dike, the east side of Camp Island may have acted to create a small back-eddy north of Goose Island. The change in water circulation pattern is relatively small and will have negligible impact on water quality or fish habitat/populations.

Mitigation

Dewatering of Goose Island Zone will be timed such that there is no cumulative impact on water balance in Third Portage Lake as a result of dewatering of Second Portage Lake. Water will be discharged over the dike east of Goose Island towards the enhanced connecting channel between Third Portage and Second Portage lakes, facilitating flow out of Third Portage Lake and minimizing water level changes. Given the smaller volume of Second Portage Lake, water discharged to Second Portage will be transported to Tehek Lake fairly quickly.

Residual Impact and Significance of Goose Island Pit Development and Dewatering

Water volume discharged from Goose Island Zone to Third Portage Lake in Year 5 is 2.2 M m^3, which is less than 1% of lake volume and may result in a small change in lake elevation (4 – 5 cm). This will not cause adverse effects on water quality or fish habitat. However, assuming this entire volume is discharged the same year of dewatering, lake elevation change will be negligible and the incremental increase in discharge to Second Portage Lake via the enhanced channel is approximately 19%. These values fall well within historic, inter-annual differences (45% observed between 2002 and 2003) in lake elevation and discharge.

Residual adverse impact of water balance change on water quality, fish habitat and fish populations from dewatering Goose Island Pit is *low* in magnitude, *local* in extent, of *short* duration and *infrequent*. Residual adverse effects are not significant. Certainty of this prediction is high.

Summary of Residual Effects – Goose Island Zone Dewatering

	Magnitude	Spatial Extent	Duration	Frequency/Timing	Significance
Water Quality	Low	Local	Short-term	Infrequent	NO
Fish Habitat	Low	Local	Short-term	Infrequent	NO
Fish Population	Low	Local	Short-term	Infrequent	NO

4.3.2 What are the Impacts of Phaser Lake Diversion to Turn Lake?

Activity

Phaser Lake will be drawn down by approximately 1 m. This reduction in water level is necessary to provide storage of spring freshet and/or extreme discharge events from non-contact water that would normally be discharged to Vault Lake. Non-contact water will be directed to Turn Lake from Phaser Lake during mine life. The incremental flow of water from Turn Lake relative to typical flows in negligible. Water balance will not be affected because the net amount of water discharged to the system is not affected. Instead, non-contact water will be directed to the middle of Drilltrail Lake from the outlet at Turn instead of at the top of Drilltrail from Wally Lake.

Mitigation

Water will be directed to Turn Lake where it will be discharged with no net change in water balance in the project lakes.

Residual Effect and Significance of Phaser Lake Diversion

Residual adverse water balance impact of directing water from Phaser Lake to Turn Lake is *low* in magnitude, *local* in extent, of *medium* duration and *frequent*. Residual adverse effects are not significant. Certainty of this prediction is high.

Summary of Residual Effects – Phaser Lake					
	Magnitude	**Spatial Extent**	**Duration**	**Frequency/Timing**	**Significance**
Water Balance	Low	Local	Medium-term	Frequent	NO

4.3.3 What is the Impact of the Turn Lake Crossing?

Activity

The road crossing at Turn Lake will consist of two 2.5 m diameter culverts beneath an earth fill dam at the shallow, narrow mouth of the lake at Drilltrail Lake. Culverts will be engineered to pass a 1:100 year flood event. Maximum water velocity through the culverts during spring freshet will not exceed 0.6 m/s and is slow enough to permit upstream movements by subcarangiform fish (lake trout, whitefish, and char) within the culverts during spring freshet and during summer/fall. The crossing is situated in an area that is frozen to the bottom between mid- to late-October and June and will not pass water out of Turn Lake, similar to existing conditions.

Mitigation

Properly sized and installed culverts will ensure that water flow out of Turn Lake is not restricted during spring freshet (and at all other times) and will not result in changes in water level within Turn Lake and will negate residual effects to fish habitat. There are no spring spawning fish within the project lake area or Quoich River watershed and there are no defined migrations by fish.

Residual Effect and Significance of Turn Lake Crossing

Culverts will be large enough in size to discharge waters under normal, freshet, and flood conditions and will not prevent upstream movement by fish. Residual effects related to the Turn Lake Road Crossing during mine operation will be *low* in magnitude, *local* in extent, of *long* duration, and will occur *frequently*. Residual effects are not significant and certainty of this prediction is high.

Summary of Residual Effects – Turn Lake Road Crossing					
	Magnitude	**Spatial Extent**	**Duration**	**Frequency/Timing**	**Significance**
Water Balance	Low	Local	Long-term	Frequently	NO

4.3.4 What is the Impact of Consumptive Use of Freshwater?

Activity

Freshwater for consumptive purposes (potable water, mine process water, dust suppression, etc.) will be collected from Third Portage Lake via a submerged intake pipe situated 75 m offshore in 10 m water depth. Freshwater will be drawn from the lake at a continual rate of approximately 21 L/s. Maximum potential water withdrawal rate is 130 L/s. Annual consumptive volume, assuming a continuous rate of 130 L/s is approximately 4.1 M m^3 or 1.8% of the total volume of Third Portage Lake on an annual basis. Note that most of this volume will be redirected back to Third Portage Lake after it has been treated. That is, water used for laundry, sewage disposal, and movement of mine tailings, etc. will be sent to the attenuation pond in Second Portage Lake before being treated and discharged back to Third Portage Lake via the effluent pipe.

Mitigation

The freshwater intake pipe will be sized to avoid entrainment of fish and situated offshore away from sensitive fish habitat. The majority of intake volume will be compensated for by effluent discharge volume, resulting in a negligible difference in water balance in Third Portage Lake.

Residual Effect and Significance of Freshwater Consumption

The volume of water withdrawn from Third Portage Lake for consumptive purposes is small (<1.8% of lake volume annually) and will largely be offset by discharge of treated water back to Third Portage Lake via the effluent pipe (up to 1.6% of North and East basin volume). Residual effects of water withdrawal from Third Portage Lake are *low* in magnitude, *local* in extent, of *long* duration and occur *frequently*. Residual adverse effects are not significant. Certainty of this prediction is high.

Summary of Residual Effects –Freshwater Consumption					
	Magnitude	**Spatial Extent**	**Duration**	**Frequency/Timing**	**Significance**
Water Balance	Low	Local	Long-term	Frequent	NO

4.3.5 What is the Impact of Effluent Discharge on Water Balance?

Activity

There are two effluent sources that will be discharged: from the attenuation pond in Second Portage Lake to the North Basin of Third Portage Lake; and from the Vault attenuation pond to Wally Lake. Monitoring of effluent quality, water volume (m^3/d) and loading from both sources is subject to the MMER. A detailed description of the study design for effluent monitoring at Meadowbank is provided in the MMER framework report.

Effluent will be discharged to each of the receiving environments via an 18” HDPE pipe that is anchored along the bottom. The end of pipe will have a diffuser to maximize dilution of effluent into the receiving environment.

Effluent discharged to Wally Lake and Third Portage Lake North Basin consists of a mixture of contact water originating from mine infrastructure-related sources (waste rock seepage and runoff, pit inflow water, runoff from waste rock piles, and drainage water collected from road and airstrip ditches) and local non-contact drainage resulting from precipitation. In addition, the Second Portage attenuation pond will receive all grey water, sewage, and water discharged to the tailings impoundment area (after Year 5). The tailings impoundment area is situated between the attenuation pond and the tailings dike.

Effluent will be discharged to the receiving environment only during open water season, between early July and mid- to late October; effluent will not be discharged under ice.

Instantaneous effluent volume discharge to Wally Lake, with the exception of dewatering, is consistent over mine life and averages 0.08 m^3/s during open water months. Total average annual discharge is approximately 391,500 m^3, which is equivalent to 0.9% of the volume of the Wally and Drilltrail lakes. Note that much of this water would normally be discharged to the lake. Instead, water is held within the attenuation pond to reduce suspended solids concentration.

Instantaneous annual discharge to Third Portage Lake North Basin is predicted to be 0.13 m^3/s in Year 1, 0.15 m^3/s in Year 3, 0.18 m^3/s in Year 5 and 0.22 m^3/s in Year 11 of mine life. Maximum annual average discharge in Year 11 is 2.13 M m^3, which is 2.5% of the volume of the North Basin of Third Portage Lake or 0.9% of total lake volume. Again, much of this water consists of contact and non-contact water that would normally enter the lake, except that it is directed towards the attenuation pond to reduce solids. Thus, the net difference in water balance in Third Portage Lake as a result of effluent flow is negligible.

Mitigation

Mitigative measures implemented at Meadowbank to minimize changes to water balance from effluent discharge to Third Portage and Wally lakes include:

- Directing contact and non-contact water within the Vault and Third Portage watersheds to attenuation ponds to improve water quality.
- Discharging water to the receiving environment lake that would normally receive this runoff, except it is first directed to an attenuation pond.
- Discharging water only during the open water season.

Residual Effect and Significance of Effluent Discharge

Third Portage Lake – The maximum annual volume discharged to Third Portage Lake North Basin from all mine-related sources is small (maximum 0.9%) relative to receiving environment volume. The majority of this water would have entered Third Portage Lake anyway, except for holding within the attenuation pond. Residual impact to water balance in Third Portage Lake is *low* in magnitude, *local* in spatial extent, *long-term* in duration, and will occur *frequently*. Residual impacts are not significant.

Vault Lake – The volume of effluent discharged from the Vault attenuation pond to Wally/Drilltrail Lake is small (0.08 m^3/s) and constitutes a small portion of the receiving environment volume of Wally Lake (0.9% annually). Again, impact on net water balance is negligible because water is simply being directed to the attenuation pond before entering Wally Lake. Residual impact to water balance in Wally/Drilltrail Lake is *low* in magnitude, *local* in spatial extent, *medium*-term in duration, and will occur *frequently*. Residual impacts are not significant.

Summary of Residual Effects – Effluent Discharge

	Magnitude	Spatial Extent	Duration	Frequency/Timing	Significance
Third Portage	Low	Local	Long-term	Frequent	NO
Wally/Drilltrail	Low	Local	Medium-term	Frequent	NO

4.3.6 What is the Impact of Mine Site Infrastructure on Water Balance?

Activity

Most mine site infrastructure facilities including mine plant and facilities (offices, storage), rock storage piles, roads, airstrip, fuel storage and power generating facilities, emulsion/ ammonium nitrate (AN) storage/explosives magazines, and camps (north and south), will be encircled by collection ditches. These ditches will collect contact water (water that contacts or drains from potential contamination sources like waste rock piles) or non-contact water (water that runs off the landscape before it contacts disturbed terrain or contamination sources) and direct them to the Vault or Second Portage attenuation ponds, where contaminants are settled or removed by treatment. Excess water volume, roughly equivalent to inflow volume is discharged from the attenuation ponds into the appropriate water body (Third Portage or Wally Lake).

Mitigation

Water collected from contact and non-contact sources will be directed to attenuation ponds for settling or treatment prior to being released to the receiving environment. Water collected from the Portage lake basin will be discharged to Third Portage Lake. Water collected from the Vault/Wally lake basin will be discharged to Wally Lake. Thus changes in water balance are minimized.

Residual Effects and Significance of Mine Site Infrastructure

There is negligible impact on water balance in receiving environment lakes from use of collection ditches to direct water to attenuation ponds for settling or treatment. This is because of very small water volumes relative to receiving environment volume and simply delays discharge (to allow settling). Residual effects of mine site infrastructure on water balance are *low* in magnitude, *local* in extent, of *long-term* duration, and will occur *frequently* during mine life. Residual effects are *not* significant. Certainty of this prediction is *high*.

	Summary of Residual Effects – Mine Site Infrastructure				
	Magnitude	Spatial Extent	Duration	Frequency/Timing	Significance
Water Balance	Low	Local	Long-term	Frequent	NO

4.4 POST-CLOSURE

During the closure and post-closure phases, mine facilities will be dismantled and landscapes restored to natural contours wherever possible, although natural storage and drainage flow patterns under both the Portage and Vault rock storage facilities will be permanently altered. Natural revegetation of waste rock piles, tailings deposits, and mine footprints will reduce the potential for erosion in the long-term. The most significant activity related to Surface Water is the rewatering of the Vault, Goose Island and Portage Pits and expansion of Third Portage Lake by flooding of terrestrial habitat and capture of part of Second Portage Lake within the new boundary between the lakes northwest of the East Dike.

4.4.1 What is the Impact of Rewatering of Pits and Associated Basins on Lake Levels and Discharge Patterns of Contributing Water Bodies?

Activity

As part of the abandonment and reclamation plan, Second Portage Pit and Vault Pit will be flooded (rewatered) over the course of several years before the Goose Island Dike and portions of the Bay Zone Dike are breached, allowing lake water to mix with pit water. This will also result in the Goose Island and Portage Pits becoming part of Third Portage Lake. The volume of the completed open pits and associated impoundments will have a volume in the order of 100 Mm^3. Instantaneous breaching of the dykes would cause a significant drawdown of Third Portage Lake, and is therefore not acceptable. Rather, pit flooding will be achieved by a combination of seepage, precipitation and some re-direction of annual freshet flows from Third Portage Lake that is expected to occur over a number of years to minimize downstream impact on water flows and to ensure that drawdown does not exceed natural fluctuations in Third Portage Lake water levels. Water in the pits will be monitored for chemistry and will be contained until such a time until it is acceptable to allow mixing with Third Portage Lake. Overall lake surface of Third Portage Lake will be greater than under current natural conditions. Second Portage Lake surface area and volumes will be significantly reduced relative to current conditions because of permanent removal of all areas west of the tailings dyke (i.e., tailings deposition area), and addition of portions between the tailings and east dykes (i.e., Portage Pit) to Third Portage Lake.

The Vault open pit will be flooded at closure and become part of Vault Lake after breaching of the dyke between Vault and Wally lakes. As with the Portage open pits, the dike will not be completely removed until water quality in Vault Pit is acceptable and can mix with Wally Lake. The rate of flooding will be determined by the rate of groundwater seepage, the surface runoff that can be directed into the pit, and the amount of water that can be directed from Wally Lake during spring freshet. One possibility being investigated is the placement of waste rock from the Vault Pit on the floor of the pit later in pit development, to reduce the volume of water required to fill the pit and improve fish habitat.

Mitigation

Instantaneous rewatering of the Vault, Portage and Goose Island pits could lead to unacceptable drawdowns of Vault and Third Portage Lakes. To ensure that drawdowns of these lakes fall within natural water level fluctuations, drawdowns will be occur during spring freshet over a number of years. Consideration is also being given to replacing some of the waste rock at the bases of the pits, thus reducing the overall volume of water required to rewater the pits. Mixing of Pit water and lake water will not occur until such time as water quality in the adjacent lake will not be compromised. As a result, no significant impacts to Vault or Third Portage surface water volumes, fish habitats or fish population is anticipated in the short-term. After flooding, long-term water levels and seasonal and annual changes will be the same as current conditions.

Residual Impacts

The greatest change in the post-closure landscape is the permanent loss of approximately two-thirds of the surface area of Second Portage Lake. Former lake area west of the tailings dike will consist of mine tailings and will become terrestrial habitat, while the lake portion between the Tailings and East Dike (i.e., Portage Pit) will become part of Third Portage Lake. It should be noted that a net gain in aquatic habitat is predicted at post-closure. Total lake area flooded (exclusive of deep portions of the pits) is approximately 198 ha. Combined with operational habitat area gained as part of the DFO No Net Loss of Habitat requirements (15 ha), the total amount of habitat is 213 ha (NNL, 2004). This amount exceeds lake area lost from diking, dewatering and development of the Second Portage Pit, Vault Pit and Tailings Disposal Facility (175 ha).

Runoff that under pre-mine conditions flowed into these altered portions of Second Portage Lake will, during post-closure, be directed to Third Portage Lake. Consequently, a minor increase in spring freshet flows to Third Portage Lake may be expected, although this is offset by the greater surface area and volume of Third Portage Lake at post-closure. Because of the large size and volume of Third Portage Lake, the magnitude of change at post-closure is relatively small and will not significantly alter water balance in the lake.

The residual areas of Second Portage Lake (i.e., areas east of the east dykes) will have significantly smaller volumes and lakes surface area than under current conditions. With the decrease in surface area, storage capacity and increased flows from Third Portage Lake, water residence time in Second Portage Lake will be significantly reduced. The magnitude of change is high and permanent and will significantly alter water balance.

Third Portage Lake water volume and surface area will be permanently increased as a result of the addition of the Goose Island and Third Portage pit volumes to the lake. These increases are not expected to impact fish habitat in Third Portage. Under terms of the NNL plan for Meadowbank, an increase in moderate to high value habitat is predicted.

Rewatering of Vault Lake Pit and attenuation pond will result in a net gain in water volume and surface area from pre-mining conditions, causing a decrease in turnover time. Lake level elevation will be the same as under current conditions. The outflow channel between Vault and Wally lakes will be engineered to maintain lake level and elevation consistent with current level and flow.

Summary of Residual Effects – Pit and Lake Rewatering					
Water Balance	**Magnitude**	**Spatial Extent**	**Duration**	**Frequency/Timing**	**Significance**
Vault	Low	Local	Permanent	Frequent	NO
Third Portage	Medium	Local	Permanent	Frequent	NO
Second Portage	High	Local	Permanent	Frequent	YES

4.4.2 What is the Impact of Alteration of Lake Morphometry on Water Circulation?

Activity

After closure, the size of Third Portage Lake will have increased to include both the Goose Island Pit, Portage Pit, and associated impoundment areas. Portions of the Bay Zone and Goose Island dykes will be removed in a sequential manner as the pits are reflooded to allow mixing with Third Portage Lake East Basin. Thus, the extent of the East Basin will be increased in a northerly direction by approximately 1.5 km. The longitudinal axis of this new arm is nearly parallel with the predominant north-east wind direction, so it is expected that mixing of water in the new arm and the remainder of East Basin will be facilitated. The residual area of the deep portion of Goose Island and Portage Pit will resist mixing and become a depositional area for sediment. Altered morphometry of Third Portage Lake East Basin will cause different wind-driven mixing patterns in the lake, although this change is not expected to significantly alter fish habitat, turnover rates or other limnological conditions (e.g., temperature/oxygen profiles, circulation).

Mitigation

Prior to flooding, shorelines and shallow lake bottom (< 8m) will be contoured to provide moderate and high value habitat for fish (spawning, rearing, feeding) to increase habitat value (NNL, 2004). Engineering of shorelines and lake bottom in the dry prior to flooding will ensure that shorelines and other features are designed to be stable and resist erosion. Pits will gradually be flooded and small sections of dikes will be removed only after water level within the flooded pits and the lake area exterior to the dikes has stabilized. Dike interiors will also be contoured to provide suitable habitat for fish. Sufficient area of the southern end of Bay Zone Dike will be breached to allow mixing between the East Basin of Third Portage Lake and the new East Basin arm.

Residual Impacts

It is difficult to predict how the change in morphology of Second and Third Portage lakes will alter circulation patterns, especially within the new arm of the East Basin at the location of the Goose and Portage pits. Given that wind-direction is roughly parallel with the new arm, mixing will be facilitated, thus there should be no alteration in vertical temperature and oxygen profiles or mixing of nutrients in the water column. Thus, there should only be negligible changes to circulation which should not adversely affect water quality, fish habitat or populations. The magnitude of change is small and limited to project lakes, although the change is permanent. The residual adverse effect is not significant. Certainty of this is moderate.

Second Portage Lake will be significantly smaller in surface area and volume because of loss of area by the Tailings Disposal Facility and loss of area to Third Portage Lake. Altered morphology of Second Portage will significantly increase turnover rate within the lake, although gross circulation patterns will not be changed and no adverse impacts to water quality, fish habitat or populations are expected. Nevertheless, the magnitude of morphological change in Second Portage Lake is high, local in extent and permanent. The residual adverse effect is not significant. Certainty of this is low to moderate.

Vault Lake will have a similar surface area but increased volume because of the flooded Vault Pit. Former shallow areas of Vault Lake now occupied by the pit will become depositional areas. However, shoreline morphometry and surface water circulation will be similar in post-closure as current conditions. Given the additional volume, residence time will increase, although discharge from the lake will be similar. The magnitude of morphological change to Vault Lake is small to moderate and is not expected to adversely affect water quality, fish habitat or populations. The residual adverse effect is not significant. Certainty of this is low to moderate.

Summary of Residual Effects – Water Circulation					
Water Balance	**Magnitude**	**Spatial Extent**	**Duration**	**Frequency/Timing**	**Significance**
Vault	Low	Local	Long-term	Frequent	NO
Third Portage	Low	Local	Long-term	Frequent	NO
Second Portage	High	Local	Long-term	Frequent	YES

4.5 WATER QUALITY ASSESSMENT CRITERIA

4.5.1 Introduction

To determine whether or not an activity or mine component may have a significant adverse effect on water quality, the timing, frequency, duration, spatial extent, and magnitude of water quality impacts associated with each project-related activity have been assessed. This section presents the definition for each of the criterion used to assess the significance of impacts. Definitions are also provided on Table 3.2. The influence of these criteria in assessing the significance of projected impacts is discussed below and summarized in Table 3.3.The intent is to document the assessment decision pathway used to determine significance of impacts both before and after the application of proposed mitigative efforts, the certainty with which the predicted impacts are made is also indicated. This serves to highlight areas where additional information is required to further refine the assessment.

Criteria for evaluating the significance of the Meadowbank Gold project effects on Water Quality have been developed based on best practice, professional judgment and experience. Where possible, quantitative and integrative methods to assess significance have been used, combining information gathered from field investigations, quantitative and semi-quantitative modeling (e.g., water quality prediction and impact modeling), and technical studies designed to address specific questions. In applying mitigation to determine residual effects, available guidelines and legislation to protect water resources have also been incorporated into the design of facilities or procedures. The impact assessment is presented in a summary form on the matrices in Appendix B. The matrices include columns for the various criteria (timing, frequency, duration, spatial extent, and magnitude), as well as additional columns for:

- impact Rating (before and after mitigation)
- influence of Mitigation on Effects Assessment
- probability (i.e. probability of the predicted impact occurring, or certainty of the predicted impact).

The assessments of unmitigated effects consider water quality produced by each mine site component even though these effluents are typically contained and controlled as part of mitigation measures before release to the receiving environment. The assessment considers what unmitigated release of this water would be on the receiving environment. The assessments typically indicate that the residual (mitigated) impacts are much reduced, as the mine design incorporates appropriate mitigation that does not allow these effluents to be released directly to the receiving environment.

4.5.2 Timing & Frequency

Timing refers to the seasonality of the effect. For example, discharge of effluent occurs frequently, but only during open water periods and has a distinct seasonal component. Frequency is a measure of how frequently residual effects on water quality will be felt, using standard measures (e.g., weeks, months, years).

	Timing
All Year	The effect can occur at any month of the year
Winter	The effect occurs during the time that rivers and lakes are frozen (i.e., October to May)
Summer	The effect occurs during the time that rivers and lakes are free flowing (i.e., June to September)
	Frequency
Continuous	Effect occurs continuously
Frequent	Effect occurs very regularly (i.e., daily or weekly)
Infrequent	Effect occurs infrequently (i.e., monthly to yearly)
Rare	Effect occurs rarely (i.e., yearly or less frequently)

Table 4.2: Evaluation Criteria for the Impact Matrices – Surface Water Quality

Attributes	Categories	Definition
Magnitude	Very High	Water Quality Concentrations > MMER
	High	One order of magnitude above CWQG (FAL) < Water Quality Concentrations < MMER
	Medium	CWQG (FAL) < Water Quality Concentrations < one order of magnitude above CWQG (FAL)
	Low	Baseline < Water Quality Concentrations < CWQG(FAL)
	Negligible	Water Quality Concentrations similar to Baseline
Spatial Extent	Regional	Impact extends beyond the project lakes (Third Portage, Second Portage and Wally Lakes) into the main basin of Tehek Lake and beyond
	Local	Impact extends through project lakes
	Footprint to Local	Impacts limited to within 1 m of in-lake dike face, or to a narrow portion of the project lake along the shoreline (i.e. within 60m)
	Footprint	Contained and confined within the mine footprint (not reaching project lakes)
Duration	Permanent	Effect continues beyond twice the estimated mine life, into the forseeable future (Year 25)
	Long-term	Effects occur over more than a 13 year period, extending up to twice the estimated mine life (i.e. to Year 25)
	Medium-term	Effects occur over more than a 3 year period, but less than 13 years (i.e. equivalent to the estimated operational life of the mine)
	Short-term	Effects occur over a three year period or less (i.e. equivalent to the estimated construction phase of the project)
Frequency	Continuous	Effect occurs continuously (daily)
	Frequent	Effect occurs very regularly (i.e. weekly)
	Infrequent	Effect occurs infrequently (i.e. monthly to yearly)
	Rare	Effect occurs rarely (i.e. yearly or less often)
Timing	All year	The effect can occur duirng any month of the year
	Winter	The effect occurs during the freezing months (.ie. October to May)
	Summer	The effect occurs during the thawing months (i.e. June to September)

Magnitude	Spatial Extent	Duration	Frequency	Timing	Significance
Very High (>MMER)	Regional	Any	Any	Any	High
	Local	Any	Any	Any	High
	Footprint to Local	Any	Any	Any	High
	Footprint	Permanent	Continuous, Frequent, infrequent	Any	Medium
			Rare	Any	Low
		Short-term, Medium-term and Long-term	Any	Any	Low
High (Between MMER and one order above CWQG)	Regional	Any	Any	Any	High
	Local	Any	Any	Any	High
		Long and Medium-term	Any	Any	High
		Short-term	Continuous, Frequent	Any	High
		Short-term	Infrequent, Rare	Any	Medium
	Footprint to Local	Medium-term, Long-term, Permanent	Any	Any	High
		Short-term	Continuous, Frequent	Any	High
		Short-term	Infrequent, Rare	Any	Medium
	Footprint	Permanent	Continuous, Frequent	Any	Medium
		Permanent	Infrequent, Rare	Any	Low
		Short-term, Medium-term and Long-term	Any	Any	Low
Medium (Between CWQG and one order above CWQG)	Regional	Any	Any	Any	High
	Local	Permanent	Any	Any	High
		Long-term	Continuous, Frequent	Any	High
		Long-term	Infrequent, Rare	Any	Medium
		Medium-term	Any	Any	Medium
		Short-term	Continuous, Frequent	Any	Medium
		Short-term	Infrequent, Rare	Any	Low
	Footprint to Local	Permanent	Continuous, Frequent	Any	High
			Infrequent, Rare	Any	Medium
		Long-term	Continuous, Frequent	Any	High
			Infrequent, Rare	Any	Medium
		Medium -term	Continuous,Frequent	Any	Medium
			Infrequent, Rare	Any	Low
		Short-term	Any	Any	Low
		Any	Any	Any	Low
Low (Less than CWQG)	Regional	Any	Any	Any	Medium
	Local	Permanent	Continuous, Frequent		Medium
			Infrequent, Rare	Any	Low
		Short-term, Medium-term and Long-term	Any	Any	Low
	Footprint	Any	Any	Any	Low

Table 4.3: Summary of Logic Used to Rate Significance of Residual Impacts on Water Quality

4.5.3 Duration

Duration is the length of time in weeks, months or years over which the effect is expected to persist. Duration is described for each project activity, such as dewatering of impoundments (short-term) or effluent discharge (medium term). Some activities, such as dike installation during construction, may occur over limited time frames, buy may cause impacts that persist for time periods equivalent to or greater than the operational life of the mine. On the other hand, the duration of impact during installation of a water withdrawal system may only persist for the amount of time it takes to install the facility. Duration has been described as outlined below.

Duration	
Permanent	Effects continue beyond twice the estimated mine life into the foreseeable future (beyond Year 25)
Long Term	Effect occur over more than a 13 year period, extending up to twice the estimated mine life (i.e. to Year 25).
Medium-term	Effect occur over more than a 3 year period, but less than 13 years, (i.e. equivalent to the estimated mine life)
Short-term	Effect occurs over a three year period or less (ie. equivalent to the estimated construction phase of the mine)

4.5.4 Spatial Extent

Spatial Extent is a measure of the geographic boundary of residual effects and has been divided into mine footprint, local, and regional areas.

The mine footprint has been included in order to allow assessment unmitigated effects of mine components. For example, without mitigation, the runoff from the rock storage facilities may flow beyond the mine impacting the shoreline of the project lakes. The mine design includes mitigation (collection systems) that direct the runoff to attenuation ponds, so that the spatial extent of the impact directly associated with the rock storage facility is controlled and confined within the mine area or footprint, and does not directly reach the receiving environment.

Spatial Extent	
Regional	Effects occur over larger spatial scales would extend beyond the project lakes (Second Portage, Third Portage and Wally Lakes) into the main basin of Tehek Lake, and beyond.
Local	Impacts occur through the project lakes.
Footprint to Local	Impacts are limited to near the project components, but may extend into the near shore of the project lakes (i.e. within 60m) or may exist in the in-lake dike porewater and adjacent water to about 1 m distance from the face of the dike.
Mine Footprint	Effects may extend beyond the component being considered but remain inside the mine footprint.

4.5.5 Magnitude

Magnitude is a measure of the intensity or severity of the effect of a mine-related activity on water quality. Magnitude is a relative term and is somewhat subjective. Water typically has value only as it relates to use: suitable water quality for the protection of fish populations, or suitable for humans and wildlife to drink. Thus predicted changes in water quality are compared to Canadian Water Quality Guidelines for the Protection of Aquatic Life (CWQG(FAL), and, where appropriate, to the Canadian Water Quality Guidelines for Drinking Water. Typically, when water is suitable for fish to live, grow and thrive, is it suitable for both humans and wildlife to consume. An exception is manganese, where aesthetic considerations for human consumption are lower than concentrations required by aquatic organisms.

As the water quality within the mine site has been included in the assessment (i.e. assessment of unmitigated effects from each mine component), the Metal Mining Effluent Regulations (MMER) have also been included in the assessment criteria for magnitude. This relates to the legislative requirement that requires mitigation such that any water released to the environment is of better quality than the concentrations specified in the MMER. Effluents associated with mine components may exceed MMER criteria, but must be controlled and managed within the mine footprint, and not released to the receiving environment without treatment to reduce the final effluent concentrations.

Specific water quality guidelines used for this project are as follows:

Canadian Water Quality Guidelines for the protection of freshwater aquatic life (CWQG (FAL)) (CCME 1999) are used for all parameters except chloride and cadmium, for which US EPA criteria (US EPA 2002) were used. The US EPA cadmium criterion was used because the CCME guideline is well below detection limits and cannot be practically applied. The US EPA cadmium criterion is very similar to the minimum chronic toxicity levels upon which the CWQG(FAL) is based. The US EPA criterion for chloride was used because there is no CWQG(FAL) for chloride.

The selected definitions for magnitude of impacts to water quality are as follows:

Magnitude	
Very High.	When water quality exceeds the Metal Mining Effluent Regulation (MMER) criteria for one or more parameter
High	When one or more parameters are predicted to become greater than an order of magnitude above Canadian Water Quality Guidelines for the Protection of Aquatic Life (and project specific guidelines as noted above)
Medium	Wwhen one or more parameters are predicted to exceed Canadian Water Quality Guidelines for the Protection of Aquatic Life (and project specfiic guidelines as noted above), but by no more than an order of magnitude
Low	Wwhen all parameters are predicted to remain below Canadian Water Quality Guidelines for the Protection of Aquatic Life (and project specific guidelines as noted above), but remain above basline values
Negligible	When all parameters remain similar to baseline values.

4.5.6 Rating of Unmitigated Effects

This column assesses the likely residual effects before mitigation has been applied. Measures of magnitude, spatial extent, duration and frequency are individually evaluated and ranked (e.g., very high, high, medium, low, negligible; continuous, frequent, infrequent, rare) for each project-related activity to assess whether the unmitigated impact is predicted to be significant or not. Significance is determined depending on the particular combination of magnitude, spatial extent, duration and frequency as shown on Table 3.3.

4.5.7 Proposed Mitigation

Mitigative efforts that have been incorporated into the mine design to reduce the water quality impacts are described.

4.5.8 Influence of Mitigation on Effects Assessment

In some cases, significant impacts in the absence of mitigation can be reduced to insignificance after mitigation is applied. In other cases, although mitigation may reduce the relative magnitude or spatial extent of significant impacts, mitigation may not be sufficiently effective to reduce significance to negligible levels. The influence of the proposed mitigation on the effects assessment is described as low, medium or high. The specific criteria influenced is described where feasible.

4.5.9 Rating of Mitigated Effects (Residual Impacts)

This column assesses the likely residual effects after mitigation has been applied and summarizes the consequences of mitigation and its influence on reducing the magnitude, extent, duration and/or frequency/timing of the activity. Measures of magnitude, spatial extent, duration and frequency are individually evaluated and ranked (e.g., very high, high, medium, low, negligible; continuous, frequent, infrequent, rare) for each project-related activity to assess whether the residual impact is predicted to be significant or not. Significance is determined depending on the particular combination of magnitude, spatial extent, duration and frequency as shown on Table 3.3.

4.5.10 Probability

This column assesses the probability or certainty that the proposed mitigation will be successful in reducing impacts and achieving the predicted residual assessment of significance stated in the previous column. This may reflect the confidence in the data and analyses on which the residual impact and its rating have been based. The probability is described as:

Probability of the Unmitigated Effect	
High	The confidence in the predicted impact is estimated to be between 51% and 100%.
Moderate	The confidence in the predicted impact is estimated to be between 1% and 50%.
Improbable	Confidence in the predicted impact is low, such that additional analyses may be required.

4.5.11 Monitor/Maintain Description

In order to confirm the predicted residual impact, monitoring is proposed. Monitoring can directly address impacts to water quality (i.e. water monitoring of receiving water sites) or can indirectly address impacts by monitoring the implementation and/or performance of identified mitigative efforts (i.e. confirming selection of appropriate construction rock).

4.5.12 Comment

In several areas, impact assessments were initially undertaken at a preliminary level to scope out potential effects. Where the preliminary analysis suggests that the rating of the mitigated effects may be high, or the certainty with which the rating has been made is low, evaluations have been, or are in the process of being, reviewed and/or refined.

SECTION 5 • WATER QUALITY IMPACT ASSESSMENT

5.1 INTRODUCTION

Area lakes are of principle interest as they are the key receiving environment and the ultimate receptors of water borne (and air-borne) contaminants. These receiving environments are of critical importance as they continue to support the fish, wildlife and supply drinking water throughout the mine life and after closure. Thus this water quality impact assessment focuses on potential impacts to the project lakes from mine activities and components. These include direct impacts to the area lakes, arising from such activities as the discharge of effluent and the construction of in-pit dikes, as well as indirect impacts such as wind-blown dust arising from tailings and waste rock deposition.

Impacts to groundwater have also been considered. However, impacts to groundwater quality within permafrost regions, such as at the Meadowbank project, tend to be limited to the small portion of the subsurface associated with the active zone. Possible exceptions are where taliks beneath large water bodies extend to the underlying groundwater system, and provide an avenue for contaminant escape at a larger scale. As noted in the baseline description (section 2.8.2.2), open taliks appear to exist beneath Third and Second Portage lakes, including Second Portage Arm, but do not occur in the vicinity of Vault Lake. These impacts are dealt with in the permafrost section. Mine components and activities also impact the quality of the water within the mine footprint, but these impacted waters are typically contained, controlled and potentially treated prior to release to the area lakes. Hence, these impacts have a lower consequence to the receiving environment. Only those aspects of the mine have been identified as eventually leading to significant impacts on the receiving environment have been discussed in this report. The discussion includes a description of the impacts on the quality of the water within the mine site footprint, and the mitigation measures that have been incorporated to reduce those impacts on water quality particularly where detailed water quality predictions have been conducted for this project. These descriptions have been included to clarify how planned mitigation efforts, which reduce impacts to mine site water quality, assist in mitigating the ultimate impacts to the receiving environment.

5.2 IMPACTS OF MINE CONSTRUCTION

The mine construction period has been defined as the years up to the point the mill begins to process ore and produced tailings. Components of the project that are constructed before the start of milling include:

- In-Lake Dikes, specifically the East Dike and Bay Zone Dike
- Diversion facilities for non-contact water away from the Northwest Arm of Second Portage Lake
- Tailings Dike
- Portage Mine Site Infrastructure, including

  Air strip
  Mine site roads, extending north to the Emulsion/Ammonium nitrate storage facilities
  Mine plant and associated facilities (offices and storage)
  Freshwater Intake and Pipeline
  Fuel storage and power generating facilities
  North and South Site Accommodations
  Sewage and Solid Waste Disposal Facilities
  Emulsion/Ammonium nitrate (AN) storage and explosives magazines
  Plant site runoff collection system and sumps
- Initial development of Portage Rock Storage Facility
- Initial development of North and Third Portage Pits
- Mine activities that occur during the construction period include:

  Dewatering of the Northwest Arm of Second Portage Lake isolated by the East Dike
  Dewatering of the portion of Third Portage Lake isolated by the Bay Zone Dike
  Operation of the mine site accommodations
  Discharge of non-contact water to the north basin of Third Portage Lake

No effluents are discharged during this period, as they are directed to the natural depressions left after dewatering of the Northwest Arm of Second Portage Lake.

Construction of similar components occur at various points during the operational period (Years 1 through 10). These components are discussed here for convenience, although the assessments are addressed in the appropriate mine life period (i.e. during operation) in Appendix B. The components and activities that are similar, but occur during operations include the following:

- in-Lake Dikes, specifically the Goose Island and South Camp Dikes in Third Portage Lake, and the Vault Dike in Wally Lake
- diversion facilities for non-contact water away from the Vault Pit, including diversions of Phaser Lake

- dewatering of the portion of Third Portage Lake isolated by the Goose Island and South Camp Dikes
- dewatering of the portion of Wally Lake isolated by the Vault Dike.

Assessments for all mine components and activities are provided in Appendix B. The activities that have been assessed as having the potential to produce significant residual impacts during construction a represented in greater detail below.

5.2.1 Impacts of In-Lake Dike Construction

Activity

This section provides a brief description of how the dikes would be constructed, potential impacts, proposed mitigation and the residual physical consequences and significance. Impacts of in-lake dike operations are addressed separately.

Development of Meadowbank mine will require construction of four dikes in the following order: East Dike (Year –1 or – 2), Bay Zone Dike (Year –1), Vault Dike (Year 4) and Goose Island and South Camp Dikes (Year 5). The East Dike and Bay Zone Dike will impound a portion of Second Portage Lake, allowing dewatering, and construction of a Tailings Dike across the Northwest Arm of Second Portage Lake. The Tailings Dike will be built using land-based construction methods, and will permanently cut off this part of the lake from the surrounding water bodies. The East Dike, Goose Island Dike and Vault Dike will temporarily (i.e., for the life of the mine) isolate the lake areas within the dikes to create open pits. These areas will be re-flooded after mine closure.

All dikes, with the exception of the Tailings Dike, will be constructed by end dumping rock from an onshore initiation point into the water to create the upstream and downstream embankments. Rockfill for the East Dike will come from initial development of the Third Portage Lake starter pit. Sources for subsequent dikes will come from other mine development areas. Rockfill will consist of iron formation rock (IF) in the upstream rockfill, and intermediate volcanic (IV) rock in the downstream rockfill. Ultramafic (UM) rock will be used for the surface cap, which extends above the lake level because this material has relatively low metals leaching capability, negligible potential to generate acidic drainage and contains excess buffering capacity.

After rockfill placement, granular filter material is to be placed adjacent to the rockfill on the downstream side of the dam, also through the water. Next, fine grained glacial till material will be dumped between the upstream rockfill and downstream filter material, also through the water, to form a core. Then a trench will be excavated through the till core to bedrock (0.5 metres into the bedrock) to construct a soil-bentonite cut off wall. Bedrock depth is estimated to range from 2 to about 9 metres below current lake level for the East Dike and Bay Zone Dike and Second Portage Dike, and up to 13 metres for short segments of the Goose Island Dike. To maintain an open trench, a bentonite slurry will be used. Excavated till material will be mixed with bentonite to create a soil-bentonite mixture and then placed back into the open trench.

Sideslopes of rockfill embankments will vary depending on water depth and foundation conditions and will likely fall within a range of about 1.5H:1V to 2.5H:1V. Total footprint width of the dikes will range between about 90 and 135 m, depending on water depth.

The construction period would be on the order of one to two months for each dike and would occur after ice-off during the open water season. There is a variable amount and thickness of fine (silt/clay) sediment that lies on the lake bottom beneath the proposed dike footprint areas. The vertical depth and grain size of this fine material varies according to water depth. Based on field investigations, the majority of sediment below 4 to 6 m depth consists primarily of clay (40 to 70%) with lesser amounts of silt (25 to 40%) and sand (<5%). At water depths between 2 and 4 m, sediment grain size consists of lesser amounts of silt/clay and greater amounts of sand/gravel. Sediment at shallow water depth (<2 m) consists of stones and boulders.

Both the water depth and sediment thickness in the immediate vicinity of each of the proposed dikes will have a considerable influence on the amount of fine sediment that would be disturbed and dispersed into the water column during dike construction.

Dikes will be constructed in as shallow water as possible to minimize costs and for engineering design considerations. Mean water depth of the East Dike, Bay Zone and Goose Island dikes are approximately 1.5 m, 2.5 m and 5 m respectively. Maximum water depth of East, Bay Zone and Goose dikes are 4 m, 3.6 m and 15.5 m respectively. It is estimated that the thickness of fine silt/clay and overburden (sand/gravel) sediment beneath the dike footprints to bedrock in water depths greater than 4 m ranges from 1 to 3 m in the Bay Zone, 2 to 6 m in the East Dike and 2 to 5 m in the Goose Island Dike The primary potential impacts to receiving water quality during construction of the in-lake dikes will be an increase in the total suspended solids (TSS), and an increase in turbidity in the receiving waters. This will come from two sources: directly from construction materials being deposited into the lake to build the dikes; and from the disturbance of the sediments below and in the immediate vicinity of the dikes being constructed. A portion of this sediment below the dike foundation will fill interstitial spaces between the rockfill materials used to construct the embankments. However, fine sediments will also disperse into the water column during deposition. All explosive residues are assumed to report to the on-land waste rock piles. Leachate from the waste rock piles flows to the attenuation pond, and the influence from explosives residues is factored in as part of the effluent discharge.

Additional impacts due to dike construction may result if till or construction rock deposited into the lakes contain soluble constituents. These constituents may then be dispersed into the receiving waters, and/or reside in the pore spaces of the deposited materials.

Five samples of till were analyzed for their potential to leach metals through short-term leaching tests. All samples showed no potential to generate acidic drainage (non-PAG) and had marginal to non-detectable levels of sulphur and excess carbonate neutralization capacity. Results from short-term leaching tests on till samples indicated dissolved concentrations of aluminum, copper, iron and fluoride above Canadian Environmental Water Quality Guidelines for the protection of freshwater aquatic life (CWQG(FAL)) and one sample had a concentration of cadmium above this guideline. It is considered likely that some release of these constituents into the water will occur under ambient conditions.

Waste rock samples were also analyzed for their potential to leach metals through short-term leaching tests. Results from the short-term leaching test indicated that various rock types could release dissolved concentrations of aluminum, arsenic, copper, chromium, nickel, lead and iron above CWQG(FAL). .

Potential impacts during construction were estimated based on average results from the first three weeks of kinetic testing to simulate leaching and dissolution of fresh rock. The resulting mass-based leaching rates were combined with expected dike materials quantities and in-place void ratio (assumed to be 0.4) to derive porewater concentrations. This constitutes a conservative estimate of initial leaching, since these rates represent first-flush values from accelerated weathering tests that would likely only be encountered immediately after dike construction. Lower leaching rates are expected during operations and after closure of the project. Moreover, the available soluble metals are likely to partially disperse during placement, such that the porewater would retain only a portion of the released soluble constituents. Thus predicted porewater chemistry likely represents the maximum exposure concentrations for aquatic life living within or near the dikes.

A summary of estimated “first-flush” porewater concentrations for submerged dike construction materials is provided in Table 5.1. The porewater concentrations presented in Table 5.1 allow for various geochemical processes (such as solubility constraints, sorption and precipitation processes) that have a potential to attenuate metal concentrations. The IV rock was found to generate poorer water quality than IF rock, and, to be conservative, leaching rates associated with the IV rock types were used for modelling near-dike water quality for all dikes.

Predicted concentrations of seven metals (arsenic, cadmium, chromium, copper, nickel, selenium and zinc) in initial porewater quality are higher than water quality guidelines (Table 5.1). The higher levels of aluminum that occurred in the subaerial kinetic tests were associated with decreases in pH during the tests. The pH of the porewater in dikes is expected to remain higher than minimum pH values measured during kinetic testing because of slower reaction kinetics and diffusion of reaction products through the porewater, thereby decreasing the chemical potential to dissolve these minerals. Consequently, predicted dike porewater concentrations for aluminum are likely overestimated.

Table 5.1: Summary of Construction Period (Initial) Porewater Concentrations from Dike Construction Materials

Parameter	CWQG(FAL)[1]	Porewater Concentrations (mg/L		
		IV	IF	VAULT
Alkalinity		77	5.4	129
Sulphate		140	96	73
Cyanide		n/a	n/a	n/a
Fluoride[2]	0.12	n/a	n/a	n/a
Nitrate-N[3]		n/a	n/a	n/a
Ammonia-N		n/a	n/a	n/a
Total Phosphorous		0.49	0.37	0.37
Metals				
Silver	0.0001	0.00001	0.00002	0.00003
Aluminum[4]	0.1	0.014	0.016	0.03
Arsenic	0.005	0.29	0.008	0.95
Boron		0.15	0.43	0.12
Barium		0.009	0.017	0.022
Beryllium		0.001	0.004	0.001
Bismuth		0.001	0.001	0.001
Calcium		35	37	38
Cadmium	0.00010 - 0.00017	0.0004	0.0002	0.0011
Cobalt		0.023	0.007	0.001
Chromium[5]	0.001 / 0.0089	0.001	0.001	0.001
Copper[6]	0.002 - 0.004	0.03	0.024	0.01
Iron	0.3	0.008	0.009	0.001
Mercury	0.0001	0.0001	0.0001	0.0001
Potassium		40	15	36
Magnesium		19	23	14
Manganese		0.65	0.97	0.075
Molybdenum	0.073	0.009	0.001	0.31
Sodium		5.1	9.3	8.0
Nickel[6]	0.025 - 0.15	0.31	0.068	0.006
Lead[6]	0.001 - 0.007	0.0019	0.004	0.0001
Antimony		0.011	0.006	0.058
Selenium	0.001	0.001	0.001	0.003
Silicon		6.3	7.5	7.8
Strontium		0.22	0.23	0.22
Thallium	0.0008	0.0002	0.0001	0.0004
Zinc	0.03	0.53	0.79	0.12

Notes: 1. CWQG freshwater guidelines and criteria are based on total metal concentrations, except for aluminum (dissolved aluminum criteria); cadmium guideline shown is US EPA. **2.** Freshwater aquatic life guideline listed for inorganic fluorides. **3:** Freshwater aquatic life guideline stipulates that concentrations that stimulate weed growth should be avoided. **4:** Freshwater aquatic life guideline is pH dependent. Based on the baseline pH values of each of the lakes (6.8 for Third Portage lake, 7.5 for Second Portage Lake, and 7.3 for Wally lake), porewater aluminum concentrations during construction are not in exceedance of the freshwater aquatic life guideline. However, long-term kinetic testing suggests that lake pH values could drop to 6.0, in which case porewater aluminum concentrations for all rock types would be in exceedance of the freshwater aquatic life guideline. **5:** Freshwater aquatic life guideline for chromium depends on valence of chromium ion (Cr(iii) = 0.0089 mg/l, Cr(vi) = 0.001 mg/l). **6:** Freshwater aquatic life guideline is hardness dependent. N/A = not analyzed.

The quality of water within and adjacent to the dikes is expected to be lower than predicted porewater quality because of molecular diffusion and advective exchange of lake water and dike porewater. Because predicted initial (construction) porewater concentrations are above water quality guidelines for a number of metals, diffusion calculations were undertaken to provide a conservative estimate of the maximum distance from the dikes that dike leaching could contribute to elevated water quality. Diffusion calculations indicated that concentrations for all metals would decrease below water quality guidelines within a distance of less than 1 m from the dikes. Sensitivity runs indicate that varying the diffusion coefficient used in the diffusion calculations has a relatively small influence on the diffusion results, such that the confidence in the prediction is high.

The results of the water quality assessment indicate that, during construction, concentrations of some metals could be above water quality guidelines in dike porewater and within less than 1 m of the dikes.

Metals and other constituents contained in the material used to construct the dikes may leach with time into the adjacent water body (upstream side of dikes) and also into the seepage water that may pass through the dike. This impact is considered likely to be minor during the construction phase due to its short duration, but has the potential to become more significant over the longer term, including the operation, closure period, and post-closure period of the mine.

During the construction of each dike there is also the potential for accidents or spills to occur, each with the potential to impact water quality. Examples of such spills may be from the bentonite slurry or soil-bentonite mixture used to construct the cutoff walls, or fuel spills from equipment used during the construction.

Mitigation

For mitigation specific to dike construction, silt curtains will be used to minimize the extent to which sediment is dispersed into the lakes. Silt curtains are commonly used and generally effective for mitigation, providing they are properly installed, monitored and maintained. The relatively short time construction period (on the order of one to two months), the shallow nature of the waters and shallow thickness of fine sediment overlying glacial till are factors that increase viability of this technique. Prior to placement of coarse material on the lake bottom, the silt curtain must be deployed to circle the development area, suspended from the lake surface to the lake bottom and anchored outside of the dike embayment. As sections of the dike are completed, the silt curtain would be disassembled and moved to afford as much containment of sediment as can be achieved. An on–site inspector will monitor the situation to ensure that the silt curtains function as designed and contain sediment within the perimeter of the curtains. In addition, water column turbidity and TSS will be monitored daily at a series of stations surrounding the perimeter of the silt curtain to ensure that significant quantities of sediment are not escaping from the containment facility. Further details can be found in the Aquatic Environment Monitoring Program (AEMP).

Provided that the silt curtains operate as designed, very little sediment should enter the water column and be dispersed beyond the dike footprint itself. However, it is recognized that silt curtains can fail (e.g., under high wind conditions, collapse from sediment on bottom, hang up on rocks). If this occurs, sediment would be dispersed into the water column beyond the curtain perimeter increasing the concentration of TSS in the lake for a period of time. Actual areas impacted and concentrations of

TSS would be vary depending on the amount of sediment lost from behind the silt curtain, sediment grain size, duration of the impact, direction and intensity of wind, water currents and local bathymetry. A monitoring strategy has been designed to detect failure in sediment containment so that the situation can be quickly remedied (AEMP). The proposed monitoring program is also designed to measure the magnitude and nature of any residual lake water quality effects, including suspended solids, metals or nutrient concentrations in the water column outside of the silt curtains.

Since testing of the till has shown that it is not acid generating, that only a few constituents are leachable from this material, and these constituents likely leach at rates similar to that occurring naturally in the area, no mitigation is considered necessary.

Metals leaching and dissolution of other materials from material used to construct the dikes may be minimized by selecting appropriate material for dike construction, with the least potential to leach constituents from the rock and, for the aerial exposed portions of the dike (on the pit side), with the least potential to generate acid rock drainage (ARD). In this regard, iron formation (IF) rock will be used for the upstream (lake side) rock fill embankment, intermediate volcanics (IV) will be used for the downstream (pit side) rock fill embankment and ultramafic rock will be used for the permanently exposed cap rock. Nitrogen species will enter the receiving waters, however by using appropriately sized blast charges and type of explosives, excess nitrogen and blasting residues should be kept to a minimum. These species will likely dissolve into the receiving waters and become dispersed.

Residual Effects & Significance of Sediment & TSS

The magnitude of residual impacts from increased TSS and sediment deposition will differ according to each dike location. The East, Bay Zone and Vault Dikes are preferentially constructed in relatively shallow water depths where sediment grain size is very coarse and there is very little fine sediment available to be dispersed into the water column. The Goose Island Dike is constructed across shallow and deep sections, up to 15 m depth. The South Camp Island Dike is constructed across the shallow small arm of Third Portage Lake.

Details of each dike are as follows:

- The East Dike in Second Portage Lake is 950 m in length with a footprint area of 7.2 ha. The maximum water depth along the dike is 3.6 m. Average water depth is 2 m. Substrate grain size at depths of 4 m or less is predominantly boulder/cobble with some fines draped over the coarse material. Therefore, the amount of sediment available to be released into the water column is small.

- The Bay Zone Dike in Third Portage Lake is 720 m in length with a footprint area of 3.0 ha. Maximum water depth along the dike is 4.0 m with a mean water depth of 2.6 m. Similar to the East Dike, sediment grain size in this area is relatively large and very little sediment is present and available for dispersion into the water column.

- The Goose Island Dike is 1724 m in length and has a plan footprint area of about 20 ha. Maximum depth of water along the dike alignment is 15.5 m with a mean depth of approximately 7.5 m. Approximately 45% of the dike will be constructed in water with a depth of 4 m or more where there is considerably more fine material available to be dispersed into the water column.

Given the greater depth and abundance of fine material, the magnitude of sediment introduced into the water column is higher here than at the other dike locations.

- The Vault Dike is constructed across a narrow (25 m) channel at the entrance to Wally Lake. The Vault Dike is approximately 180 m in length with a plan footprint area of about 0.5 ha. The bottom consists of large boulders and there is no fine sediment beneath the dike footprint. Impacts due to sediment introduction into the water column at this location are expected to be minimal.

The area between the dike and the silt curtains will be negatively impacted through dike construction. It is expected that this space will experience *high* turbidity and TSS and possibly elevated metals. Effects may be *continuous* during the *summer* construction season; however the area of impact is small (*footprint to local*) and the duration *short-term*. Thus, the impacts may be *medium*.

Residual impacts on lake water quality beyond the silt curtain should be of *negligible* magnitude unless a problem occurs (i.e. a silt curtain breaks). Then the magnitude might increase to *medium*, and extend over a larger (*local*) area, but should be of *short* duration and is expected to occur *infrequently* over the summer months. The impact rating of this residual effect is *low*

Summary of Residual Effects of Lake Water Quality– Sediment and TSS from Dike Construction					
	Magnitude	Spatial Extent	Duration	Frequency/Timing	Significance
Water Quality – inside silt curtains	High	Footprint to Local	Short-term	Continuous/Summer Only	Medium
Water Quality – beyond silt curtains	Medium	Local	Short-term	Infrequent/Summer Only	Low

Residual Effect & Significance of Introduction of Nitrates or Other Soluble Species

Nitrate enrichment of the receiving environment water may occur as a result of residue from explosives adhered to the external surface of the blasted rock. The project lakes are very nutrient poor and introduction of nitrates from blasting sources will cause a small increase in overall nitrogen species levels, but these are expected to be of *medium* magnitude, occur in the *foot print* area only, of *short* duration and will occur *continuously* to *frequently*, in summer months during dam construction activities. The residual impact is expected to have a *low* significance. The certainty of this prediction is *moderate*.

Summary of Residual Effects – Nutrient Release from Dike Construction					
	Magnitude	**Spatial Extent**	**Duration**	**Frequency/Timing**	**Significance**
Water Quality	Medium	Footprint	Short-term	Continuously/Summer Only	Low

The initially released load of soluble metals and other soluble constituents from the construction rockfill will be largest during construction when the materials are deposited through the water column, but are likely to decrease over time as the initial soluble components are flushed from the construction materials by water moving through the dikes. The residual impact of the initial soluble constituents from the rockfill affecting water quality (as conservatively estimated for porewater quality) is expected to be *high* in magnitude, and will be relatively contained near the *footprint* of the mine but may extend somewhat into the *local* lakes. Soluble component losses are expected to occur *continuously* during construction of the dikes as material is deposited. The residual impact is expected to be *medium* to *low*. The certainty of this prediction is *moderate*, and predicted impacts may be overstated due to the use of conservative assumptions.

Summary of Residual Effects – Soluble Metal Release from Dike Construction					
	Magnitude	**Spatial Extent**	**Duration**	**Frequency/Timing**	**Significance**
Water Quality	Medium	Footprint/Local	Short-term	Continuously/Summer Only	Medium/Low

The leaching of materials used in dike construction will not cease after placement, or once the initial soluble load has been stripped, but will continue both from submerged rock and exposed cap rock. Further discussion of this impact is contained in the operation component of the project.

5.3 IMPACTS OF MINE OPERATION

Once the mine infrastructure is in place, the in-lake dikes and tailings dike have been constructed, the pits dewatered and the mine has become operational, there are several areas where potential impacts to water quality may be generated. These include:

Continued release of metals from dikes and their effect on water quality in the immediate vicinity.

Release of metals and explosive residues from pit walls, and seepage through the dikes into the pit, influencing mine water quality.

Release of metals and explosive residues from seepage and runoff from the waste rock storage facilities.

Release of contaminated runoff from the plant site.

Discharge of mill effluent and sewage treatment plant effluent to the tailings facility within the mine footprint.

Release of metals from exposed tailings beaches to tailings supernatant.

Influence of water generated around the mine (items 2 through 6 above) on water quality within the Vault and Portage attenuation ponds, and potential loss of contaminants through the underlying taliks to the regional groundwater.

Effects of effluent discharges from the Vault and Portage Attenuation Ponds (TSS, explosive residues, metals) on the receiving lakes.

Indirect effects on lake water quality from dust generated from mine site activities and wind-blown dust and tailings.

Effect of diverted non-contact water on receiving waters.

The potential unmitigated and residual impacts from each of these areas are considered in the operations matrix in Appendix B. The mine design confines many of these potential effluents within the mine site footprint (i.e. items 2 through 7), such that they have little direct impact on lake or regional ground water quality. They do, however, combine to form the basis for the final effluent discharged to the receiving environment. The effect of diverted non-contact water on the receiving environment is anticipated to be low if Best Management Practices for sediment control are applied and the diversion structures are properly designed and maintained. Releases to regional groundwater are considered to be minimal due to permafrost confinement of the thawed region below Vault Lakem and analyses that suggests that the aggradation of permafrost into the tailings and the talik below Second Portage Lake Arm will move to seal off potential downward movement of contaminants, Thus the only water quality impacts that have been assessed as potentially significant are effluent discharges from the Portage Attenuation Pond and the Vault Attenuation Pond. These are described in some detail below, along with a description of the effluent sources that make up the quality of the two attenuation ponds.

As the in-lake dikes will continue to leach a small amount of metals into the project lakes, they provide an additive component to the effluent discharges from the two attenuation ponds. Therefore, the impacts associated with in-lake pit operations are also described in some detail below.

5.3.1 Impacts of In-Lake Dike Operation

Activity

Once the in-lake dikes are operational, they will continue to leach small quantities of metals to the water flowing within the upstream shell of the dikes and to the adjacent lake. This section addresses how dike exteriors will function during mine life.

Four dikes will be constructed at Meadowbank in the following order: East Dike (Year –1 or – 2), Bay Zone (Year –1), Vault Dike (Year 1), and Goose Island Dike (Year 5). The East Dike will form the new shoreline extending north from Third Portage Peninsula to North Portage deposit area. The Portage South Dike will form new shoreline on Third Portage Lake, with a portion it replaced when the Goose Island Dike is constructed within Third Portage Lake. The Vault Dike will separate Wally Lake from the Vault Attenuation Pond. Side slopes of dike exteriors will depend on water depth and foundation conditions, and will likely vary within the range of about 1.5H:1V to 2.5H:1V.

Lake water will initially seep through the dikes into the pits, influencing pit water quality. Some seepage through the dike during operations is anticipated, but is expected to be limited, with predicted flux ranging from about 10^{-2} to 10^{-4} l/s per metre of dike. Depending on the actual flux, permafrost may aggrade into the dikes, further limiting seepage.

Dike porewater quality and loadings from the Goose Island and Third Portage Dikes during operations were predicted based on long-term kinetic test results from iron formation (IF) rock, which is considered to be the most likely rock type to be used for construction of the upstream (lake side) portion of the dikes. Post-construction loadings from the Vault Lake dike were based on long-term kinetic test results from Vault area intermediate volcanic (IV) rock. Leach rates were adjusted to reflect submerged conditions and field temperatures. Loss of ammonia associated with blast residues was not considered in this analysis as it is assumed to be completely flushed upon placement of the dike rock, not constituting a long-term source of mass load.

The resulting mass-based leaching rates were then combined with the estimated submerged dike surface areas, an assumed 1 m thick reactive rock layer and in-place void ratio (of 0.4) to derive porewater concentrations.

Table 5.2 shows the estimated porewater concentrations, and leaching rates for the three different kinds of dike construction materials under operational (post-construction) conditions. The predicted pore chemistry is expected to evolve to towards these levels after construction. Levels may be further reduced because of molecular diffusion and advective exchange of lake water and dike porewater.

Predicted post-construction porewater concentrations are below water quality guidelines for all parameters and all rock types, with the exception of fluoride in IF rock and aluminum in IV rock. The higher levels of fluoride and aluminum occur in subaerial kinetic tests associated with decreases in pH during the tests. The pH of the dike porewater is expected to remain higher than minimum pH values measured during kinetic testing because of slower reaction kinetics and diffusion of reaction products through the porewater, thereby decreasing the chemical potential to dissolve these minerals. Consequently, predicted dike porewater concentrations for fluoride and aluminum are likely overestimated.

During the under-ice season (which typically lasts for approximately eight months), there is very little mixing and dilution of porewaters with lake waters. If diffusion processes dominate, substances released from dike porewater into the lake will likely accumulate near the dikes, undergoing mixing throughout the lakes only after the spring break up period. Diffusion calculations indicate that concentrations for all metals would decrease below water quality guidelines within a distance of less than 1 m from the dikes.

Table 5.2: Expected Post-Construction Dike Porewater Concentrations & Leaching Rates Under Submerged Conditions

			Submerged Rocks							
						Annual Leaching Rate (kg/yr)				
		Factor Applied to the Long-term (kinetic test) Leaching Rates[7]	Porewater Concentrations (mg/L)			Third Portage Dike (Second Portage Lake)		Goose Island Dike (Third Portage Lake)		Vault Dike (Wally Lake)
Parameter	**CWQG(FAL)[1]**		**IV**	**IF**	**VAULT**	**IV**	**IF**	**IV**	**IF**	**VAULT**
Alkalinity		1	36	5.8	83	2548	408	35973	5764	1549
Sulphate		0.01	0.1	0.5	0.05	7.1	35	100	500	0.94
Cyanide		1	0	0	0	0	0	0	0	0
Fluoride[2]	0.12	1	0.047	0.20	0.03	3.3	14	47	198	0.65
Nitrate-N[3]		1	0.071	0.043	0.06	5.1	3	72	43	1.14
Ammonia-N		n/a	0	0	0	0	0	0	0	0
Total Phosphorous		1	0.034	0.01	0.12	2.4	0.72	34	10	2.18
Metals										
Aluminum[4]	0.1	1	0.08	0.05	0.2	5.7	3.6	80	50	3.8
Arsenic	0.005	0.01	0.0003	0.00004	0.0016	0.0016	0.003	0.32	0.041	0.029
Barium		1	0.006	0.053	0.017	0.017	3.7	6.5	52.7	0.33
Calcium		1	12	10	26	856	684	12094	9662	496
Cadmium	0.00010 - 0.00017	0.01	1.2E-06	4.8E-06	9.00E-07	0.00008	0.00034	0.0012	0.0048	0.00002
Cobalt		1	0.024	0.039	0.00012	1.7	2.8	23	39	0.002
Chromium[5]	0.001 / 0.0089	0.01	6.0E-06	6.0E-06	5.80E-06	0.0004	0.0004	0.0056	0.0056	0.00011
Copper[6]	0.002 - 0.004	0.01	0.000016	0.000028	6.90E-06	0.0011	0.002	0.016	0.028	0.0001
Iron	0.3	0.01	0.01	0.01	0.0003	0.71	0.71	10	10	0.007
Mercury	**0.0001**	1	0.00006	0.00006	0.00006	0.004	0.004	0.056	0.056	0.001
Potassium		1	2.3	3.6	2.3	159	252	2254	3567	43.5
Magnesium		1	5.1	5.7	4.5	359	403	5070	5702	84

Table 5.2 – Continued

			Submerged Rocks							
						Annual Leaching Rate (kg/yr)				
		Factor Applied to the Long-term (kinetic test) Leaching Rates[7]	Porewater Concentrations (mg/L)			Third Portage Dike (Second Portage Lake)		Goose Island Dike (Third Portage Lake)		Vault Dike (Wally Lake)
Parameter	CWQG(FAL)[1]		IV	IF	VAULT	IV	IF	IV	IF	VAULT
Manganese		1	0.22	1.4	0.033	15.7	98.4	222	1389	0.62
Molybdenum	**0.073**	1	0.00075	0.00006	0.030	0.053	0.004	0.75	0.056	0.57
Sodium		1	2.25	2.25	2.051	159	159	2254	2251	39
Nickel[6]	**0.025 - 0.15**	0.01	0.0013	0.003	6.0E-06	0.094	0.21	1.32	3.02	0.00011
Lead[6]	**0.001 - 0.007**	0.01	0.00003	0.00006	5.80E-07	0.002	0.004	0.033	0.056	0.00001
Antimony		1	0.0025	0.001	0.011	0.17	0.07	2.46	0.95	0.21
Selenium	**0.001**	0.01	0.00001	0.00001	1.20E-05	0.001	0.001	0.011	0.011	0.0002
Zinc	**0.03**	0.01	0.0008	0.002	0.0001	0.06	0.15	0.79	2.1	0.001

Notes: 1: CWQG Freshwater Guidelines and Criteria are based on total metal concentrations, except for aluminum (dissolved aluminum criteria); cadmium guideline shown is US EPA. **2:** Freshwater aquatic life guideline listed for inorganic fluorides. **3:** Freshwater aquatic life guideline stipulates that concentrations that stimulate weed growth should be avoided. **4:** Freshwater aquatic life guideline is pH dependent. based on the baseline pH values of each of the lakes (6.8 for third portage lake, 7.5 for second portage lake, and 7.3 for wally lake), only post-construction vault iv porewater aluminum concentrations are in exceedance of the freshwater aquatic life guideline. however, long-term kinetic testing suggests that lake ph values could drop to 6.0, in which case porewater aluminum concentrations for all rock types would be in exceedance of the freshwater aquatic life guideline.
5: Freshwater aquatic life guideline for chromium depends on valence of chromium ion (cr(iii) = 0.0089 mg/l, cr(vi) = 0.001 mg/l). **6: F**reshwater aquatic life guideline is hardness dependent. 7.n/a = not analyzed.

For the lake wide water quality impact assessments, associated with effluent discharge from the attenuation ponds, substance loading from post-construction dike leaching (rates shown in Table 5.2) were assumed to remain constant for the life of the project. Two scenarios were modelled, one with attenuation pond effluent, and one with both attenuation pond effluent and input from dike leaching. The results indicate that, with the exception of manganese, long-term loadings from IF dike material to the lake are substantially lower than those from effluent releases, and represent only a minor contribution to changes in whole lake water quality.

Mitigation

Predicted concentrations near the dikes are strongly influenced by the initial substance concentrations within dike porewaters. The planned use of IF rock as dike material in the upstream dike (lake side) rock embankment would result in lower than predicted concentrations. Following are the mitigation measures that will be implemented to reduce potential impacts to lake water quality during dike operation:

- The upstream submerged shell of the dikes will be constructed of IF rock, which has a relatively low metal leaching rate.
- Exposed areas will be capped with UM rock, which has negligible potential to produce acidic drainage, has acid buffering capability, and has a lower metal leaching capability than IV or IF rock.

Residual Effects & Significance of Dike Operations

Predicted post-construction porewater concentrations are below water quality guidelines for all parameters and all rock types, with the exception of fluoride in IF rock and aluminum in IV rock. The higher levels of fluoride and aluminum occur in subaerial kinetic tests associated with decreases in pH during the tests. The pH of the porewater in dikes is expected to remain higher than minimum pH values measured during kinetic testing because of slower reaction kinetics and diffusion of reaction products through the porewater, thereby decreasing the chemical potential to dissolve these minerals. Consequently, predicted dike porewater concentrations for fluoride and aluminum are likely overestimated.

The residual effects of the dikes on water quality post-construction are therefore anticipated to be *low* in magnitude, close to the dike *footprint* but perhaps *local* in extent, of *permanent* duration and occur *continuously*. The significance of the residual impacts is expected to be *low*. The certainty of this prediction is *moderate*, because of the uncertainty regarding the time required to transition from predicted construction porewater quality to post-construction (operational) quality. However, advection is anticipated to flush out the initially available soluble metals relatively rapidly. The ability to predict impacts of low significance is considered *medium to high.*

In terms of broader impacts, the contribution of metal load attributed to the dikes on a lake wide (local) scale is small relative to the effluent discharge.

Summary of Residual Effects –Dikes During Operations

	Magnitude	Spatial Extent	Duration	Frequency/Timing	Significance
Water Quality	Low	Footprint/Local	Permanent	Continuous/ Summer	Low

5.3.2 Impacts on Mine Sources on Portage Attenuation Pond Water Quality during Operations

Annual predictions for water quality in the Portage Attenuation Pond throughout the mine life includes Years 1 through 4 when the attenuation pond operates independently from the tailings storage facility, and Years 5 to 10 when the attenuation pond merges with the tailings storage facility to operate as a single facility.

Maximum predicted concentrations in the Portage Attenuation Pond in Years 1, 3, 6, and 10 are summarized on Table 5.3. The values shown for Years 6 and 10 are prior to treatment. Portage effluent water quality in Years 1 to 4, originating from storm water alone (i.e. no mill effluent) is predicted to meet MMER, although pH adjustment may be required should acidic drainage develop during this period. Parameters that are predicted to exceed CWQG(FAL) include aluminum, arsenic, cadmium, copper, nickel, lead and zinc.

Effluent water quality after Year 5 (when the tailings and attenuation pond become one facility) is predicted to exceed MMER for copper, nickel and zinc and possibly pH, such that treatment would be required before discharge to the receiving environment. Parameters that are predicted to exceed CWQG(FAL) include aluminum, silver, arsenic, cadmium, chromium, copper, fluorine, mercury, molybdenum, nickel, lead, selenium, thallium and zinc. Total cyanide levels in the effluent are predicted to comply with MMER. The concentrations of cyanate (CNO) and thiocyanate (SCN), by-products of the cyanide destruction process, are two orders of magnitude higher than cyanide levels. Natural degradation of cyanide species will generate nitrate and/or ammonia, and, although the northern climate of the Meadowbank site is not conducive to rapid degradation year-round, summer water quality in the attenuation pond may experience concentrations pikes of nitrate and/or ammonia.

Table 5.3: Maximum Predicted Concentrations for Portage & Vault Attenuation Pond Effluents

			Portage Attenuation Pond				Vault Attenuation Pond	
			Stormwater Pond		Mixed Pond Untreated			
	CWQG (FAL)	MMER	Year 1	Year 3	Year 6	Year 10	Year 5	Year 10
PH	**6.5 - 9.0**	**6.0 - 9.5**	**5.5**	**5.5**	**5.5**	**5.5**	7.5	7.5
Alkalinity			7	19	62	69	16	21
Sulphate			11	29	2100	1700	3.7	4.2
Cyanide		**1.0**	0	0	0.18	0.17	0	0
Fluoride[2]	**0.12**		0.1	0.11	0.63	1.1	0.03	0.03
Nitrate-N[3]			0.7	1.3	1	1	1.6	0.9
Unionized AmmoniaNH3-N	**0.019**		0.00003	0.00005	0.00002	0.00002	0.0031	0.0011
Total Phosphorous			0.017	0.034	0.28	0.38	0.017	0.023
Metals	**0.1**		0.038	0.087	0.090	0.090	0.07	0.08
Aluminum[4]	**0.1**		0.038	0.087	0.090	0.090	0.07	0.08
Arsenic	**0.005**	**0.5**	0.0051	0.010	0.033	0.072	**0.08**	**0.11**
Barium			0.021	0.023	0.003	0.003	0.015	0.018
Calcium			5.2	11	120	140	5.6	6.8
Cadmium	**0.00010 - 0.00017**		0.00007	0.00010	0.0028	0.0055	**0.0014**	**0.0013**
Cobalt			0.0032	0.0065	0.25	0.38	0.00017	0.00018
Chromium[5]	**0.001 / 0.0089**		0.00083	0.00065	**0.029**	**0.12**	0.0005	0.0006
Copper[6]	**0.002 - 0.004**	**0.3**	**0.0036**	**0.0060**	**5.0**	**14.3**	0.0005	0.0007
Iron	**0.3**		0.040	0.040	0.001	0.001	0.003	0.003
Mercury	**0.0001**		0.00003	0.00004	0.00008	**0.00016**	0.00004	0.00005
Potassium			1.9	2.1	84	55	1.0	1.1
Magnesium			2.4	5.9	21	31	1.3	1.5

Table 5.3 – Continued

	CWQG (FAL)	MMER	Portage Attenuation Pond				Vault Attenuation Pond	
			Stormwater Pond		Mixed Pond Untreated			
			Year 1	Year 3	Year 6	Year 10	Year 5	Year 10
Manganese			0.19	0.35	3.3	79	0.16	0.24
Molybdenum	**0.073**		0.002	0.004	**0.07**	0.066	0.015	0.021
Sodium			2.3	3.6	560	350	1.5	1.3
Nickel[6]	**0.025 - 0.15**	**0.5**	0.024	**0.46**	**1.14**	**2.4**	0.0005	0.0006
Lead[6]	**0.001 - 0.007**	**0.2**	**0.001**	**0.0015**	**0.0084**	**0.016**	0.0006	0.0006
Antimony			0.0014	0.0023	0.018	0.020	0.0054	0.0078
Selenium	**0.001**		0.0009	0.0006	**0.009**	**0.01**	0.0008	**0.0010**
Zinc	**0.03**	**0.5**	**0.11**	**0.18**	**0.67**	**1.4**	0.004	0.006

Note: 1: CWQG Freshwater Guidelines are based on total metal concentrations, except for aluminum (dissolved aluminum criteria); cadmium guideline shown is US EPA. **2:** Freshwater Aquatic Life Guideline listed for inorganic fluorides. **3.** Freshwater Aquatic Life Guideline stipulates that concentrations that stimulate weed growth should be avoided. **4.** Freshwater Aquatic Life Guideline is pH dependent. Based on the baseline pH values of each of the lakes (6.8 for Third Portage Lake, 7.5 for Second Portage Lake, and 7.3 for Wally Lake), only post-construction Vault IV porewater aluminum concentrations are in exceedance of the Freshwater Aquatic Life Guideline. However, long-term kinetic testing suggests that lake pH values could drop to 6.0, in which case porewater aluminum concentrations for all rock types would be in exceedance of the Freshwater Aquatic Life Guideline. **4.** Freshwater Aquatic Life Guideline for chromium depends on valence of chromium ion (Cr(III) = 0.0089 mg/L, Cr(VI) = 0.001 mg/L). **5.** Freshwater Aquatic Life Guideline is hardness dependent.

Mitigation

Mitigation to reduce water quality contaminants in the Portage Attenuation Pond include:

- diversion of non-contact water
- separation of the tailings pond from the Attenuation Pond for as long as feasibly possible (to Year 5)
- recirculation of tailings decant water in Years 1 through 4 to reduce the volume of impacted water requiring treatment or discharge
- recirculation of mixed attenuation pond water from Years 5 through 10 to reduce the volume of impacted water requiring treatment or discharge.

Mitigation to minimize water quality impacts at the individual mine components that direct their effluent sources to the Portage Attenuation Pond include the following:

- For Portage area pits:

  diversion of clean non contact water away from pits and mine operation areas to reduce the volume of impacted water

  best management practices for explosives, and use of appropriate sized charges, and selection of explosives utilized

  dust control on haul roads and surrounding areas (see Air Monitoring Plan)

  minimizing contact time of water within the pits

  maintenance of equipment and adherence to and implementation of the spills and Contingency Plan, Emergency Response Plan, and Accidents and Malfunctions Plan as required

  implementation of sediment control practices and structures to reduce levels of TSS and turbidity in mine water

  monitoring mine water quality within the mine footprint to validate predictions.

- For Portage Rock Storage Facility:

  post-closure capping of Portage waste rock pile with low metal leaching and low ARD potential rock

  promotion of freezing in the Rock Storage Facility to reduce potential for generation of metals and acidic drainage.

- For the Tailings Storage Facility:

  destruction of cyanide residues in the mill effluent using INCO SO2/Air treatment, prior to discharge of tailings to the storage facility

  progressive capping of the potentially acid generating (PAG) tailings with ultramafic (UM) rock, which has a negligible potential to generate acidic drainage, acid buffering capacity and a relatively low potential for metal leaching

  progressive capping to reduce runoff contact with tailings, and erosion of tailings from runoff water eventual freezing of the tailings to the base of the cover material

recirculation of tailings decant water to reduce the volume of impacted water requiring treatment or discharge

submerged placement of tailings for the first three years of operation

diversion of clean no contact water or site impact water away from the tailings storage facility.

5.3.3 Impacts of Effluent Discharges from the Portage Attenuation Pond during Operations

Activity

The main effluent source that will be discharged from the Meadowbank project will be from the Portage Attenuation Pond to the North Basin of Third Portage Lake. Effluent will be discharged to Third Portage Lake via an 18" HDPE pipe. The end of discharge pipe will have a diffuser to maximize dilution of effluent into the receiving environment. Effluent will be discharged to the receiving environment only during open water season, between early July and mid- to late-October. Effluent will not be discharged under ice.

Before Year 5, the Portage Attenuation Pond will function independently of the Tailings Storage Facility. Therefore, effluent discharged to North Basin Third Portage Lake consists of a mixture of contact water collected from the rock storage pile, a small ore stockpile, three open pits, and water from the Portage mine area for the first five years of operations. During this period, mine effluent is not expected to contain contaminants or other constituents that exceed MMER water quality concentrations, and no water treatment plant is planned. Maximum predicted effluent values that will be discharged in Years 1 and 3 are shown on Table 5.3.

After year 5 tailings reclaim water (including all grey water and sewage effluent from the plantsite and camp) is mixed with the attenuation pond water as the two facilities are merged. Effluent will require treatment prior to release to Third Portage Lake. Initial achievable levels of treatment have been estimated for selected metals of environmental interest based on preliminary treatment evaluations. The Portage water treatment will consist of the following:

- Ferric sulphate and lime addition in a reactor clarifier or HDS-type system, along with flocculent to aid in clarification. Ferric sulphate added as both a coagulant, to assist with arsenic removal, and to precipitate some ferrocyanide complexes, which would reduce both cyanide and iron. Lime added to adjust pH to further reduce metals, namely copper, nickel, lead and zinc.
- Direct filtration in a sand filter to remove remaining particulate.
- Final pH adjustment with CO_2 or acid to meet permit limits and reduce NH_3 toxicity if it is an issue.

Table 5.4 indicates typical monthly average treatment levels that are considered achievable. Table 5.4 also includes predicted maximum concentrations of various parameters in untreated effluent and the applicable Metal Mining Effluent Regulations (MMER) (DFO 2002) for comparative purposes. The estimated achievable level of treatment will result in maximum untreated concentrations being reduced for arsenic, copper, cadmium, chromium, cyanide, manganese, nickel, lead, selenium and zinc. Parameters other than those noted will discharge at the maximum predicted effluent concentrations presented in Table 5.3 for Years 6 and 10.

Effluent treatment levels shown in Table 5.4 are considered preliminary, pending further analysis of water treatment options for the project, such as pilot plant studies to determine actual treatment efficiencies. They are not indicative of day-to-day treatment levels, which can vary by a factor of three or more, depending on concentrations in the untreated feed. As a result, these values should not be considered as targets for a future water licence application for the site. These values are, however, considered appropriate for predicting whole lake average concentrations in the lakes, which will depend primarily on average loadings associated with water releases and dike leaching.

Table 5.4: Predicted Maximum Concentrations of Selected Parameters in Portage Effluent, MMER Limits & Estimated Treatment Levels

Parameter	Units	Predicted Maximum Concentration in Untreated Effluent [1]	MMER Limits[2]	Estimated Achievable Treatment Level[3]
Total Suspended Solids	mg/L		15	
Total Cyanide	mg/L	0.263	1.0	
Arsenic	mg/L	0.1	0.50	0.02
Copper	mg/L	20.3	0.30	0.08
Nickel	mg/L	3.42	0.50	0.01
Cadmium	mg/L	0.008		0.001
Chromium	mg/L	0.2		0.01
Lead	mg/L	0.021	0.2	0.001
Selenium	mg/L	0.014		0.005
Manganese	mg/L	10.8		0.1
Zinc	mg/L	1.7	0.50	0.01

Notes: 1: Based on results of site water quality predictions using the GoldSim model (Table A.1; Appendix A). **2:** Metal Mining Effluent Regulations (DFO, 2002). Values shown are maximum monthly averages. **3:** Based on initial evaluation of achievable treatment levels using predicted Year 10 Portage effluent quality data.

Instantaneous annual discharge to Third Portage Lake North Basin is predicted to be 0.13 m^3/s in Year 1, 0.15 m^3/s in Year 3, 0.18 m^3/s in Year 5 and 0.22 m^3/s in Year 11 of mine life. Maximum annual average discharge in Year 11 is 2.13 million m^3, which is 2.5% of the volume of the North Basin of Third Portage Lake or 1.6% of the combined volume of the North and East basins. Water moving into the East Basin from the South Basin will further dilute the effluent before entering the East Basin, and eventually Second Portage Lake

Dissolved metals leached from exterior dike surfaces will add to metals concentrations from mine effluent discharged to the North Basin. Thus there is an additive impact in Third Portage East Basin and in Second Portage Lake from metals contributed by the various dikes.

Modeling of water quality was completed to make tentative predictions of whole lake temporal changes in water quality in Third and Second Portage Lakes over the mine life, assuming that all water quality parameters behaved conservatively in the lakes and are fully mixed. Predictions were undertaken for dissolved components excluding and including estimates for the potential contributions from the dikes using post-construction loading rates.

5.3.3.1 Third Portage Lake

Maximum whole lake average water quality prediction for Third Portage Lake are summarized in Table 5.5 for a range of mixing conditions, representing the east basin discharge location (40,000,000 m^3 volume), and a lower and upper mixing estimate for the north basin discharge location (92,000,000 and 169,000,000 m^3 volumes). The model includes treated water releases from the project, and long-term substance loading due to leaching from the Goose Island Dike. Whole lake average concentrations are influenced by the degree of assumed mixing in Third Portage Lake. Predicted substance concentrations in the lake vary by a factor of approximately two, depending on the degree of mixing assumed.

Maximum concentrations of five parameters (copper, cadmium, chromium, selenium and cyanide) are predicted to be above water quality guidelines for aquatic life in Third Portage Lake, and one parameter (manganese) is predicted to be above an aesthetic objective for drinking water supply.

With the exception of manganese, long-term loadings from dike material are substantially lower than those from water releases and represent only a minor contribution to changes in whole lake water quality. Manganese loading from dikes is 7.3 times higher than loadings from water releases. Elevated manganese concentrations in test leachates attest to the relative mobility of manganese from IF rock. Leaching of manganese was not considered to be affected by temperature or decreased sulphide oxidation rates; therefore, the kinetic test leaching rate was applied directly to submerged dikes. As such, the reported manganese concentrations represent possible maximum dike porewater concentrations.

Maximum predicted average copper concentrations in Third Portage Lake range from 0.006 to 0.014 mg/L, depending on the mixing scenario. These values are three to seven times higher than the aquatic life water quality guideline (0.002 mg/L) for copper. Effluent treatment will result in significant reductions in copper loadings to the lake.

Maximum concentrations of other metals (cadmium, chromium, selenium) are predicted to be above guidelines. Maximum predicted cadmium concentrations in Third Portage Lake vary from 0.00012 mg/L to 0.0002 mg/L, depending on the mixing assumptions. These values range from 1.1 to 1.2 times the hardness-dependent guideline value for cadmium (based on USEPA water quality criterion). Maximum predicted selenium concentrations are predicted to vary from 0.0013 to 0.0017 mg/L depending on mixing assumptions, which ranges from 1.3 to 1.7 times the CWQG of 0.001 mg/L.

Maximum predicted chromium concentrations range from 0.0016 mg/L to 0.0025 mg/L, depending on mixing assumptions. These values are well below the CWQG for trivalent chromium (0.0089 mg/L), but are 1.6 to 2.5 times higher than the CWQG for hexavalent chromium (0.001 mg/L). Geochemical conditions in the lakes are expected to favour the less toxic trivalent form of chromium.

Predicted maximum concentrations of manganese range from 0.01 to 0.132 mg/L, which ranges from below to 2.6 times higher than the aesthetic objective for this parameter (0.05 mg/L). Simulation results for the three mixing scenarios show that predicted maximum manganese concentrations are below the aesthetic objective when loadings from dikes are excluded for all three scenarios. These results confirm that predicted rates of loading from dikes contributes significantly to predicted manganese exceedances in Third Portage Lake.

Maximum predicted total cyanide concentrations range from 0.005 to 0.013 mg/L, which ranges from equal to the CWQG level (0.005 mg/L) to 2.7 times guidelines. The predicted maximum concentrations do not take into account natural degradation processes that will reduce cyanide concentrations in the lake. Cyanide is likely to undergo natural degradation in surface waters, thus reducing concentrations. That the breakdown of metal cyanide complexes would not increase the reported metal loading as these metals are already accounted for in the total metal loads. Modelling of the degradation of cyanide in Third Portage Lake would be required to determine if maximum predicted cyanide concentrations would decrease to below CWQG levels.

Table 5.5: Predicted Maximum Whole Lake Water Quality, Third Portage Lake

				Simulated Maximum Lake Concentration (mg/L)[3]							
	Expected Loadings (kg/yr)			Lower mixing estimate (40 Mm^3)		Mid-range mixing estimate (92 Mm^3)		Upper Mixing Estimate (169 Mm^3)		Water Quality Guideline Concentrations (mg/L)[1]	
Parameter	Water Releases[4]	Dike Leaching	Average Baseline Conc. (mg/L)[2]	Without Dike Leaching	With Dike Leaching			Without Dike Leaching	With Dike Leaching	Aquatic Life	Drinking Water Supply
Conventional Parameters											
Hardness	468730	0	5.3	59	63	39	43	27	30		
PH	n/a	n/a	6.8	n/a	n/a	n/a	n/a	N/a	n/a	6.5-8.5	
Dissolved Anions											
Total Alkalinity	91552	5765	4.0	14	14	10	11	8.0	8.3		
Chloride	53216	2913	0.5	6.2	6.4	4.2	4.4	2.9	3.1	230	250
Fluoride	1033	198	0.07	0.19	0.21	0.14	0.16	0.11	0.12		1.5
Sulphate	2475771	501	1.3	290	290	185	185	121	121		500.0
Nutrients											
Ammonia Nitrogen	1031	0	0.010	0.11	0.11	0.077	0.077	0.056	0.056	7.2	
Total Kjeldahl Nitrogen	n/a	n/a	0.09	n/a	n/a	n/a	n/a	N/a	n/a	n/a	n/a
Nitrate Nitrogen	1793	43	0.0040	0.17	0.18	0.12	0.12	0.085	0.087	2.9	10.0
Nitrite Nitrogen	n/a	n/a	0.0010	n/a	n/a	n/a	n/a	N/a	n/a		3.2
Total Phosphate-P	140	0.0	0.0020	0.016	0.016	0.010	0.010	0.0067	0.0067		
Total Phosphorus	422	10.2	n/a	0.052	0.053	0.032	0.033	0.021	0.021		
Organic Parameters											
Dissolved Organic Carbon	n/a	n/a	1.4	n/a	n/a	n/a	n/a	N/a	n/a		
Cyanides											
Total Cyanide	102	0	0.0000	**0.013**	**0.013**	**0.0080**	**0.0080**	**0.0051**	**0.0051**	0.005	0.2
Cyanate (CNO)	169769	n/a	0.5000	19	19	13	13	8.5	8.5		
Thiocyanate (SCN)	243468	n/a	0.5000	27	28	18	18	12	12		
Total Metals											
Aluminum	154	50	0.006	0.021	0.025	0.016	0.019	0.013	0.015	0.1	
Antimony	26	0.95	0.0005	0.0035	0.0035	0.0023	0.0024	0.0017	0.0017		

Table 5.5 – Continued

				Simulated Maximum Lake Concentration (mg/L)[3]							
	Expected Loadings (kg/yr)			Lower mixing estimate (40 Mm^3)		Mid-range mixing estimate (92 Mm^3)		Upper Mixing Estimate (169 Mm^3)		Water Quality Guideline Concentrations (mg/L)[1]	
Parameter	**Water Releases[4]**	**Dike Leaching**	**Average Baseline Conc. (mg/L)[2]**	**Without Dike Leaching**	**With Dike Leaching**			**Without Dike Leaching**	**With Dike Leaching**	**Aquatic Life**	**Drinking Water Supply**
Arsenic	31.2	0.0	0.0005	0.0038	0.0038	0.0027	0.0027	0.0019	0.0019	0.005	
Barium	14	53	0.02	0.02	0.02	0.02	0.02	0.02	0.02		
Beryllium	29	0.00	0.0010	0.0047	0.0047	0.0032	0.0032	0.0024	0.0024		
Boron	648	0.0	0.100	0.16	0.160	0.136	0.136	0.12	0.12		
Bismuth	3.7	0.00	0	0.0004	0.0004	0.0003	0.0003	0.0002	0.0002		
Cadmium	1.5	0.00	0.0001	**0.00021**	**0.00021**	**0.00015**	**0.00015**	**0.00012**	**0.00012**	0.00010 – 0.00017	0.005
Calcium	182772	9662	1.2	23	24.2	14.9	15.6	10	11		
Chromium	14	0.01	0.0010	**0.0025**	**0.0025**	**0.0019**	**0.0019**	**0.0016**	**0.0016**	0.001/0.0089	0.05
Cobalt	416	39	0.0003	0.057	0.0597	0.0334	0.0361	0.021	0.023		
Copper	116	0.0	0.001	**0.014**	**0.014**	**0.009**	**0.009**	**0.006**	**0.006**	0.002	1
Iron	22	10.0	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.3	0.3
Lead	1.9	0.1	0.0006	0.0007	0.0007	0.0006	0.0007	0.0006	0.0006	0.001	0.01
Lithium	39	0.0	0.0050	0.0083	0.0083	0.0071	0.0071	0.0064	0.0064		
Magnesium	37084	5703	0.5	5.1	5.5	3.3	3.7	2.3	2.6		
Manganese	190	1389	0.001	0.019	**0.132**	0.014	**0.108**	0.010	**0.080**		0.05
Mercury	0.156	0.056	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.001
Molybdenum	104.3	0.1	0.001	0.013	0.013	0.009	0.009	0.006	0.006	0.073	
Nickel	19.0	3.0	0.001	0.003	0.003	0.002	0.002	0.002	0.002	0.025	
Potassium	88335	3567	2.0	11.4	11.7	8.1	8.4	6.0	6.2		
Selenium	7.43	0.01	0.0010	**0.0017**	**0.0017**	**0.0014**	**0.0014**	**0.0013**	**0.0013**	0.001	0.01
Silver	0.385	0.016	0.00002	0.00006	0.00006	0.00005	0.00005	0.00004	0.00004	0.0001	
Silicon	5530	6459		0.67	1.19	0.42	0.85	0.27	0.59		
Sodium	575149	2252	2.0	65.0	65.2	43.3	43.4	29.1	29.2		
Strontium	1046	97		0.12	0.13	0.08	0.08	0.05	0.06		
Thallium	2.02	0.00	0.0002	0.0004	0.0004	0.0003	0.0003	0.0003	0.0003	0.0008	

Table 5.5 – Continued

Parameter	Expected Loadings (kg/yr)		Average Baseline Conc. (mg/L)[2]	Simulated Maximum Lake Concentration (mg/L)[3]						Water Quality Guideline Concentrations (mg/L)[1]	
				Lower mixing estimate (40 Mm³)		Mid-range mixing estimate (92 Mm³)		Upper Mixing Estimate (169 Mm³)			
	Water Releases[4]	Dike Leaching		Without Dike Leaching	With Dike Leaching			Without Dike Leaching	With Dike Leaching	Aquatic Life	Drinking Water Supply
Tin	n/a	n/a	0.0006	n/a	n/a	n/a	n/a	n/a	n/a		
Titanium	n/a	n/a	0.01	n/a	n/a	n/a	n/a	n/a	n/a		
Uranium	20.61	0.91	0.0002	0.0028	0.0028	0.0018	0.0018	0.0012	0.0012		0.02
Vanadium	24.5	1.1	0.03	0.03	0.03	0.03	0.03	0.03	0.03		
Zinc	19	2	0.005	0.006	0.006	0.006	0.006	0.005	0.006	0.03	5

Notes: 1. Canadian Water Quality Guidelines are used, except for aquatic life guidelines for chloride and cadmium, which are US EPA. **2.** Total metals. **3.** Dissolved metals.
4. Average loadings per year based on predicted data for the 10 years of operations. Concentrations of As, Cd, Cu, CN, Fe, Pb, Ni, Zn were set to achievable treatment levels (Table 3) where maximum concentrations exceeded treatment levels. Maximum predicted arsenic concentrations are predicted to vary from 0.003 to 0.029 mg/L, which ranges from less than the guideline to six times the guideline of 0.005 mg/L. Maximum predicted nickel concentrations are predicted to vary from 0.005 to 0.035 mg/L, which ranges from less than the guideline to 1.6 times the guideline of 0.025 mg/L.

5.3.3.2 Second Portage Lake

The Second Portage Lake water quality model includes substance loading from the Third Portage and East Dikes and inflow from Third Portage and Wally lakes.

The water released into Third Portage Lake (via lake outflow into Second Portage lake) dominates changes in water quality in Second Portage Lake, with the ouflow from Wally Lake and dike leaching having only a minor influence.

The lower and higher mixing scenarios (40,000,000 m^3 and 169,000,000 m^3 volumes) were carried forward in assessing additive impacts in Second Portage Lake to bracket predicted impacts. The effluent discharge from the Attenuation Pond has a smaller influence on changes in water quality in Second Portage Lake because the additional watershed inflow into Second Portage Lake provides for a greater level of dilution.

Changes in water quality in Second Portage Lake were modelled for two different mixing scenarios of water releases into Third Portage Lake (40,000,000 m^3 and 169,000,000 m^3 mixing volumes). These two scenarios bracket the range of predicted outflow quality from Third Portage Lake. Predicted changes in water quality in Second Portage Lake for these two scenarios are summarized in Table 5.6. The water release into Third Portage Lake has a lesser influence on changes in water quality in Second Portage Lake because the additional watershed inflow into Second Portage Lake provides for a greater level of dilution.

All parameters are predicted to remain below water quality guidelines in Second Portage Lake, with the exception of cadmium, chromium and copper. Predicted maximum concentrations of cadmium range from 0.00007 to 0.00011 mg/L, which ranges from below the hardness-dependent USEPA aquatic life criterion for this parameter to 1.1 times the guideline. Chromium concentrations are predicted to remain below the water quality guideline for the trivalent (Cr(III)) form of this metal. Using the more conservative aquatic life guideline for hexavalent chromium (0.001 mg/L), maximum predicted concentrations are a factor of 1.2 to 1.5 higher than the guideline. Predicted copper concentrations vary from 0.003 to 0.006 mg/L, which ranges from 1.5 to three times the guideline value of 0.002 mg/L.

Table 5.6: NEED NEW TABLE FROM EIS!!!!!! Predicted Maximum Whole Lake Water Quality, Second Portage Lake

	Expected Loadings (kg/yr)		Simulated Maximum Lake Concentration (mg/L)				Water Quality Guideline Concentrations (mg/L)[1]	
			Lower mixing estimate (40 Mm^3)		Upper Mixing Estimate (169 Mm^3)			
Parameter	Dike Leaching	Average Baseline Conc. (mg/L)[2]	Without Dike Leaching	With Dike Leaching	Without Dike Leaching	With Dike Leaching	Aquatic Life	Drinking Water Supply
Conventional Parameters								
Hardness	0	8.9	27.2	27.3	15.7	15.9		
PH	n/a	7.5	n/a	n/a	n/a	n/a	6.5-8.5	
Dissolved Anions								
Total Alkalinity	408	7.00	9.43	9.45	7.36	7.38		
Chloride	206	0.6	2.6	2.6	1.5	1.5	230	250
Fluoride	14	0.070	0.11	0.115	0.087	0.087		1.5
Sulphate	35	2.8	107.4	107.4	46.4	46.4		500.0
Nutrients								
Ammonia Nitrogen	0	0.020	0.051	0.051	0.033	0.033	7 2	
Total Kjeldahl Nitrogen	n/a	0.08	n/a	n/a	n/a	n/a	n/a	n/a
Nitrate Nitrogen	3	0.007	0.067	0.067	0.036	0.036	2.9	10.0
Nitrite Nitrogen		0.0010						3.2
Total Phosphate-P	0.0	0.0030	0.0058	0.0058	0.0025	0.0025		
Total Phosphorus	0.7		0.019	0.019	0.0076	0.0077		
Organic Parameters								
Dissolved Organic Carbon	n/a	1.7	n/a	n/a	n/a	n/a		
Cyanides								
Total Cyanide	0	0.000	0.005	0.005	0.002	0.002	0.005	0.2
Cyanate (CNO)	0	0.50	7.35	7.35	3.47	3.47		
Thiocyanate (SCN)	0	0.50	10.11	10.11	4.75	4.75		
Total Metals								
Aluminum	4	0.007	0.012	0.012	0.009	0.009	0.1	
Antimony	0.07	0.0005	0.0016	0.0016	0.0009	0.0009		
Arsenic	0.0	0.0005	0.0017	0.0017	0.0010	0.0010	0.005	0.0250
Barium	3.7	0.02	0.02	0.02	0.02	0.02		
Beryllium	0.00	0.0010	0.0023	0.0023	0.0015	0.0015		
Boron	0.0	0.1	0.1	0.1	0.1	0.1		

Table 5.6 – Continued

Parameter	Expected Loadings (kg/yr)		Simulated Maximum Lake Concentration (mg/L): Lower mixing estimate (40 Mm^3)		Upper Mixing Estimate (169 Mm^3)		Water Quality Guideline Concentrations (mg/L)[1]	
	Dike Leaching	Average Baseline Conc. (mg/L)[2]	Without Dike Leaching	With Dike Leaching	Without Dike Leaching	With Dike Leaching	Aquatic Life	Drinking Water Supply
Bismuth	0.00	0	0.0001	0.0001	0.0001	0.0001		
Cadmium	0.00	0.00005	**0.00011**	**0.00011**	**0.00007**	**0.00007**	0.00006 – 0.000097	0.005
Calcium	684	2.3	9.9	10.0	5.2	5.2		
Chromium	0.00	0.0010	**0.0015**	**0.0015**	0.0012	0.0012	0.001	0.05
Cobalt	2.79	0.0003	0.0206	0.0207	0.0080	0.0081		
Copper	0.0	0.0010	**0.0058**	**0.0058**	**0.0030**	**0.0030**	0.002	1
Iron	0.7	0.03	0.03	0.03	0.03	0.03	0.3	0.3
Lead	0.0	0.001	0.001	0.001	0.0010	0.0010	0.001	0.01
Lithium	0.0	0.0050	0.0062	0.0062	0.0055	0.0055		
Magnesium	404	0.8	2.3	2.4	1.3	1.4		
Manganese	98	0.0016	0.0079	0.0117	0.0047	0.0084		0.05
Mercury	0.004	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.001
Molybdenum	0.0	0.0010	0.0053	0.0053	0.0028	0.0028	0.073	
Nickel	0.2	0.001	0.002	0.002	0.001	0.001	0.025	
Potassium	253	2.0	5.4	5.4	3.5	3.5		
Selenium	0.00	0.001	0.001	0.001	0.001	0.001	0.001	0.01
Silver	0.001		0.00002	0.00002	0.00001	0.00001	0.0001	
Silicon	458	0	0.24	0.26	0.10	0.12		
Strontium	160		23.8	23.8	10.8	10.8		
Sodium	7	2.00	2.00	2.00	2.00	2.00		
Thallium	0.00	0.0002	0.0003	0.0003	0.0002	0.0002	0.0008	
Tin	n/a	0.0005	n/a	n/a	n/a	n/a		
Titanium	n/a	0.01	n/a	n/a	n/a	n/a		
Uranium	0.06	0.0002	0.0011	0.0011	0.0006	0.0006		0.02
Vanadium	0.1	0.03	0.03	0.03	0.03	0.03		
Zinc	0	0.005	0.005	0.005	0.005	0.005	0.03	5

Note: 1. Canadian Water Quality Guidelines are used, except for aquatic life guidelines for chloride and cadmium, which are US EPA. **2.** ..

Mitigation

Following are the major mitigative measures being implemented at Meadowbank to minimize impacts to water quality in the receiving environments of Third Portage and Second Portage Lakes:

- Isolation of the northwest arm of Second Portage Lake to function as an attenuation pond (Year 0 – 5) will reduce suspended solids, nutrient and metals concentrations in effluent prior to discharge to Third Portage Lake. No tailings water will b released to the lake during this period
- After Year 5, when the tailings storage facility and Portage Attenuation Pond are merged, effluent will be treated prior to release to Third Portage Lake.
- Effluent will only be discharged during the open water season.
- Effluent quality will meet or exceed all criteria stipulated under the MMER.
- A diffuser will be installed in deep water, offshore to maximize effluent dilution.
- Additional mitigation measures have been applied to the mine components that act as sources for the Attenuation Pond effluent, prior to treatment.

Residual Effect & Significance of Effluent Discharges from the Portage Attenuation Pond During Operations

Prior to Year 5, effluent will consist of contact water from roads, ditches, pit water, mill site water and runoff from the Portage/Goose waste rock pile. Given the small annual volume relative to receiving environment volume (maximum 1.6% prior to Year 5) and the relatively uncontaminated nature of the effluent, impacts to water quality in Third Portage Lake are expected to be *low* in magnitude, *local* in spatial extent, *medium-term* in duration, and occur *frequently*. The significance of the residual impacts is *low.*

Certainty of the prediction is considered *low.* Although the assumptions used in the predictions are considered conservative, the analyses of lake impacts were conducted for average whole lake values only, and did not address areas of relatively higher impacts located near the effluent discharge points, or the subtle effects of lake circulation on water quality effects. More refined analyses will be conducted for the Final EIA to better define the spatial extent and magnitude of the impacts within Third and Second Portage Lakes.

After Year 5, the tailings storage facility will be combined with the Portage Attenuation Pond, such that tailings process water and tailings beach runoff will be added to the mix held within the Portage Attenuation Pond. The predicted quality of Attenuation Pond water over this period indicates that a water treatment facility will be required prior to release of the combined effluent to Third Portage Lake. The level of treatment has not been finalized, but initial estimates indicate that treatment will result in reduced concentrations for arsenic, copper, cadmium, chromium, cyanide, manganese, nickel, lead selenium and zinc.

Whole lake modeling of water quality in Third Portage Lake showed increases for five metals, with maximum average copper predicted to 7 times above water quality guideline for the protection of aquatic life. Other metals were predicted to be less than twice the guidelines, and cyanide was predicted to be 2.7 times the guidelines. Therefore, residual effects are *medium* in magnitude, *local* in extent, *medium-term* in duration and occur *frequently*. Although no discharge occurs under the ice, impaired water quality may persist through the fall and early winter. The significance of residual impacts is *high*. Certainty of this prediction is considered low. There is some uncertainty with respect to treatment levels. In addition *the analyses* of lake impacts were conducted for average whole lake values only, and did not address areas of relatively higher impacts located near the effluent discharge points, or the subtle effects of lake circulation on water quality effects. More refined analyses will be conducted for the Final EIA to better define the spatial extent and magnitude of the impacts within Third and Second Portage Lakes.

All parameters are predicted to remain below water quality guidelines in Second Portage Lake, with the exception of cadmium, chromium and copper. These parameters are predicted to marginally above the guidelines. Therefore, residual effects are *medium* in magnitude, *local* in extent, *medium-term* in duration and occur *infrequently*. The significance of residual impacts is *medium*. Certainty of this prediction is *low* for the reasons noted above.

Summary of Residual Effects – Third Portage Lake

	Magnitude	Spatial Extent	Duration	Frequency/Timing	Significance
Water Quality < Year 5	Low	Local	Medium-term	Frequent	Low
Water Quality > Year 5	Medium	Local	Medium-term	Frequent	Medium

Summary of Residual Effects – Second Portage Lake

	Magnitude	Spatial Extent	Duration	Frequency/Timing	Significance
Water Quality < Year 5	Low	Local	Medium-term	Frequent	Low
Water Quality > Year 5	Medium	Local	Medium-term	Infrequent	Medium

5.3.4 Impacts on Mine Sources on Vault Attenuation Pond Water Quality

Maximum predicted concentrations in the Vault Attenuation Pond for Years 5 and 10 are provided on Table 5.3.

The concentration of dissolved constituents in all drainage water from the Vault area, including the Vault attenuation pond, and consequently, effluent to Wally Lake, are predicted to comply with MMER throughout operations. Some exceedances of CWQG are predicted for a limited number of constituents (arsenic, cadmium, lead and selenium) in effluent to Wally Lake, although the lake mixing study suggests that discharge of Vault effluent without further treatment may be possible depending on the initial mixing properties of effluent in Wally Lake.

The additional load provided by assuming a maximum allowable total suspended solids discharge of 15 mg/L, with a makeup similar to the solids makeup of the Vault Rock Storage Facility, will increase constituent concentrations in effluent, but the resulting water quality is predicted to still meet MMER discharge criteria.

Mitigation

Mitigation to reduce water quality contaminants in the Vault Attenuation Pond include:

- Diversion of clean no contact water or site impact water away from the Attenuation Pond.

Mitigation to impacts to the mine components that direct their effluent to the Vault Attenuation Pond include the following:

For Vault Pit:

- Diversion of clean non contact water away from pits and mine operation areas to reduce the volume of impacted water;
- Best management practices for explosives, and use of appropriate sized charges, and selection of explosives utilized;
- Dust control on haul roads and surrounding areas (see Air Monitoring Plan)
- Minimizing contact time of water within the pits;
- Maintenance of equipment and adherence to and implementation of the Spills and Contingency Plan, Emergency Response Plan, and Accidents and Malfunctions Plan as required;
- Implementation of sediment control practices and structures to reduce levels of TSS and turbidity in mine water); and
- Monitoring mine water quality within the mine footprint to validate predictions.

For Vault Rock Storage Facility

- Direct non-contact water away from Rock Storage Facility.

5.3.5 Impacts of Effluent Discharge from the Vault Attenuation Pond

Activity

The second main effluent source that will be discharged to Meadowbank project area aquatic receiving environments is from the Vault attenuation pond to Wally Lake.

Effluent will be discharged to Wally Lake via an 18” HDPE pipe. The pipe will be anchored along the bottom and the end of pipe will be situated at least 50 m away from coarse shoreline substrate or shoal habitat in at least 10 m of water. The end of pipe will have a diffuser to maximize dilution of effluent into the receiving environment.

Because effluent source to the Vault attenuation pond are simply waste rock seepage and runoff, dike seepage and pit water, no exceedances of MMER criteria are anticipated and no water treatment plant will be required. Routine monitoring will be conducted to ensure compliance.

Effluent will be discharged to the receiving environment only during open water season, between early July and mid- to late-October; effluent will not be discharged under ice. The total annual and monthly volumes of effluent discharged to Wally Lake have been estimated.. Instantaneous effluent volume discharge to Wally Lake, with the exception of dewatering, is consistent over mine life and averages 0.08 m^3/s . The total average annual discharge is approximately 391,500 m^3, which is equivalent to 1.4% of the volume of the receiving environment.

Preliminary modeling of whole lake water quality in the receiving environment water bodies. The Wally Lake model incorporates long-term loadings from the Vault Dike and effluent releases from the Vault Attenuation pond. Maximum predicted whole lake concentrations are shown on Table 5-7. Predicted changes in water quality in Wally Lake are generally less than in Third Portage and Second Portage Lakes because no tailings water will be released to Wally Lake and the length of Vault Dike is shorter than the Goose Island and Third Portage dikes.

With the exception of arsenic and cadmium, maximum concentrations of all substances are predicted to remain below guidelines in Wally Lake. Maximum predicted arsenic concentrations range from 0.005 to 0.006 mg/L, which is equal to the guideline (0.005 mg/L) to 1.2 times the guideline. The maximum predicted concentration of cadmium is 0.00019 mg/L, which is 2.7 times the USEPA criterion for this parameter.

Table 5.7: Predicted Maximum Whole Lake Water Quality, Wally Lake

Parameter	Expected Loadings (kg/yr)		Average Baseline Conc. (mg/L)[2]	Simulated Maximum Lake Concentration (mg/L)		Water Quality Guideline Concentrations (mg/L)[1]	
	Water Releases	Dike Leaching		Without Dike Leaching	With Dike Leaching	Aquatic Life	Drinking Water Supply
Conventional Parameters							
Hardness	6423	0	17.2	17.2	17.2		
pH	n/a	n/a	7.3	n/a	n/a	6.5-8.5	
Dissolved Anions							
Total Alkalinity	11394	1550	13.00	13.24	13.34		
Chloride	436	17	0.7	0.7	0.7	230	250
Fluoride	30	1	0.05	0.05	0.05		1.5
Sulphate	2408	1	5.3	5.3	5.3		500.0
Nutrients						Nutrients	
Ammonia Nitrogen	776	0	0.0200	0.0890	0.0890	7	
Total Kjeldahl Nitrogen	n/a	n/a	0.11	n/a	n/a	n/a	n/a
Nitrate Nitrogen	879	1	0.0240	0.1020	0.1020	2.9	10.0
Nitrite Nitrogen			0.0010				3.2
Total Phosphate-P	1.8	0.00	0.0030	0.0030	0.0030		
Total Phosphorus	9.0	2.2	0.0030	0.0039	0.0040		
Organic Parameters						Organic Parameters	
Dissolved Organic Carbon	n/a	n/a	2.2	n/a	n/a		
Cyanides						Cyanides	
Total Cyanide	0	0	0.000	0.000	0.000	0.005	0.2
Total Metals							
Aluminum	45	4	0.008	0.012	0.013	0.1	
Antimony	3.32	0.21	0.0005	0.0009	0.0009		
Arsenic	15.1	0.03	0.0005	0.005	**0.006**	0.005	
Barium	9.7	0.3	0.02	0.02	0.02		
Beryllium	0.23	0.00	0.0010	0.0010	0.0010		
Boron	22.9	0.0	0.100	0.100	0.100		
Bismuth	0.00	0.00	0	0.0000	0.0000		
Cadmium	0.73	0.00	0.00005	**0.00018**	**0.00019**	0.00007	0.005
Calcium	3782	497	4.6	4.7	4.7		
Chromium	0.40	0.00	0.0010	0.0010	0.0010	0.001/0.0089	0.05
Cobalt	0.10	0.00	0.0003	0.0003	0.0003		
Copper	0.4	0.0	0.002	0.002	0.002	0.002	1

Parameter	Expected Loadings (kg/yr)		Average Baseline Conc. (mg/L)[2]	Simulated Maximum Lake Concentration (mg/L)		Water Quality Guideline Concentrations (mg/L)[1]	
	Water Releases	Dike Leaching		Without Dike Leaching	With Dike Leaching	Aquatic Life	Drinking Water Supply
Iron	2.4	0.0	0.03	0.03	0.03	0.3	0.3
Lead	0.7	0.0	0.0007	0.0007	0.0007	0.001	0.01
Lithium	1.1	0.0	0.0050	0.0050	0.0050		
Magnesium	851	84	1.3	1.3	1.3		
Manganese	10	1	0.001	0.002	0.002		0.05
Mercury	0.028	0.001	0.0001	0.0001	0.0001	0.0001	0.001
Molybdenum	9.1	0.6	0.001	0.002	0.002	0.073	
Nickel	0.4	0.0	0.0010	0.0010	0.0010		
Potassium	637	43	2.0	2.0	2.0	0.025	
Selenium	0.57	0.00	0.0010	0.0010	0.0010		
Silver	0.008	0.0002	0.00002	0.00002	0.00002	0.001	0.01
Silicon	298	73	0	0.04	0.04	0.0001	
Sodium	908	38	2.0	2.0	2.0		
Strontium	38	2	0	0.00	0.00		
Thallium	0.05	0.00	0.0002	0.0002	0.0002		
Tin	n/a	n/a	0.0005	n/a	n/a	0.0008	
Titanium	n/a	n/a	0.01	n/a	n/a		
Uranium	4.01	0.25	0.0002	0.0007	0.0007		
Vanadium	7.2	0.0	0.03	0.03	0.03		0.02
Zinc	3	0	0.013	0.013	0.013		

Note: 1. Canadian Water Quality Guidelines are used, except for aquatic life guidelines for chloride and cadmium, which are US EPA.

Mitigation

Following are the major mitigative measures being implemented at Meadowbank to minimize impacts to water quality in the receiving environment of Wally Lake:

- Isolation of a portion of Vault Lake to function as an attenuation pond and reduce suspended solids, nitrogen specie and metals concentrations in effluent prior to discharge to Wally Lake.
- Effluent will only be discharged during the open water season.
- Effluent quality will meet or exceed all criteria stipulated under the MMER.
- A diffuser will be installed in deep water, offshore to maximize effluent dilution.

Residual Effect & Significance of Vault Effluent Discharge

The volume of effluent discharged from the Vault attenuation pond to Wally Lake is small (0.08 m3/s) and constitutes a small portion of the receiving environment volume of Wally Lake (1.4% annually). Furthermore, effluent is uncontaminated by mine-related facilities, with the exception of the Vault waste rock tailings facility, and is predicted to have only minor exceedances of water quality guidelines for the protection of aquatic life for copper, cadmium and chromium.. Residual impacts to water quality metals, TSS and nutrients in Wally Lake are *medium* in magnitude, *local* in spatial extent, *medium-term* in duration, and occur in*frequently*. The significance of residual impacts is *medium*. Certainty of this prediction is *moderate*.

Summary of Residual Effects – Vault Effluent					
	Magnitude	**Spatial Extent**	**Duration**	**Frequency/Timing**	**Significance**
Water Quality	Medium	Local	Medium-term	Infrequent	Medium

5.4 MINE ABANDONMENT &CLOSURE

5.4.1 Impacts of Temporary or Indefinite Shutdown

Temporary Shutdown is defined as a cessation of mining and processing operations fro 3 to 12 months. The intention is that the mine will resume operations as soon as possible after the cause for the temporary shutdown has been removed. Possible causes for a temporary shutdown include a major mechanical equipment failure, later delivery of critical equipment or supplies, or labour conflict.

Indefinite Shutdown is defined as a cessation of mining and processing operations for an indefinite period of time greater than 12 months. The intention is that the mine will resume operations as soon as possible after the cause for the indefinite shutdown has been removed. Possible causes for an indefinite shutdown include prolonged adverse economic conditions or extended labour disputes.

In both cases, the mine site and Baker Lake staging facilities would be placed on a care and maintenance basis. . At the minesite, this would essentially be similar to operations, other than the rock storage facilities would remain static in size, the mill would not be operating, discharge of tailings would cease, and the number of staff on site, with related volumes of sewage, refuse and grey water would decrease. As such, effluent quality from the rock storage facilities, pits and dikes would remain similar to those predicted for operations. Effluent quality from the tailings storage facility and plant site would improve over levels predicted during operations. Therefore, the expectation is that the effluent discharge from the Portage Attenuation Pond would be slightly reduced in volume and would improve substantially in quality. The effluent discharge from the Vault Attenuation Pond would remain similar to that predicted during operations.

5.4.2 Impacts of Rock Storage Facility at Closure & Post-Closure

Activity & Mitigation

At the end of mine life it is expected that a cover of acid buffering waste rock will be placed on the surface and edges of the Portage waste rock stockpile to provide a long-term source of alkalinity and develop an active layer within the waste rock that is the most environmentally benign. Ultramafic rock will be used to cover the Portage Rock Storage Facility. The material will be placed to a nominal thickness of 2 m or greater, which roughly coincides with the predicted active layer thickness within the rock pile. The actual required thickness of cover material will be determined through thermal monitoring of the waste pile during operations (adaptive management). The active layer will therefore remain within the cover materials, while the material within the rock pile will remain frozen. This will limit the potential for the generation of acidic drainage and metal leaching from the pile. Predictions suggest that post-closure water quality could exceed MMER criteria for As, as a result of leaching of the cover material. Other metals that may exceed CWQG in the waste rock seepage and runoff include cadmium, chromium, mercury and selenium. This analysis is in the process of being refined on the basis of ongoing field and laboratory kinetic test results.

Water quality predictions indicate that an equivalent cover is not required at the Vault waste rock pile. As the configuration of the Vault rock stockpile area does not change after closure, constituent concentrations pots-closure are essentially the same as those of Year 10. All constituents in the Vault waste rock seepage and runoff are predicted to meet MMER criteria. Some metals may exceed water quality guidelines (aluminum, arsenic, cadmium and selenium.

Predicted water quality at year 25, 15 years after the end of mining, for the Portage and Vault Waste Rock Storage Facilities are shown in Table 5.8.

Runoff from the Rock Storage Facilities are to continue to be directed to the associated attenuation ponds until the water quality is of acceptable quality to discharge to the receiving environment.

Table 5.8: Predicted Maximum Concentrations for Waste Rock Storage Facilities - Year 25

	CWQG Criteria	MMER Criteria	Portage Waste Rock	Vault Waste Rock
pH	**6.5 - 9.0**	**6.0 - 9.5**	7.5	8.0
Alkalinity			16	37
Sulphate			3.1	6.4
Cyanide			na	Na
Fluoride[2]	**0.12**		0.010	0.017
Nitrate-N[3]			0.049	0.029
Unionized AmmoniaNH3-N	**0.019**		0	0
Total Phosphorous			0.064	0.056
Metals				
Aluminum[4]	**0.1**		0.0075	**0.15**
Arsenic	**0.005**	**0.5**	**0.34**	**0.26**
Barium			0.012	0.030
Calcium			3.1	13
Cadmium	**0.00010 - 0.00017**		0.000092	0.00015
Cobalt			0.00049	0.00020
Chromium[5]	**0.001 / 0.0089**		0.00092	0.00099
Copper[6]	**0.002 - 0.004**	**0.3**	0.00030	0.0012
Iron	**0.3**		0.00050	0.0015
Mercury	**0.0001**		0.000092	0.000099
Potassium			1.0	1.1
Magnesium			1.3	2.1
Manganese			0.010	0.056
Molybdenum	**0.073**		0.00013	0.052
Sodium			1.0	0.98
Nickel[6]	**0.025 - 0.15**	**0.5**	0.0013	0.00099
Lead[6]	**0.001 - 0.007**	**0.2**	0.000018	0.000045
Antimony			0.025	0.019
Selenium	**0.001**		0.0018	0.0020
Zinc	**0.03**	**0.5**	0.0054	0.011

Note: 1: CWQG Freshwater Guidelines and Criteria are based on total metal concentrations, except for aluminum (dissolved aluminum criteria); cadmium guideline shown is US EPA. **2:** Freshwater Aquatic Life Guideline listed for inorganic fluorides. **3:** Freshwater Aquatic Life Guideline stipulates that concentrations that stimulate weed growth should be avoided. **4:** Freshwater Aquatic Life Guideline is pH dependent. Based on the baseline pH values of each of the lakes (6.8 for Third Portage Lake, 7.5 for Second Portage Lake, and 7.3 for Wally Lake), only post-construction Vault IV porewater aluminum concentrations are in exceedance of the Freshwater Aquatic Life Guideline. However, long-term kinetic testing suggests that lake pH values could drop to 6.0, in which case porewater aluminum concentrations for all rock types would be in exceedance of the Freshwater Aquatic Life Guideline. **5:** Freshwater Aquatic Life Guideline for chromium depends on valence of chromium ion (Cr(III) = 0.0089 mg/L, Cr(VI) = 0.001 mg/L). **6:** Freshwater Aquatic Life Guideline is hardness dependent. n/a = not analyzed

Residual Effect & Significance of Waste Rock Storage after Closure

Residual effects of the Portage waste rock storage facilities on waste rock seepage and runoff after closure will be *high* in magnitude due to potentially elevated arsenic, will remain contained within the mine *footprint*, of *long* duration, and will occur *frequently* over the *summer* months. Residual effects on waste rock seepage and runoff are of *medium* significance, since an elevated arsenic level may require continued management of the collection system to direct the runoff to the Portage Attenuation Pond. The certainty of this prediction is *low,* as conservative assumptions have been used to predicting the elevated arsenic values. Predictions of long-term runoff quality will be refined using additional field kinetic test data for the Final EIA. Predicted volumes of runoff will be reassessed, such that an assessment can be made of the potential impacts to the receiving environment should the runoff be allowed to discharge in an uncontrolled manner.

Residual effects of the Vault waste rock storage facilities on waste rock seepage and runoff after closure will be *medium to high* in magnitude, remain contained within the mine *footprint*, of *long* duration, and will occur *frequently* over the *summer* months. Residual effects on waste rock seepage and runoff are of *medium* significance. The certainty of this prediction is again *low,* and will be refined using additional field kinetic test data for the Final EIA.

Summary of Residual Effects –Post-Closure					
	Magnitude	**Spatial Extent**	**Duration**	**Frequency/Timing**	**Significance**
Portage Waste Rock	High	Footprint	Permanent	Frequent/Summer	Medium
Vault Waste Rock	High	Footprint	Permanent	Frequent/Summer	Medium

5.4.3 Impact of the Pits Re-flooding at Closure

Activity

During the closure period, the Goose Island and Portage open pits will be flooded over a period of about five years. The pit lake water levels will eventually equilibrate with the adjacent lake elevations. Instantaneous breaching of the dike would cause a significant drawdown of Third Portage Lake. Such a drawdown would have a significant impact on fish habitat and would be unacceptable. Therefore, rapid flooding of the open pits by instantaneous breaching of the Goose Island dike will not be acceptable. Flooding will be through a combination of seepage, precipitation and some re-direction of spring freshet flows from Third Portage Lake. The control of the rate of flooding will be through the incorporation of engineered structures into the detailed design of the dikes, which could eventually involve spillway structures, side decant structures, or other engineering designs.

The Vault Pit will be flooded during the closure period over a period of about six years, and will be come part of Vault Lake. The dike between Vault Lake and Wally Lake will be removed. In the same manner as for the Portage open pits, the dike will only be completely removed when it is acceptable for water in the Vault pit lake to mix with Wally Lake. The rate of flooding will be determined by the rate of groundwater seepage, the surface runoff that can be directed into the pit, and by the amount of water that can be directed from Wally Lake during the spring freshet.

Post-closure Portage pit lake quality predictions are presented in Table 5.9. Considering the conceptual nature of the mine closure plan at this stage of the project, the water quality predictions for post-closure pit lake water represent order-of-magnitude conditions, once the pits have completely flooded and are connected to Third Portage Lake. The predicted pH of the post-closure pit lake is 7.0. Concentrations in lake water are predicted to meet MMER for all constituents, and meet CCME criteria for all but cadmium, copper and zinc at steady state. The concentrations of these constituents are modeled to be of the same order of magnitude as their respective water quality criteria.

The flooded Vault Pit water merges with that of the Vault attenuation pond to become one water body, in the location of the former Vault Lake. This is anticipated to occur after about 6 years. Post-closure pit lake or attenuation pond water quality predictions are presented in Table 5.9.

Table 5.9: Predicted Maximum Concentrations for Portage Pit Lake, Portage & Vault Attenuation Ponds - Year 25

	CWQG Criteria	MMER Criteria	Portage Pit Lake	Portage Attenuation Pond	Vault Attenuation Pond
pH	**6.5 - 9.0**	**6.0 - 9.5**	7.0	7.0	7.5
Alkalinity			6.70	9.50	0.14
Sulphate			5.6	2.4	4.1
Cyanide			na	0	0
Fluoride[2]	**0.12**		0.066	0.042	0.042
Nitrate-N[3]			0.0044	0.023	0.011
Unionized AmmoniaNH3-N	**0.019**		na	0	0.000083
Total Phosphorous			0.009	0.028	0.0087
Metals					
Aluminum[4]	**0.1**		0.0098	0.005	0.036
Arsenic	**0.005**	**0.5**	0.0013	**0.17**	**0.047**
Barium			0.015	0.011	0.013
Calcium			3.8	2.5	4.9
Cadmium	**0.00010 - 0.00017**		0.000049	0.000058	0.0013
Cobalt			0.001	0.00032	0.00015
Chromium[5]	**0.001 / 0.0089**		0.00056	0.00071	0.00056
Copper[6]	**0.002 - 0.004**	**0.3**	**0.0027**	0.00044	0.00059
Iron	**0.3**		0.21	0.01	0.012
Mercury	**0.0001**		0.000031	0.000058	0.000037
Potassium			1.4	1	0.95
Magnesium			1.7	0.97	1.2
Manganese			0.097	0.0061	0.01
Molybdenum	**0.073**		0.0012	0.00038	0.0094
Sodium			1.5	1.0	0.93
Nickel[6]	**0.025 - 0.15**	**0.5**	0.008	0.0009	0.00056
Lead[6]	**0.001 - 0.007**	**0.2**	0.00067	0.00017	0.00066
Antimony			0.001	0.012	0.0035
Selenium	**0.001**		0.00062	**0.0012**	0.00073
Zinc	**0.03**	**0.5**	**0.073**	0.0039	0.0039

Notes: 1: CWQG Freshwater Guidelines and Criteria are based on total metal concentrations, except for aluminum (dissolved aluminum criteria); cadmium guideline shown is US EPA. **2:** Freshwater Aquatic Life Guideline listed for inorganic fluorides. **3:** Freshwater Aquatic Life Guideline stipulates that concentrations that stimulate weed growth should be avoided. **4:** Freshwater Aquatic Life Guideline is pH dependent. Based on the baseline pH values of each of the lakes (6.8 for Third Portage Lake, 7.5 for Second Portage Lake, and 7.3 for Wally Lake), only post-construction Vault IV porewater aluminum concentrations are in exceedance of the Freshwater Aquatic Life Guideline. However, long-term kinetic testing suggests that lake pH values could drop to 6.0, in which case porewater aluminum concentrations for all rock types would be in exceedance of the Freshwater Aquatic Life Guideline. **5:** Freshwater Aquatic Life Guideline for chromium depends on valence of chromium ion (Cr(III) = 0.0089 mg/L, Cr(VI) = 0.001 mg/L). **6:** Freshwater Aquatic Life Guideline is hardness dependent.

Mitigation

Proposed mitigation at the Portage Pit location consists of filling the pits slowly over 5 summer seasons to minimize impacts to lake elevations as water is drawn from the lakes to fill the pits. Water quality in the flooding pits will be monitored and managed until the water quality is considered suitable for mixing with the adjacent lakes.

5.4.4 Impact to the Portage Attenuation Pond at Closure

Activity & Mitigation

Steady state post-closure effluent water quality from the Portage Attenuation pond is predicted to meet MMER. Predicted water quality in the Portage Attenuation Pond, post-closure, is presented in Table 5.9. Values are predicted to improve rapidly over operational water quality in approximately two years due to the reduction in tailings decant and runoff over the exposed tailings beach.

5.5 PERMAFROST ASSESSMENT CRITERIA

5.5.1 Introduction

The meanings of three terms, permafrost, active layer, and ground ice, are important to clarify when considering the permafrost VEC. Definitions taken from Everdingen (2002) are as follows:

Permafrost – Ground (soil or rock and included ice and organic material) that remains at or below 0 degrees Celsius for at least two consecutive years.

Active Layer – The layer of ground that is subject to annual thawing and freezing in areas underlain by permafrost.

Ground Ice – A general term referring to all types of ice contained in freezing and frozen ground.

The preservation and enhancement of permafrost is treated as a positive effect in this assessment. Conversely, the degradation of permafrost is considered a negative impact.

The following criteria were included for the permafrost VEC impact assessment. These appear as individual columns on the matrices (Appendix C).

- timing
- frequency
- duration
- spatial extent
- magnitude

- potential Impact Rating (applied before and after mitigation)
- probability.

The rating methodology used is qualitative and based on best engineering practices, professional judgement and references to other impact assessments for similar northern projects.

5.5.2 Timing & Frequency

Related definitions for frequency and timing terms are given below:

Timing	
All Year	The effect can occur at any month of the year
Winter	The effect occurs during the net freezing months (i.e., October to May)
Summer	The effect occurs during the net thawing months (i.e., June to September)
Frequency	
Continuous	Effect occurs continuously.
Frequent	Effect occurs very regularly (i.e., daily or weekly).
Infrequent	Effect occurs infrequently (i.e., monthly to yearly).
Rare	Effect occurs rarely (i.e., yearly or less frequently).

5.5.3 Duration

Duration relates to the period of time for construction, operation, closure, and post-closure. The development or degradation of permafrost during each of these phases has been evaluated based on the following criteria. :

Duration	
Permanent	Effect continues beyond the mine life
Medium-term	Effect occurs during the mine operation period
Short-term	Effect occurs during the mine construction period

5.5.4 Spatial Extent

Spatial extent is a measure of the area limits of a given impact. The related terms are defined as follows:

Spatial Extent	
Regional	Effect extends beyond the component considered but remains inside the mine footprint.
Local	Effect is restricted to the component being considered

5.5.5 Magnitude

Magnitude is a measure of the intensity or severity of the impact relative to baseline conditions. The related impact assessment terms for magnitude are defined below:

Magnitude (in comparison to the baseline conditions)	
Gain	Net increase in permafrost distribution and/or decrease in ground temperatures
Loss	Net decrease in permafrost distribution and/or increase in ground temperatures
Negligible	Minor and undifferentiated net gain or loss of permafrost

5.5.6 Rating of Unmitigated Effects

This column assesses the likely impact before applying any mitigative measures. The potential impact rating is qualitatively estimated using engineering / geoscience judgement and experience. The potential impacts were rated as High, Medium or Low and the definitions of these terms are as follows:

Potential Impact Rating Prior to Possible Mitigation / Monitoring	
High	The effect is difficult to predict, hence requires further field and engineering assessments during the next phase of study, likely followed by mitigation and/or monitoring to confirm the actual performance
Medium	The effect is understood and its potential extent bounded, hence limited need for further assessment; most emphasis on monitoring to confirm predictions
Low	The effect is well understood and bounded
Enhancement	The effect involves net gain in the distribution of the permafrost VEC, hence the effect is considered an enhancement.

5.5.7 Proposed Mitigation

Mitigative measures that have been incorporated into the mine design to reduce the unmitigated impacts are described in this column.

5.5.8 Influence of Mitigation on Effects Assessment

As indicated on the permafrost VEC matrices, many of the effects are positive enhancements. In these cases the influence of mitigation is not applicable, hence the acronym N/A is entered in this column. In other situations the negative effect of the permafrost impact is managed rather than mitigated. In these situations the word “none” is entered in this column.

5.5.9 Rating of Mitigated Effects (Residual Impacts)

This assessment follows the methodology described in sub-section 3.5.6 and indicates likely residual significant impacts after mitigative measures have been applied. In general, a rating of high in this column shows an impact of significance.

Potential Impact Rating Prior to Possible Mitigation / Monitoring	
High	The effect is difficult to predict, hence requires further field and engineering assessments during the next phase of study, likely followed by mitigation and/or monitoring to confirm the actual performance
Medium	The effect is understood and its potential extent bounded, hence limited need for further assessment; most emphasis on monitoring to confirm predictions
Low	The effect is well understood and bounded
Enhancement	The effect involves net gain in the distribution of the permafrost VEC, hence the effect is considered an enhancement.

5.5.10 Probability

This column assesses the probability or certainty for the unmitigated impact to occur. The related impact assessment terms are as follows:

Probability of the Unmitigated Effect	
Certain	The likelihood of the occurrence of the effect is estimated to be 100%.
High	The likelihood of the occurrence of the effect is estimated to be between 51% and 99%
Moderate	The likelihood of the occurrence of the effect is estimated to be between 1% and 50%
Improbable	The impact is not likely to occur.

5.5.11 Monitor / Maintain Description

In some cases monitoring is proposed to address impacts to permafrost. Details are provided in this column.

SECTION 6 • PERMAFROST IMPACT ASSESSMENT

6.1 Introduction

The permafrost VEC impact assessment is shown on matrices in Appendix C. As stated, the majority of impacts result in permafrost aggradation, hence are considered enhancements from both engineering and environmental standpoints. Several components, however, are associated with medium and high residual impacts. These include:

- De-watering
- Rock storage facilities
- Tailings storage facility
- Tailings dike
- Heated buildings
- Re-watering

Each of these is discussed in a separate section below. Since the permafrost issue is a long-term matter, no attempt is made to distinguish temporal-phase impacts into subsections in the following discussion.

6.2 Dewatering

Dewatering of Second Portage Lake is considered to have high residual impact during construction. Dewatering of Third Portage Lake and lowering of Vault and Phaser lakes is considered to have high (Third Portage Lake only) and medium (Vault and Phaser) residual impacts during operations.

Prior to the construction of the tailings dike, Second Portage Lake will require dewatering from elevation 133.1 m A.S.L. down to elevation 105 m A.S.L. within the area bounded by the East Dike. Later, construction of the Bay Zone and Goose Island dikes will allow for additional dewatering of an isolated portion of Third Portage Lake. Construction of the Vault Dike will allow the level of Vault Lake to be lowered from 139.4 m A.S.L. down to elevation 136.4 m A.S.L. Phaser Lake will also be lowered.

As a consequence of these dewatering activities, inflowing streams will degrade where their present thalwegs are not controlled by rock. Additionally, wetlands along the lake shorelines and the tributary streams will be affected by lowered water tables. This will cause the underlying permafrost to warm and the active layer to increase in thickness. As wetlands are associated with excess ground ice, some combination of thaw subsidence, local thaw instability and sediment production is expected.

Thaw subsidence is considered a low impact effect and no mitigation is necessary. High impacts are associated with thaw instability and sediment production effects. Typically these will occur where excess ground ice and fine grained soils are encountered by the deepening active layer. The effects are expected to be short lived, spanning construction but quickly stabilizing during construction or early operations.

These high impacts may require no mitigation since the lakes affected are contained. If suspended sediment or shoreline instability becomes a problem, however, proactive measures are available to manage the effects. Silt fences can be used to control the movement of fines into the remaining lake water or ponds. Drawdown pumping can be curtailed. Clarification ponds can be constructed in diked off portions of the lake bottoms, including the use of natural obstructions and closed depressions on the lake bottoms for this purpose. Other measures involve the placement of a stabilizing rock fill, commonly in conjunction with a geotextile, thus insulating the thaw unstable area and slowing the rates of thaw and sediment production. Where instability encroaches on the proposed Vault-Phaser Lake berm this relatively more aggressive approach may be needed.

6.3 Rock Storage Facilities

Construction and closure of the rock storage facilities is expected to be straightforward except for a few locations where these structures have wetlands in the foundations. Here the unmitigated impacts are considered to be high. Uncertainty about the internal temperatures of the facilities is considered a medium residual impact at closure.

Waste mine rock will be trucked to storage areas. Waste rock from the North Portage, Third Portage and Goose Island open pits will be stored in the Portage rock storage facility located to the north of Second Portage Arm and to the west of the Vault haul road. Waste rock from the Vault open pit will be stored in the Vault rock storage facility to the northwest of the Vault pit. Both facilities will be constructed to minimize the disturbed areas and both will be contoured to provide a shape consistent with the surrounding topography, and to encourage runoff from the final surface to designated drainage paths.

The Portage rock storage facility will be capped with a layer of non-acid generating rock to constrain the active layer within relatively inert materials. The thickness will be sufficient to confine the active layer within the capping layer, and hence maintain the underlying potentially acid generating waste rock in a frozen state. This material will be placed progressively as portions of the waste rock storage area reach the desired final configuration. The material will either be placed directly on completed portions of the dump, or stockpiled at one side of the rock storage area for subsequent placement. The waste rock below the capping layer will freeze, resulting in low rates of ARD generation in the long term. Current geochemical predictions indicate that a capping layer will not be required over the Vault facility.

The presence of wetlands in foundations of the waste rock piles will require the following construction control measures:

- Schedule placement of waste rock on wetlands during winter months when the active layer is frozen.

- Use proactive measures to enhance ground chilling (e.g., snow removal or compaction, sub excavation of thaw sensitive materials).

- Decrease the nearby waste rock side slopes where the pile converges on wetlands until such time as the waste rock cover over the wetland serves as a passive stabilizing component.

The internal temperature of the rock storage piles is expected to become super chilled as a result of convective heat transfer by circulating cold air during the winter months (BGC 2004). This may limit internal drainage significantly as infiltrating runoff becomes frozen. The internal temperature of the rock storage pile will be monitored during operation so that the final topographic configuration and capping thickness can be optimized.

6.4 Tailings Storage Facility

Uncertainty about ice entrapment during tailings placement, and freeze-back of the tailings are considered to have high and medium residual impacts during operations and at closure.

Tailings will be stored in the northwest arm of Second Portage Arm, west of the tailings dike. Initially the tailings will be deposited in a subaqueous environment, but the majority will be deposited subaerially. A reclaim pond will be operated within the tailings storage facility. Properties of the tailings relevant to the design of a tailings storage facility are presented in Table 6.1.

Table 6.1: Relevant Data for Tailings Storage Facility

Property	Value	
Mine Design life	10 years	
Mill Production (solids)	5500 tpd	
Ore Processed	19.8 million tonnes (Mt)	
Goose Pit	2 Mt	(S.G. = 3.15)
Vault Pit	8 Mt	(S.G. = 2.75)
Portage Pits	10 Mt	(S.G. = 2.93)
Average Specific Gravity of ore	2.9 t/m^3	
Assumed Settled Void Ratio (unfrozen)	1.0	
Assumed Settled Dry Density (unfrozen)	1.45 t/m^3	
Assumed Settled Moisture Content (by weight)	34%	
Volume of settled tailings (no ice entrapment)	12 to 14 million m^3	

It is likely that some ice will be trapped in the tailings, as a result of tailings transport water freezing before reaching the decant pond or reclaim pond ice being incorporated into the tailings. The quantity of ice trapped will depend on the tailings beach management, but volumes of up to 30% have been reported by some mines in similar environments. The impact of possible ice entrapment on the final elevation of the tailings storage facility is summarized in Table 6.2, based on the quantity of tailings shown in Table 6.1. As indicated, the maximum volume considered would result in the final height of the tailings storage facility increasing by about 3 m relative to the height that would be required if no ice is entrapped. This increase would require minor extensions of containment berms and would have a negligible impact on the visibility of the tailings impoundment.

Table 6.2: Tailings Surface Elevation for Various Amounts of Ice Entrapment

Proportion of Entrapped Ice	Final Elevation of Tailings
0%	El. 137 m
10%	El. 138 m
20%	El. 139 m
30%	El. 140 m

Ice entrapment can be minimized to a large degree by effective beach management and through the implementation of appropriate operational strategies. A detailed deposition plan will be developed during the detailed design phase of the project that will consider various scenarios for reducing ice entrapment. Actual amounts of ice entrapment will not be known until the commencement of operation of the tailings facility.

The tailings storage facility will be progressively reclaimed during mine operations with a nominal 2 m thick cover layer of non-potentially acid generating ultramafic rock. The active layer will be confined within the capping layer, hence maintaining the underlying tailings in a frozen state. The capping material will have a relatively low permeability to reduce the potential for infiltration to the tailings in both frozen and thawed conditions. The upper surface of the cap will be contoured to direct runoff from the area and towards nearby lakes. The proposed 2 m thickness will be further assessed in detailed design and modified, as required, particularly if climate change predictions show it to be inadequate. Alternatively, the runoff configuration of the cap may be modified to increase the moisture content of the near-surface soils, which would reduce the active layer thickness. The freeze-back conditions and final cap configuration will be confirmed by performance monitoring with ground temperature measurements during operations and closure.

Thermal modelling suggests that the tailings will freeze in the long term, and that the talik below Second Portage Arm will freeze before seepage from the tailings impoundment reaches groundwater below the permafrost or Third Portage Lake (closure). Therefore the potential for groundwater contamination to occur as a result of seepage from the tailings impoundment is considered to be low. Ground temperature monitoring will be undertaken during operations and closure to confirm the predicted freeze-back conditions.

6.5 Tailings Dike

The proposed tailings dike is considered to have medium residual impact at closure.

The proposed tailings dike is needed to contain within the Second Portage Lake northwest arm approximately 20 million tonnes of tailings. The dike will be constructed ‘in the dry’, after drawing down the water in the northwest arm of Second Portage Lake by approximately 28 m. It will be built in two stages: Stage 1 will be required in Year –1 of the mine life to a crest elevation of 120 m A.S.L., while Stage 2 construction will occur in Year 3, up to the final crest elevation of 139.6 m A.S.L. At closure, the downstream side of the dike will be flooded by the waters of Third Portage Lake to elevation approximately 133 m A.S.L.

During operation of the mine, the dike will need to control seepage from the tailings storage facility toward the west wall of the Portage Pit both through and beneath the dike structure. After closure the dike will need to prevent the movement of contaminants into Third Portage Lake.

Due to uncertainty about whether the in situ foundation material will perform adequately as a seepage control barrier, two designs have been considered A Full Cutoff (conservative) design assumes that the foundation material will be permeable and that a cutoff trench and grout curtain will be required. The Partial Cutoff design assumes that the foundation material is of sufficiently low permeability to control seepage. Therefore, neither the till cutoff nor the grout curtain would be required, and only a nominal key-in trench for the till core would be constructed.

The potential for groundwater movement from the tailings storage area into the Portage pit will be one of the determining factors in choosing the Full or Partial cutoff alternative as described above. During final design and during construction, the condition of rock in the dike foundation will also be assessed, particularly the nature of the Second Portage Fault, which is expected to trend northeast beneath the structure. If any zone is determined to be problematic, extra grouting effort will be used during dike construction.

Aggradation into and preservation of permafrost in the core and upstream (tailings) side of the dike is a key aspect of both the Full and Partial design concepts. Both steady state and transient thermal modeling for the post-closure indicate that the dike will become frozen during operation and remain frozen after closure, even with Third Portage Lake waters lapping against the downstream side and even when climate change warming is considered.

Monitoring of ground temperatures and sub permafrost pore pressures in the dike and its foundation will be undertaken during operation and post closure to ensure that freeze-back and grouting are effectively mitigating groundwater flow between the tailings storage facility and Portage Pit / Third Portage Lake.

6.6 DITCHES

Non contact ditches are considered to have potentially high impacts in isolated areas during construction, possibly extending into operations.

Interceptor ditches will be constructed around the Portage and Vault rock storage facilities and adjacent to the airstrip and plant site to manage contact water. The network of haul roads will also have ditches for this purpose. Non-contact ditches will be constructed south of Vault Lake and north of the tailings storage facility.

The approach to ditch design will involve the implementation of local best management practices during construction, operation and closure. Designs with a minimum uniform base width of 1.0 m and minimum depths adjusted to suit discharge requirements have been assumed. Although no specific overburden information has been collected along the proposed ditch alignments, properly designed excavated channels are considered feasible. Specific channel configurations will be developed during the detailed engineering design.

The final designs will consider measures to minimize the impact on permafrost. Some loss of permafrost occurs as a result of excavation during construction as well as during periods of ditch flow when convective heat transfer warms the remaining permafrost. These impacts are considered low provided no ice-rich permafrost is present.

Final designs will recognise the potential challenges presented by ice-rich ground including icing, localized thawing, local ground instabilities, subsidence and transport of fine-grained soils. The design and maintenance procedures for the ditches will take into consideration these challenges. Design features that can be adopted to avoid problems include alignment of channels to take advantage of favorable foundation conditions, oversizing of the drainage structures, the provision of training berms instead of, or in combination with, channels, lining and insulating of channels to prevent sedimentation and permafrost degradation.

Mitigation of thaw-related problems that develop despite these design precautions are straightforward. For contact ditches they simply involve placement of a stabilizing apron comprising granular fill, often used in conjunction with geotextile. Such mitigation is considered unlikely given the design precautions listed above. If aprons are needed, however, the residual impacts are considered low. Where thaw-related impacts affect non-contact ditches, impacts may be somewhat higher because placement of a stabilizing fill is not consistent with the “non-contact” designation. In these cases, special care will be taken to ensure aprons comprise non acid generating and non metal leaching granular materials.

6.7 Heated Buildings

Heated buildings are considered to have high unmitigated impacts during operations. With mitigation alternatives described below, the residual impacts are considered low.

The foundations of heated buildings will be built using one of three approaches:

- Where thaw sensitive soil / rock is present or suspected in the subgrade, foundations will be designed to prevent thaw of underlying permafrost.
- Where there is little likelihood of thaw sensitive soil / rock and buildings can tolerate limited deformations, foundations will be designed to retard thaw of underlying permafrost.
- Where thaw stable foundation conditions exist, no special measures will be taken to control the rate or extent of thaw during mine operations.

Measures to prevent thaw could include any of the following:

- Buildings are elevated on piles or sills leaving a dead air space between the floor slab and the subgrade.
- Slab-on-grade placed on a well compacted structural fill with ventilation pipes in the fill. The ventilation pipes, which are operated in the winter to super chill the ground, may be forced air or non assisted convective air flow.
- Slab-on-grade placed on a well compacted structural fill with thermo syphons used to chill the fill year-round.

Measures to retard thaw could include either of the following:

- Buildings are elevated on a well compacted structural fill where the fill itself slows heat flow from the building to the foundation.
- Buildings are placed on a nominal thickness of well compacted fill with insulation used to slow the rate of heat transfer into the subgrade.

6.8 REWATERING

Rewatering or flooding of affected portions of Third Portage Lake as well as Vault and Phaser lakes is considered to have generally medium residual impact at closure. Second Portage Lake is considered to have potentially high residual impact at closure.

Table 6.3 summarizes the estimates of time required for flooding of the Vault and Portage / Goose deposit areas during closure, considering the availability of a 60-day low flow period. The times to flood were computed assuming 100% and 50% efficiency in capturing the available annual flood volumes.

Table 6.3: Estimate of Pit Flooding

Deposit Area	60-Day Low Flow Criteria				
	Required Flood Volume Mm^3		Available Annual Flood Volume Mm^3	Time to Flood - Full Efficiency Years	Time to Flood - 50% Efficiency Years
	Pit	Lake			
Vault	19.6	2.2	7.1	3.1	*6.1*
Portage/Goose	35.9	5.2	9.0	*4.6*	9.1

Note: Bold values in italics are considered appropriate estimates for the current level of study.

The volume of the completed Portage and Goose open pits will be in the order of 30 million m^3. Instantaneous breaching of the dike would cause a significant and unacceptable drawdown of Third Portage Lake. Flooding will be through a combination of seepage, precipitation and some re-direction of spring freshet flows from Third Portage Lake. The control of the rate of flooding will be through the incorporation of engineered structures into the detailed design of the dikes, which could potentially involve spillway structures, side decant structures, or other engineering designs. The final lake level within the Portage pit lake will be equal to that of Third Portage Lake (approximately 134 m A.S.L.). For the original portion of Second Portage Lake, this is about 1 m higher water level.

The Vault pit will be flooded at closure and will become part of Vault Lake. The dike between Vault Lake and Wally Lake will be removed. In the same manner as for the Portage open pits, the dike will only be completely removed when it is acceptable for water in the Vault Lake to mix with Wally Lake. The rate of flooding will be determined by the rate of groundwater seepage, the surface runoff that can be directed into the pit, and by the amount of water that can be directed from Wally Lake during the spring freshet.

Three geotechnical impacts are forecast during the rewatering.

The shoreline of the affected portion of Second Portage Lake will experience approximately a 1 m higher water level than the baseline elevation of 133.1 m A.S.L. This is assigned a high impact pending further assessment of possible effects during the next phase of study. In general, the lower water tables described in Section 6.2 will cause potential problems to express themselves during construction and early operation and they will be mitigated, as required, at that time.

As the water level rises it will cause permafrost that formed on the floors of previous lake bottoms to degrade. Although this loss of permafrost is considered a low impact, where excess ground ice melts it may result in localized mud-line instability and/or elevated sediment entrainment. Fortunately, this condition is expected to be both very localized and short-lived, hence it is considered a medium impact. Silt fences can be deployed to manage locally significant sediment entrainment problems.

Rewatering of the Vault pit will flood portions of the original Vault Lake bottom. As stated in Section 2.9.2.2, any talik that existed below Vault Lake was unlikely to extend to the base of the permafrost. Rewatering will create a through going talik that will connect with the deep water groundwater flow regime. Although this will take many centuries, it is foreseeable. The impact is considered low because water chemistry in Vault Lake is expected to reach discharge standards quickly and the through going talik will be similar to taliks under most large lakes, including that beneath Second and Third Portage lakes where the rewatered Portage pits are locate

6.9 SUMMARY

Dewatering

Shoreline wetlands and some inflowing streams will be affected by lowered water tables, which will cause nearby active layer thickness to increase. As wetlands are associated with excess ground ice, some combination of thaw subsidence, local thaw instability and sediment production is expected. Second Portage Lake is considered to have high residual impact during construction and Third Portage Lake a high residual impact during operations. Vault and Phaser lakes are considered to have medium residual impacts during operations. The effects are expected to be short lived, spanning construction but quickly stabilizing during construction or early operations. If mitigation is needed effective methods are available. Silt fences can be used to control the movement of fines into the remaining lake water or ponds. Drawdown pumping can be curtailed. Clarification ponds can be constructed in diked off portions of the lake bottoms, including the use of natural obstructions and closed depressions on the lake bottoms. Other measures involve the placement of a stabilizing rock fill, commonly in conjunction with a geotextile, thus insulating the thaw unstable area and slowing the rates of thaw and sediment production.

Rock Storage Facilities

Construction of the rock storage facilities is expected to be straightforward except for a few isolated locations where foundations comprise wetlands. Here the unmitigated impacts are considered to be high. Special construction control measures are available to limit residual impacts.

Uncertainty about internal temperatures of the rock storage facilities is considered a medium residual impact at closure. The internal temperature is expected to become super chilled, which will limit internal drainage as infiltrating runoff becomes frozen. The internal temperature will be monitored during operation so that the final topographic configuration and capping thickness can be optimized.

Tailings Storage Facility

Ice is expected to become entrapped during placement and freeze-back of the tailings. Uncertainty about how much ice is identified as a high residual impact during operations and a medium residual impact at closure. Up to 30% has been allowed for but actual amounts will not be known until the commencement of operations. The amount can be minimized by effective beach management and through the implementation of appropriate operational strategies. A detailed deposition plan will be developed during the detailed design phase that will consider various scenarios for reducing ice entrapment. The maximum of 30% would result in the final height of the tailings storage facility increasing by about 3 m relative to the height that would be required if no ice is entrapped. Minor extensions of containment berms would be needed. This increase would have a negligible impact on the closure configuration.

The tailings storage facility will be progressively reclaimed during mine operations with a nominal 2 m thick cover layer of non-potentially acid generating ultramafic rock. The active layer will be confined within the capping layer, hence maintaining the underlying tailings in a frozen state. The capping material will have a relatively low permeability to reduce the potential for infiltration to the tailings in both frozen and thawed conditions. The upper surface will be contoured to direct runoff from the area and towards nearby lakes. The proposed 2 m thickness will be further assessed during detailed design and modified, as required, particularly if climate change predictions show it to be inadequate. Alternatively, the runoff configuration of the cap may be modified to increase the moisture content of the near-surface soils, which would reduce the active layer thickness. The freeze-back conditions and final cap configuration will be confirmed by performance monitoring with ground temperature measurements during operations and closure.

Thermal modelling suggests that the tailings will freeze in the long term, and that the talik below Second Portage Arm will freeze before seepage from the tailings impoundment reaches groundwater below the permafrost or Third Portage Lake (closure). Therefore, the potential for deep groundwater contamination to occur as a result of seepage from the tailings impoundment is considered to be low. Ground temperature monitoring will be undertaken during operations and closure to confirm the predicted freeze-back conditions.

Tailings Dike

The proposed tailings dike is considered to have medium residual impact at closure.

The proposed tailings dike is needed to contain within the Second Portage Lake northwest arm approximately 20 million tonnes of tailings. The dike will be constructed 'in the dry', after drawing down water in the northwest arm of Second Portage Lake. During operations it will prevent movement of contaminants from the tailings facility into the Portage pit. At closure, after rewatering of the Portage pit, it will prevent contaminant movement into Third Portage Lake.

During final design and during construction, the condition of soil and rock in the dike foundation will also be assessed, particularly the nature of the Second Portage Fault, which is expected to trend northeast beneath the structure. A range of designs has been proposed. The final design will be selected to deal with actual conditions encountered.

Aggradation into and preservation of permafrost in the core and upstream (tailings) side of the dike is a key aspect of the design concept. Both steady state and transient thermal modeling for the post-closure indicate that the dike will become frozen during operation and remain frozen after closure, even with Third Portage Lake waters lapping against the downstream side and even when climate change warming is considered.

Monitoring of ground temperatures and sub permafrost pore pressures in the dike and its foundation will be undertaken during operation and post closure to ensure that freeze-back and grouting are effectively mitigating groundwater flow between the tailings storage facility and Portage Pit / Third Portage Lake.

Ditches

Ditches are considered to have potentially high impacts in isolated areas during construction, possibly extending into operations. Some loss of permafrost occurs as a result of excavation during construction as well as during periods of ditch flow. These are considered low provided no ice-rich permafrost is present. Final designs will recognise the potential challenges presented by ice-rich ground including icing, localized thawing, local ground instabilities, subsidence and transport of fine-grained soils. Design features that can be adopted to avoid problems include alignment of channels to take advantage of favorable foundation conditions, oversizing of the drainage structures, the provision of training berms instead of, or in combination with, channels, lining and insulating of channels to prevent sedimentation and permafrost degradation. Mitigation of thaw-related problems that develop despite these design precautions are straightforward. For contact ditches they involve placement of a stabilizing apron, however, this is not consistent with the “non-contact” designation. In these cases, special care will be taken to ensure aprons comprise non acid generating and non metal leaching granular materials.

Heated Buildings

Heated buildings are considered to have high unmitigated impacts during operations, however a range of mitigation alternatives available mean the residual impacts are considered low.

Rewatering

Rewatering or flooding of affected portions of Third Portage Lake as well as Vault and Phaser lakes is considered to have generally medium residual impact at closure. Second Portage Lake is considered to have potentially high residual impact at closure.

Flooding will be through a combination of seepage, precipitation and some re-direction of spring freshet flows. The control of the rate of flooding will be through the incorporation of engineered structures into the detailed design of the dikes, which could potentially involve spillway structures, side decant structures, or other engineering designs.

The shoreline of the affected portion of Second Portage Lake will experience approximately a 1 m higher water level than the baseline elevation of 133.1 m A.S.L. This is assigned a high impact pending further assessment of possible effects during the next phase of study. In general, the lower water tables will cause potential problems to express themselves during construction and early operation and they will be mitigated, as required, at that time.

As the water level rises it will cause permafrost that formed on the floors of previous lake bottoms to degrade. Although this loss of permafrost is considered a low impact, where excess ground ice melts it may result in localized mud-line instability and/or elevated sediment entrainment. Fortunately, this condition is expected to be both very localized and short-lived, hence it is considered a medium impact. Silt fences can be deployed to manage locally significant sediment entrainment problems.

Rewatering of the Vault pit will flood portions of the original Vault Lake bottom. Any talik that existed below Vault Lake was unlikely to extend to the base of the permafrost, hence rewatering will create a through going talik although this will take many centuries. The impact is considered low because water chemistry in Vault Lake is expected to reach discharge standards quickly and the through going talik will be similar to taliks under most large nearby lakes, including that beneath Second and Third Portage lakes where the rewatered Portage pits are located.

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APPENDIX A

Table A1: Surface Water Quantity Impact Matrix – Construction

Project Components	Potential Effects	Assessment of Unmitigated Effects: Spatial Boundaries		Assessment of Unmitigated Effects: Temporal Boundaries			Assessment of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects			Mine Waste and Water Management Plan
		Magnitude	Spatial Extent	Frequency	Duration	Timing	Significance of Unmitigated Effects		Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	
MAIN FACILITIES												
Construction Noise and Activity	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA	
Dykes												
East Dyke	Isolation of northwest arm of Second Portage Lake (~135 ha); impoundment of 35% surface area and 58% volume of Second Portage Lake (see dewatering section); dyke itself displaces very little water volume	Low	Local	Continuous	Permanent	All Year	No	None	Construction of East Dyke will have very small impact on water volume within the project lake because of the very small footprint and volume of dykes relative to the lake	No	Certain	No mitigation required because of small area displaced by dykes
	Change in lake circulation patterns in residual areas of Second Portage Lake; residence time of water in Second Portage Lake is expected to decrease	Low	Local	Continuous	Permanent	All Year	No	None recommended.	NA	No	NA	Ongoing hydrological monitoring will be conducted at the Second Portage Lake outlet channel
West Dyke	No impact since West dyke on Second Portage Lake is constructed within the dewatered Second Portage Lake arm after the construction of East dyke	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Mine Waste and Water Management Plan
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Bay Zone Dyke	Isolation of a small portion of Third Portage Lake (~20 ha); impoundment of 0.5% surface area and ~0.2% volume of Third Portage Lake (see dewtaering section); dyke itself displaces very little water volume	Low	Local	Continuous	Permanent	All Year	No	None	Small footprint and volume of dykes relative to the lake	No	Certain	No mitigation required because of small area displaced by dykes
	Construction of Bay Zone Dyke will eliminate the westernmost connecting channel (the main outlet of three channels, holding ~50% of the flow) between Third Portage and Second Portage lakes; increased flow to other outlet channel(s) with potential for channel overtopping and erosion; rise in Third Portage Lake water levels leading to shoreline erosion	High	Regional	Continuous	Permanent	All Year	Yes	One of the existing channels between Third Portage and Second Portage lakes will be modified to accept larger flows. Bottom elevation of the new channel will be engineered to ensure that discharge will not be constrained and that the the existing 1 m elevation difference between Third Portage and Second Portage lakes is maintained	The new channel will ensure that discharge capacity is not diminished below current conditions; concerns related toThird Portage Lake water levels and erosion of exisitng channels due to high flows will not reduced	No	High	Ongoing hydrological monitoring will be conducted at the Third Portage Lake outlet channel
	Change in lake circulation patterns; increased mixing between basins within Third Portage Lake is expected with the removal of the Bay Zone area	Low	Local	Continuous	Medium-term	All Year	No	None recommended.	NA	No	High	Ongoing hydrological monitoring will be conducted at the Third Portage outelt channel.
Goose Island and Third Portage Arm Dykes	Constructed during the operation phase.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Extent	Temporal Boundaries: Frequency	Duration	Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Mine Waste and Water Management Plan
Dewatering												
Second Portage Arm & Pumping Facilities	Approximately 12 million cubic meters of water will be pumped from Second Portage Arm (i.e., area impounded by East Dyke) to Third Portage Lake resulting in increased volume (5%) and water levels (20-30 cm) in Third Portage Lake; because of constraints at outlet channels, in the absence of mitigation, the increased water volume will be released back to residual areas of Second Portage Lake over several years; although water level increases fall within natural lake level fluctuations, some shoreline erosion due to ice and wave scour is possible; increased discharge volumes may also cause erosion of outlet channels, particularly since the main channel is eliminated by the Bay Zone Dyke	High	Regional	Continuous	Short-term	Summer	Yes	One of the existing channels between Third Portage and Second Portage lakes will be modified to accept greater flows.	The new channel will ensure that discharge capacity is not diminished below current conditions.	No	High	Ongoing hydrological monitoring will be conducted at the Third Portage Lake outlet channel
	Anticipated increase in discharge from Second Portage Lake to Tehek Lake fall within natural fluctuation and is not expected to impact outlet channel integrity between Second Portage and Tehek lakes or lake levels in Tehek Lake	Low	Regional	Continuous	Short-term	Summer	No	No mitigation is required since flows fall well within seasonal norms.	NA	No	Certain	Ongoing hydrological monitoring will be conducted on the outlet channel from Second Portage Lake to Tehek Lake
	Decrease in Second Portage Lake volume	High	Local	Continuous	Permanent	All Year	Yes	No mitigation is possible since dewatered area will be used as permanent disposal area for mine tailings	NA	Yes	Certain	NA

Table A.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Mine Waste and Water Management Plan
Bay Zone	Dewatering will not occur until the operation phase	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pits												
Portage Pits	Portage Pit will be excavated within area impounded by East and West dykes, so no additional impacts on water quantity anticipated; some potential for seepage from Second and Third Portage lakes into the pit and then pump-back from the sumps to the attenuation pond	Low	Local	Continuous	Medium	All Year	No	Seepage water pumped into attenuation pond.	NA	No	High	Pit limits defined by reserves and geotechnical parameters; set back of 80m between pit and dyke might be reduced through further study or after initial experience gained.
Goose Island Pit	Constructed when the mine is in operation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Waste Dump (Portage & Goose)	Gradual loss of natural surface drainage equal to the area of the waste dump; loss of storage capacity in small ponds and wetlands	Low	Local	Continuous	Permanent	All Year	No	Collect seepage and runoff from waste dumps in the attenuation pond and discharge to Third Portage Lake.	Overall small changes in inputs to Third Portage Lake	No	Certain	Minimize footprint and separate clean from contaminated runoff as far as possible through appropriate layout; discharge clean run-off to Third Portage Lake
Borrow Pit(s)	No borrow pits required. All construction materials to be produced from on-site crushing & screening of pre-stripping material.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tailings Disposal (Facilities & Ponds)	Reduction of lake area and water volume in Second Portage Lake. Impacts resulted from construction of East Dyke and dewatering of Second Portage Lake arm (see above)	High	Local	Continuous	Permanent	All Year	Yes	No mitigation is possible since dewatered area will be used as permanent disposal area for mine tailings	NA	Yes	Certain	NA
Main Site Roads & Traffic	Disruption of surface drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Maintain roads & culverts in good condition and maintain adequate drainage patterns.	NA	No	Certain	Use sedimentation traps, selection of more durable materials for road surfacing.

Table A.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Mine Waste and Water Management Plan
Airstrip & Air Traffic	Disruption of surface drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Maintain adequate drainage patterns	NA	No	Certain	Strip straddles a ridge and drainage disruption minor. Ensure drainage pattersn are not disrupted.
	Reclamation of portion of Third Portage Lake for northwest end of runway; small amount of volume displaced	Low	Local	Continuous	Permanent	All Year	No	Minimize length of runway	NA	No	Certain	None recommended.
	Alteration of circulation patterns in Third Portage Lake is expected to be negligible	Low	Local	Continuous	Permanent	All Year	No	Minimize length of runway	NA	No	Certain	None recommended.
Plant Site (Footprint & Ground Activity)	Interference with surface drainage patterns; runoff directed to the attenuation pond	Low	Local	Infrequent	Medium	Summer	No	Grade site to control and collect runoff.	NA	No	Certain	Clean runoff will be directed to attenuation pond and eventually discharged to Third Portage Lake; monitor integrity of surface drainage structures
Process Plant Activity	Processing commences after the construction is completed and the mine is in operation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Freshwater Intake & Pipeline	Intake structure and pipeline constructed in construction phase. Fresh water demand for the process commences in operations; negligible reduction in Third Portage Lake volume for water consumption during construction. Minor interference with surface drainage patterns.	Low	Local	Infrequent	Medium	Summer	No	Minimize freshwater requirements	NA	No	High	Monitor freshwater intake volumes.
Discharge Facilities & Pipeline	Extra volume (`2.1 million cubic metres/ year; 0.9% of total lake volume) discharged to Third Portage Lake during operations phase; discharge during construction phase is expected to be minimal; Interference with surface drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Discharging water to the receiving environment lake that would normally receive this runoff; discharging only during the open water season	NA	No	Certain	Monitor discharge volumes.

Table A.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Mine Waste and Water Management Plan
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Non-Contact Diversion Facilities	Drainage patterns changed. Runoff diverted from Second Portage Lake catchment to Third Portage Lake catchment resulting in increased runoff volumes to Third Portage Lake.	Low	Local	Infrequent	Permanent	Summer	No	Diverted to Third Portage Lake.	NA	No	Certain	Monitor discharge volumes of non-contact water.
Fuel Storage (at Plant Site)	Minor loss of runoff volume to Third Portage Lake due to fuel containment berm. Site runoff directed to attenuation pond	Low	Local	Infrequent	Medium	Summer	No	None	NA	No	Certain	None recommended,
AN / Explosives Storage & Emulsion Plant	Minor loss of runoff volume to Third Portage Lake due to containment berm. Interference with drainage patterns	Low	Local	Infrequent	Medium	Summer	No	None	NA	No	Certain	None recommended.
Site Accommodations	Interference with local drainage patterns (see Plant Site above)	Low	Local	Infrequent	Medium	Summer	No	Grade site to control runoff.	NA	No	Certain	None recommended.
Sewage & Waste Disposal	No effects on surface water quantity	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
VAULT FACILITIES												
Construction Noise and Activity	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vault Dyke	Complete isolation of Vault Lake from Wally and Drilltrail lakes with natural discharge eliminated; small volume of water displaced by dyke	Low	Local	Continuous	Permanent	All Year	No	None	Small footprint and volume of dykes relative to the lake	No	Certain	No mitigation required because of small are displaced by dykes

Table A.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Mine Waste and Water Management Plan
Dewatering												
Vault Lake Dewatering & Drainage Facilities	Approximately 1.5 million cubic meters of water will be pumped from Vault Lake to Wally/Drilltrail lakes resulting in a small increase in volume of receiving lakes (~3.4%); discharge volumes are expected to be well within inter-annual variation and the exisitng discharge channel can easily pass this additional flow	Low	Regional	Continuous	Medium	Summer	No	None required	NA	No	High	Ongoing hydrological monitoring will be conducted on the outlet channel between Second Portage Lake (ie., receiving water for Wally and Driltrail lakes) and Tehek Lake
	Decrease in Vault Lake volume	High	Local	Continuous	Medium	All Year	Yes	No mitigation is possible since dewatered area will be used as temporary attenutaion pond	NA	Yes	Certain	NA
Vault Pit	Pit developed within dewatered area, so no further impacts to water quantity anticipated	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Discharge Volumes & Facilities	Extra volume (`0.4 million cubic metres/ year; 0.9% of total lake volume) discharged to Wally and Drilltrail lakes; Interference with surface drainage patterns	Low	Local	Continuous	Medium	Summer	No	Discharging water to the receiving environment lake that would normally receive this runoff; discharging only during the open water season	NA	No	High	Monitor discharge volumes.
Vault Waste Dump	Gradual loss of natural surface drainage equal to the area of the waste dump; loss of storage capacity in small ponds and wetlands	Low	Local	Continuous	Permanent	All Year	No	Collect seepage and runoff from waste dumps in the attenuation pond and discharge to Wally/ Drilltrail lakes	Overall small changes in inputs to Wally/ Drilltrail lakes	No	Certain	Minimize footprint and separate clean from contaminated runoff as far as possible through appropriate layout
Vault Access Road & Traffic	Disruption of surface drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Maintain roads & culverts in good condition and maintain adequate drainage patterns.	NA	No	Certain	Use sedimentation traps, selection of more durable materials for road surfacing.

Table A.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Mine Waste and Water Management Plan
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Access Road Culverts (Turn Lake)	Culverts will reduce ability of Turn Lake to discharge spring freshet and Phaser Lake diversions resulting in increases in water levels	Medium	Local	Continuous	Medium-term	Summer	Yes	Culverts will be sized (ie., 2.5 m diameter) to handle 1:100 year flood events and increased discharge due to annual Phaser Lake dewatering; culverts will be installed in winter when the outlet from Turn Lake to Drilltrail Lake is frozen to the bottom, ensuring no disruption of flow	With no constraints on water discharge, the potential magnitude of the impact would be low	No	High	Ongoing hydrological monitoring wil be conducted at the Turn Lake outlet to Drilltrail Lake
Mine Shop / Office	Interference with surface drainage patterns; runoff directed to the attenuation pond	Low	Local	Infrequent	Medium	Summer	No	Grade site to control and collect runoff.	NA	No	Certain	Clean runoff will be directed to attenuation pond and eventually discharged to Third Portage Lake; monitor integrity of surface drainage structures
OTHER FACILITIES												
Winter Road & Traffic	No impact on surface water anticipated	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Existing route used traditionally
Baker Lake Access Road & Traffic	Interference with local surface drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Maintain roads in good condition and maintain adequate drainage pattern.	NA	No	Certain	Use sedimentation traps, selection of more durable materials for road surfacing.
Barge Landing Facility	Small changes or interference with local drainage patterns and lake circulation	Low	Local	Infrequent	Medium	Summer	No	Minimize footprint.	NA	No	Certain	None recommended
Barge Traffic	No measurable impacts on surface water anticipated	NA	NA	NA	NA	NA	NA	NA		NA	NA	NA
Staging Facility (approx. 1.5 km east of town)	Interference with local drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Minimize footprint; construct in area with minimal impacts to drainage patterns, install culverts as required	NA	No	Certain	Runoff directed to Baker Lake.

Table A.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Mine Waste and Water Management Plan
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Explosives Magazine	Interference with local drainage patterns	Low	Local	Infrequent	Medium	Summer	No	None recommended	NA	No	Certain	None recommended
Tank Farm	Small loss of surface drainage area and interference with drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Maintain adequate drainage patterns.	NA	No	Certain	Monitor integrity of drainage facilities.

Table A.2: Surface Water Quantity Impact Matrix – Operation

Project Components	Potential Effects	Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects	Proposed Mitigation	Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Mine Waste and Water Management Plan
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
MAIN FACILITIES												
Construction Noise and Activity	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dykes												
East Dyke	Impact occurred during construction phase	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
West Dyke	No impact - dyke is constructed after East dyke within already dewatered arm of Second Portage Lake	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bay Zone Dyke	Impact occurred during construction phase	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Goose Island and Third Portage Arm Dykes	Isolation of a small portion of Third Portage Lake (~73 ha), small reduction in Third Portage Lake surface area and volume	Low	Local	Continuous	Medium	All Year	No	None	NA	No	Certain	None recommended.
	Change in lake circulation patterns. Water entering the East basin of Third Portage Lake from the North and South basins will be forced further east, possibly resulting in increased mixing. This change in potential circulation pattern is considered to be relatively small.	Low	Local	Continuous	Medium	All Year	No	Dewatering will be timed such that there is no cumulative impact on water balance in Third Portage Lake as a result of dewatering of Second Portage Lake	NA	No	Certain	Ongoing hydrological monitoring will be conducted at the Third Portage Lake outlet.
Dewatering												
Second Portage Lake	No further dewatering anticipated during operations	NA	NA	NA	NA	NA	NA	None	None	NA	Certain	

Table A.2 Continued

Project Components	Potential Effects	Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects	Proposed Mitigation	Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Mine Waste and Water Management Plan
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Bay Zone	Approximately 0.4 million cubic meters of water will be pumped to residual areas of Third Portage Lake resulting in a negligible increase in volume (0.2%) and water levels. Given that dewatering takes place at least two years after dewatering of Second Portage Lake, negligible cumulative effects in water volume and levels in Third Portage Lake are anticipated.	Low	Local	Continuous	Medium	All Year	No	Enhancement of one of Third Portage Lake outlet channels will ensure that increased discharge is easily handled	NA	No	Certain	Ongoing hydrological monitoring will be conducted at the Third Portage Lake outlet.
Goose Island (Third Portage Lake)	Approximately 2.2 million cubic meters of water will be pumped to residual areas of Third Portage Lake in Year 4 or 5 resulting in an increase in volume (<1%) and water levels (maximum of 4 -5 cm), well within annual variations. Given that dewatering takes place at least four years after dewatering of Second Portage Lake, negligible cumulative effects in water volume and levels in Third Portage Lake are anticipated.	Low	Local	Continuous	Medium	Summer	No	Controlled rate of dewatering to minimize flow fluctuations	NA	No	Certain	Ongoing hydrological monitoring at Third Portage Lake outlet to Second Portage Lake

Table A.2 Continued

Project Components	Potential Effects	Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects	Proposed Mitigation	Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Mine Waste and Water Management Plan
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Pits												
Portage Pit	Some potential for high seepage rates from Second Portage and Third Portage lakes into pit, but minor effect lake water levels	Low	Local	Continuous	Medium	All Year	No	Dykes designed with suitable cutoffs to minimize seepage rates. Treatment plant and Attenuation Pond designed to handle projected seepage rates.	NA	No	Moderate	Monitoring of pit seepage rates.
Goose Island Pit	Some potential for high seepage rates from Third Portage lakes into pit, but minor effect lake water levels	Low	Local	Continuous	Medium	All Year	No	Dykes designed with suitable cutoffs to minimize seepage rates. Treatment plant and Attenuation Pond designed to handle projected seepage rates.	NA	No	Moderate	Monitoring of pit seepage rates.
Waste Dump (Portage & Goose)	Loss of natural surface drainage equal to the area of the waste dump. Loss of natural storage capacity in small ponds and wetlands. Changed local drainage patterns.	Low	Local	Infrequent	Medium	Summer	No	Collect and treat any runoff and/or seepage from waste dump. Divert non-contact water away from waste dump.	NA	No	Certain	Minimize footprint and separate clean from contaminated runoff as far as possible through appropriate layout; discharge clean run-off to Third Portage Lake
Borrow Pit(s)	No borrow pits required. All construction materials to be produced from on-site crushing & screening of pre-stripping material.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A.2 Continued

Project Components	Potential Effects	Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects	Proposed Mitigation	Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Mine Waste and Water Management Plan
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Tailings Disposal Facilities	Impacts previously resulted from construction of East Dyke (see dewatering during Construction phase)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Pumping of tailings water to treatment plant for discharge to Third Portage Lake after year 6. Minor increase in flows to Third Portage Lake, no measurable water level changes expected	Low	Local	Continuous	Medium	All Year	No	Pace treatment plant releases to receiving water flows; dishcarge water only during open water season.	NA	No	Certain	Monitor discharge volumes and timing.
Main Site Roads & Traffic	Disruption of surface drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Maintain roads & culverts in good condition and maintain adequate drainage patterns.	NA	No	Certain	Use sedimentation traps, selection of more durable materials for road surfacing.
Airstrip & Air Traffic	Disruption of surface drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Maintain adequate drainage patterns	NA	No	Certain	Strip straddles a ridge and drainage disruption minor. Ensure drainage pattersn are not disrupted.
Plant Site Footprint & Ground Activity	Interference with surface drainage patterns; runoff directed to the attenuation pond	Low	Local	Infrequent	Medium	Summer	No	Grade site to control and collect runoff.	NA	No	Certain	Clean runoff will be directed to attenuation pond and eventually discharged to Third Portage Lake; monitor integrity of surface drainage structures
Process Plant Activity including Freshwater Intake and Pipeline	Lower seasonal water levels in Third Portage Lake from freshwater consumption; annual consumption is estimated at 4.1 million cubic metres or 1.8% of the total volume of Third Portage Lake on an annual basis	Low	Local	Continuous	Medium	All Year	No	Minimize intake of fresh water; treat tailings and reclaim water and discharge back to Third Portage Lake; ensure reclaim system operates all year.	Decrease net process-related flows to/from Third Portage Lake	No	Certain	Monitor fresh water pumped, monitor reclaim system.

Table A.2 Continued

Project Components	Potential Effects	Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Mine Waste and Water Management Plan
Discharge Facilities & Pipeline	Possible minor increase in water levels in Third Portage Lake during discharge periods.	Low	Local	Continuous	Medium	Summer	No	Pace treatment plant releases to receiving water flows.	Minimize or eliminate possible effects	No	Certain	Monitor treated water flow at discharge point.
Non-Contact Diversion Facilities	Drainage patterns changed. Runoff diverted from Second Portage Lake catchment to Third Portage Lake catchment resulting in increased runoff volumes to Third Portage Lake.	Low	Local	Infrequent	Permanent	Summer	No	Diverted to Third Portage Lake.	NA	No	Certain	Monitor discharge volumes of non-contact water.
Fuel Storage (at Plant Site)	Minor loss of runoff volume to Third Portage Lake due to fuel containment berm. Site runoff directed to attenuation pond	Low	Local	Infrequent	Medium	Summer	No	None	NA	No	Certain	None recommended,
AN / Explosives Storage & Emulsion Plant	Minor loss of runoff volume to Third Portage Lake due to containment berm. Interference with drainage patterns	Low	Local	Infrequent	Medium	Summer	No	None	NA	No	Certain	None recommended.
Site Accommodations	Interference with local drainage patterns (see Plant Site above)	Low	Local	Infrequent	Medium	Summer	No	Grade site to control runoff.	NA	No	Certain	None recommended.
Sewage & Waste Disposal	Very small effects on surface water quantity. Treated water is discharged to tailings pond, treated again before being discharged to Third Portage Lake	Low	Local	Infrequent	Medium	All Year	No	Discharge treated water back to Third Portage Lake.	NA	No	Certain	None recommended.
VAULT FACILITIES												
Construction Noise and Activity	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A.2 Continued

Project Components	Potential Effects	Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Mine Waste and Water Management Plan
Vault Dyke	Impact on water circulation patterns in Wally Lake	Low	Local	Continuous	Medium	All Year	No	None	NA	No	Certain	None recommended.
Dewatering												
Vault Lake Dewatering & Drainage Facilities	Dewatering occurred during Construction phase	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Ongoing discharge into Wally Lake from attenuation pond, not expected to be greatly different from pre-development	Low	Local	Infrequent	Medium	Summer	No	Control discharge rates to minimize/eliminate impacts on Wally Lake levels	NA	No	Certain	Monitor attenuation pond discharge rates.
Phaser Lake dewatering	Decrease in water volumes and levels in Phaser Lake	Low	Local	Infrequent	Medium-term	Summer	No	Control pumping rates to minimize the rate of summer drawdown in Phaser Lake	NA	No	Certain	Minimize fluctuations in water levels.
	Increased runoff volume into Turn Lake due to Phaser Lake diversion (ie., approximately 1m); additional volume during summer from lowering of Phaser Lake	Low	Local	Infrequent	Medium-term	Summer	No	Control pumping rates to minimize or eliminate impacts on Turn Lake levels	NA	No	Certain	Ongoing hydrological monitoring will be conducted at the Turn Lake outlet
Vault Pit	Pit water collected and pumped to attenuation Pond.	Low	Local	Infrequent	Medium	Summer	No	Attenuation Pond designed with adequate storage, controlled release or treat/release to Wally Lake	NA	No	Certain	Monitor attenuation pond levels.
Vault Waste Dump	Loss of natural surface drainage equal to the area of the waste dump. Loss of natural storage capacity in small ponds and wetlands. Changed local drainage patterns.	Low	Local	Infrequent	Medium	Summer	No	Collect and treat any runoff and/or seepage from waste dump. Divert non-contact water away from waste dump.	NA	No	Certain	Minimize footprint and separate clean from contaminated runoff as far as possible through appropriate layout; discharge clean run-off to Wally Lake

Table A.2 Continued

Project Components	Potential Effects	Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects	Proposed Mitigation	Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Mine Waste and Water Management Plan
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Vault Access Road	Disruption of surface drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Maintain roads & culverts in good condition and maintain adequate drainage patterns.	NA	No	Certain	Use sedimentation traps, selection of more durable materials for road surfacing.
Access Road Culverts (Turn Lake)	Culverts will reduce ability of Turn Lake to discharge spring freshet and Phaser Lake diversions resulting in increases in water levels	Medium	Local	Continuous	Medium-term	Summer	Yes	Culverts will be sized (ie., 2.5 m diameter) to handle 1:100 year flood events and increased discharge due to annual Phaser Lake dewatering; culverts will be installed in winter when the outlet from Turn Lake to Drilltrail Lake is frozen to the bottom, ensuring no disruption of flow	With no constraints on water discharge, the potential magnitude of the impact would be low	No	High	Ongoing hydrological monitoring wil be conducted at the Turn Lake outlet to Drilltrail Lake; check culverts on regular basis for blockages and ensure free-flowing
Mine Shop / Office	Interference with surface drainage patterns; runoff directed to the attenuation pond	Low	Local	Infrequent	Medium	Summer	No	Grade site to control and collect runoff.	NA	No	Certain	Clean runoff will be directed to attenuation pond and eventually discharged to Third Portage Lake; monitor integrity of surface drainage structures
OTHER FACILITIES												
Winter Road	No impact on surface water anticipated	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Existing route used traditionally
Baker Lake Access Road	Interference with local surface drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Maintain roads in good condition and maintain adequate drainage pattern.	NA	No	Certain	Use sedimentation traps, selection of more durable materials for road surfacing.
Barge Landing Facility	Small changes or interference with local drainage patterns and lake circulation	Low	Local	Infrequent	Medium	Summer	No	Minimize footprint.	NA	No	Certain	None recommended
Barge Traffic	No measurable impacts on surface water anticipated	NA	NA	NA	NA	NA	NA	NA		NA	NA	NA

Table A.2 Continued

Project Components	Potential Effects	Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects	Proposed Mitigation	Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Mine Waste and Water Management Plan
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Staging Facility (approx. 1.5 km east of Baker Lake)	Interference with local drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Minimize footprint; construct in area with minimal impacts to drainage patterns, install culverts as required	NA	No	Certain	Runoff directed to Baker Lake.
Explosives Magazine	Interference with local drainage patterns	Low	Local	Infrequent	Medium	Summer	No	None recommended	NA	No	Certain	None recommended
Tank Farm	Small loss of surface drainage area and interference with drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Maintain adequate drainage patterns.	NA	No	Certain	Monitor integrity of drainage facilities.

Table A.3: Surface Water Quantity Impact Matrix – Closure & Post-Closure

		Assessment of Unmitigated Effects							Assessment of Residual Effects			
		Spatial Boundaries			Temporal Boundaries							
Project Components	**Potential Effects**	**Magnitude**	**Spatial Extent**	**Frequency**	**Duration**	**Timing**	**Significance of Unmitigated Effects**	**Proposed Mitigation**	**Residual Effects/ Influence of Mitigation**	**Significance of Residual Impacts**	**Probability**	**Mine Waste and Water Management Plan**
MAIN SITE												
Construction Noise and Activity	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dykes											**High**	
East Dyke	Impact occurred during construction phase; remains permanently; will provde shoreline for arm of Third Portage Lake after reflooding	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
West Dyke	Impact occurred during construction phase; remains permanently; will provde shoreline for arm of Third Portage Lake after reflooding	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bay Zone Dyke	Breached on closure to allow controlled flooding of Portage pit; area of Third Portage Lake increased; some continued alteration of lake circulation patterns	Low	Local	Continuous	Permanent	All Year	No	Construct permanent breach openings to minimize water level differentials	NA	No	Certain	None recommended.
Goose Island and Third Portage Arm Dykes	Breached on closure to allow controlled flooding of Goose Island pit, portion of Third Portage Lake "recovered"; some continued alteration of lake circulation patterns	Low	Local	Continuous	Permanent	All Year	No	Construct permanent breach openings to minimize water level differentials	NA	No	Certain	None recommended.

Table A.3 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Extent	Frequency	Temporal Boundaries: Duration	Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Mine Waste and Water Management Plan
Rewatering												
Portage and Goose Island Pit	Instantaneous rewatering of the Portage and Goose Island Pit (100 million cubic metres) has the potential for significant drawdowns of Third Portage Lake	High	Regional	Infrequent	Short	All Year	Yes	Rather than instantaneous rewatering, pit flooding will be achieved by a combination of seepage, precipitation and some re-direction of annual freshet flows from Third Portage Lake	Impact of rewatering will be of low magnitude	No	High	Rewatering volumes will be carefully monitored.
	Third Portage Lake surface area and volume will increase after rewatering - POSITIVE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Lake circulation patterns will be altered with increased mixing expected due to the presence of a new arm of Third Portage Lake (formerly Portage Pit); because of the depth of pits, they will become a depositional area for sediment	Low	Local	Continuous	Permanent	All Year	No	None recommended	NA	No	High	None recommended
Dewatering	Construction phase	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A.3 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects					Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects			Mine Waste and Water Management Plan
		Spatial Boundaries			Temporal Boundaries							
		Magnitude	Spatial Extent	Frequency	Duration	Timing			Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	
Pits												
Portage Pit	Instantaneous rewatering of the Portage and Goose Island Pit (100 million cubic metres) has the potential for significant drawdowns of Third Portage Lake	High	Regional	Infrequent	Short	All Year	Yes	Rather than instantaneous rewatering, pit flooding will be achieved by a combination of seepage, precipitation and some re-direction of annual freshet flows from Third Portage Lake; complete breaching of dykes will not occur until water levels have stabilized	Impact of rewatering will be of low magnitude	No	High	Rewatering volumes will be carefully monitored.
Goose Island Pit	Instantaneous rewatering of the Portage and Goose Island Pit (100 million cubic metres) has the potential for significant drawdowns of Third Portage Lake	High	Regional	Infrequent	Short	All Year	Yes	Rather than instantaneous rewatering, pit flooding will be achieved by a combination of seepage, precipitation and some re-direction of annual freshet flows from Third Portage Lake; complete breaching of dykes will not occur until water levels have stabilized	Impact of rewatering will be of low magnitude	No	High	Rewatering volumes will be carefully monitored.
Waste Dump (Portage & Goose)	Recontoured surface drainage equal to the area of the waste dump gained on closure; loss of storage capacity in small local ponds and wetlands	Low	Local	Continuous	Permanent	All Year	No	Design stable drainage channels	NA	No	Certain	Monitor drainage volumes.

Table A.3 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects					Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects			Mine Waste and Water Management Plan
		Spatial Boundaries			Temporal Boundaries							
		Magnitude	Spatial Extent	Frequency	Duration	Timing			Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	
Borrow Pit(s)	No borrow pits identified in the project. All construction material locally generated.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tailings Disposal (Facilities & Ponds)	Permanent reduction of lake area and water volume in 2nd Portage Lake	High	Local	Continuous	Permanent	All Year	Yes	None recommended.	NA	Yes	Certain	None recommended.
	Larger catchment area diverted to Third Portage Lake	Low	Local	Continuous	Permanent	All Year	No	Design stable channels and outlets toThird Portage Lake	NA	No	High	Monitor diversion channel discharge volumes.
Main Site Roads & Traffic	Site roads to be decommissioned and reclaimed to restore drainage patterns - POSITIVE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Airstrip & Air Traffic	Upon completing closure activities the airstrip to be decommissioned and surface recontoured to restore drainage patterns; some ongoing disruption of circulation patterns in Third Portage Lake anticipated	Low	Local	Continuous	Permanent	All Year	No	Recontour and restore natural drainage patterns.	NA	No	High	Maintain drainage structures.
Plant Site Footprint	Upon completing closure activities the plant site to be decommissioned and surface recontoured to restore drainage patterns	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Process Plant Activity	No impacts during closure	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A.3 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects					Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects			Mine Waste and Water Management Plan
		Spatial Boundaries			Temporal Boundaries				Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Freshwater Intake & Pipeline	Intake structure and pipeline removed; temporary very minor disturbance in lake during removal activities.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Discharge Facilities & Pipeline	Discharge facilities and pipeline removed; temporary very minor disturbance in lake during removal activities.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Non-Contact Diversion Facilities	On closure all surfaces to be reclaimed and recontoured to provide adequate drainage to the natural environment	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fuel Storage (at Plant Site)	Upon completing closure activities the fuel storage site will be decommissioned and surface recontoured to restore drainage patterns	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AN / Explosives Storage & Emulsion Plant	Upon completing closure activities the fuel storage will be decommissioned and surface recontoured to restore drainage patterns	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Accommodations Complex	See Plantsite Footprint	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage & Waste Disposal	No impacts during closure; facilities removed.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
VAULT FACILITIES												

Table A.3 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Extent	Frequency	Temporal Boundaries: Duration	Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Mine Waste and Water Management Plan
Construction Noise and Activity	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA	NA
Vault Dyke and Pit	Instantaneous rewatering of the Vault Pit has the potential for significant drawdowns of Third Portage Lake	High	Regional	Infrequent	Short	All Year	Yes	Rather than instantaneous rewatering, pit flooding will be achieved by a combination of seepage, precipitation and some re-direction of annual freshet flows from Wally Lake; complete breaching of dykes will not occur until water levels have stabilized	Impact of rewatering will be of low magnitude	No	High	Rewatering volumes will be carefully monitored.
Vault Waste Dump	Recontoured surface drainage equal to the area of the waste dump gained on closure; loss of storage capacity in small local ponds and wetlands	Low	Local	Continuous	Permanent	All Year	No	Design stable drainage channels	NA	No	Certain	Monitor drainage volumes.
Vault Access Road & Traffic	Site roads to be decommissioned and reclaimed to restore drainage patterns - POSITIVE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Access Road Culverts (Turn Lake)	Culverts removed to restore natural drainage patterns - POSITIVE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mine Shop / Office	Upon completing closure activities the mine shop and office to be decommissioned and surface recontoured to restore drainage patterns	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OTHER FACILITIES												

Table A.3 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Extent	Frequency	Temporal Boundaries: Duration	Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Mine Waste and Water Management Plan
Winter Road & Traffic	No impact.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Baker Lake Access Road & Traffic	Interference with local surface drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Maintain roads in good condition and maintain adequate drainage pattern.	NA	No	Certain	Use sedimentation traps, selection of more durable materials for road surfacing.
Barge Landing Facility	Activities cease on closure.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barge Traffic	Activities cease on closure.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Staging Facility (approx. 1.5 km east of town)	Interference with local drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Maintain drainage patterns.	NA	No	Certain	Runoff directed to Baker Lake.
Explosives Magazine	Interference with local drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Maintain drainage patterns.	NA	No	Certain	Runoff directed to Baker Lake.
Tank Farm	Interference with local drainage patterns	Low	Local	Infrequent	Medium	Summer	No	Maintain drainage patterns.	NA	No	Certain	Runoff directed to Baker Lake.

APPENDIX B

Table B.1: Water Quality Impact Matrix – Construction

		Assessment of Unmitigated Effects							Assessment of Residual Effects			
		Spatial Boundaries		Temporal Boundaries								
Project Component	**Potential Effect**	**Magnitude**	**Spatial Extent**	**Frequency**	**Duration**	**Timing**	**Significance of Unmitigated Effects**	**Proposed Mitigation**	**Influence of Mitigation on Effects Assessment**	**Significance of Residual Impacts**	**Probability**	**Management and Monitoring**
MAIN FACILITIES												
Construction Noise & Activity (General)	Sedimentation may degrade nearby water quality.	medium	footprint to local	Continuous	Short-term	Summer	low	Best management practices for sediment control (silt fences, settling ponds, silt curtains, sediment traps). See Mine Waste and Water Management Plan	high	low	medium	Maintain and monitor conditions. See Mine Waste and Water Management Plan and Aquatic Environmental Management Plan.
	Dust and emission from construction activities may degrade nearby water quality	low	footprint to local	Continuous	Short-term	Summer	low	Use of dust suppressants, watering, road preparation and/or other dust control procedures. See Air Quality and Noise Management Plan.	high	low	high	See Air Quality and Noise Management Plan and Aquatic Environment Management Plan
	Potential for blasting residues (nitrogen species) to be released to lakes in runoff or melting of lake ice	medium	footprint to local	Frequent	Short-term	Summer	low	Appropriate selection of explosive type, and charge load. Best Management Practices to minimize spills and excess explosives loss. See Aquatic Environment Management Plan and Mine Waste and Water Management Plan)	medium	low	medium	See Aquatic Environment Management Plan
	Spills of fuel and/or loads on ice and in close proximity to water bodies may result in water quality degradation.	medium	footprint to local	Rare	Short-term	All Year	low to medium	Implement Spill Contingency Plan and other emergency responses, when required.	medium	low	medium	Spill Contingency Plan, Emergency Response Plan, and Accidents and Malfunctions Plan

Table B.1 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Dykes												
All Dikes	Dust and emission from construction activities may degrade water quality in 2PL and 3PL	low	local	Continuous	Short-term	Summer	low	Use of dust suppressants, watering, road preparation and/or other dust control procedures. See Air Quality and Noise Management Plan.	high	low	high	See Air Quality and Noise Management Plan and Aquatic Environment Management Plan
East Dike	Disturbance of lake sediment during rock placement releasing TSS to 2PL	very high to high	footprint to local	Continuous	Short-term	Summer	high	Utilize silt curtains, and other sediment control practices and monitoring (BMP). See Aquatic Environment Management Plan.	High: Spatical extent reduced to vicinity of dikes inside silt curtains	medium to low	medium	See Aquatic Environment Management Plan and other relevant monitoring documents
	Release of soluble rock and/or till constituents to dike porewaters and 2PL as material is placed into water (blasting residues, metals, TSS).	high to medium	footprint	Continuous	Short-term	Summer	medium	Appropriate selection of explosive type (use emulsion explosives rather than dry ANFO), and charge load. Selection of appropriate rock type for use to minimize metals loading (rocks with low leaching potential) and potential acid generation. See Aquatic Environment Management Plan.	Medium: Magnitude reduced	medium to low	medium to low	Monitor water quality. See Aquatic Environment Management Plan
	Seepage through dike to pit area during and after drawdown	high	footprint	Continuous	Short-term	Summer	low	Collect seepage water and direct to the settling pond.	high	low	high	Mine Waste and Water Management Plan

Table B.1 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
West (Tailings) Dike	Runoff from construction materials will enter the de-watered area of the northwest arm of Second Portage Lake, and will likely be contained within shallow remnant ponds.	very high to high	footprint	Continuous	Short-term	Summer	low	Best management practices for sediment control (silt fences, settling ponds, sediment traps). Construct diversion facilities to capture and direct water to settling ponds.	medium	low	medium	Maintain and monitor conditions. See Mine Waste and Water Management Plan and Aquatic Environmental Management Plan.
Portage South (Bay Zone) Dike	Disturbance of lake sediment during rock placement, releasing TSS to 3PL	very high to high	footprint to local	Continuous	Short-term	Summer	high	Utilize silt curtains, and other sediment control practices and monitoring (BMP). See Aquatic Environment Management Plan.	High: Spatical extent reduced to vicinity of dikes inside silt curtains	medium to low	medium	See Aquatic Environment Management Plan and other relevant monitoring documents
	Release of soluble rock and/or till constituents to 3PL as material is placed into water (blasting residues, metals, TSS)	high to medium	footprint	Continuous	Short-term	Summer	medium	Appropriate selection of explosive type (use emulsion explosives rather than dry ANFO), and charge load. Selection of appropriate rock type for use to minimize metals loading (rocks with low leaching potential) and potential acid generation. See Aquatic Environment Management Plan.	Medium: Magnitude reduced	medium to low	medium to low	Monitor water quality. See Aquatic Environment Management Plan
	Seepage through dike during and after drawdown	high	footprint	Continuous	Short-term	Summer	low	Collect seepage water and direct to the settling pond.	high	low	high	Mined Waste and Water Management Plan
Goose Island & 3rd Portage Arm (South Camp Island) Dikes	Constructed during operations (see comments in Operations Matrix)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table B.1 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Dewatering												
2nd Portage Lake	Release of TSS to 3PL in dewatering discharge	very high to high	footprint to local	Frequent	Short-term	Summer	high	Only relatively clean water to be discharged directly to 3PL; non-compliant water to be directed to tailings storage facility or attenuation storage pond. Monitor location of suction pipe to minimize sediment disturbance. Monitor outlet pipe location and use silt curtains.	high	low	medium	Monitor conditions. See Mine Waste and Water Management Plan and Aquatic Environmental Management Plan.
Portage Pit (3rd Portage Lake)	Release of TSS to 3PL in dewatering discharge	very high to high	footprint to local	Frequent	Short-term	Summer	high	Only relatively clean water to be discharged directly to 3PL; non-compliant water to be directed to tailings storage facility or attenuation storage pond. Monitor location of suction pipe to minimize sediment disturbance. Monitor outlet pipe location an use silt curtains.	high	low	medium	Monitor conditions. See Mine Waste and Water Management Plan and Aquatic Environmental Management Plan.
Goose Island (3rd Portage Lake)	Dewatered during operations (see comments in Operations Matrix)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table B.1 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Pits												
Portage Pit	Release of sediments, metals and contaminants to local sumps, and possibly local lakes and groundwater, from surface water runoff during overburden and lake sediment prestripping and initial mining.	very high to high	footprint to local	Continuous	Short to medium term	Summer	low to high	Direct sump water to tailings storage facility, use sediment control structures and BMP. Contain water and treat, if required before discharge. Impacts to groundwater are likely limited to surface active layer within mine footprint, as groundwater flows into, not out of, dewatered pit. See Mine Waste and Water Management Plan.	high	low	medium	Monitor conditions. See Mine Waste and Water Management Plan and Aquatic Environmental Management Plan.
	Generation of dust from blasting, overburden stripping, excavation and other construction activities depositing in 2PL and 3PL.	medium	footprint	Frequent	Short-term	All Year	low	Use of dust suppressants, watering, road preparation and/or other dust control procedures (see Air Quality and Noise Management Plan). Select appropriate explosives and charge weight. Maintain and operate equipment in an efficient manner.	medium	low	medium	See Air Quality and Noise Management Plan and Aquatic Environment Management Plan
Goose Island Pit	Constructed during operations (see comments in Operation Matrix)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table B.1 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Portage Rock Storage Facility	TSS, metals and acidity from waste rock seepage and runoff released to tundra, surface water and ground water	very high to high	footprint	Continuous	Short to medium term	Summer	medium	Material to be placed in containment facility. Seepage and runoff to be collected by collection facilities and sumps, and directed to Attenuation Storage Pond for discharge and treatment if required. Release to groundwater will be limited by collection facilities. Rock will eventually freeze (below the active zone) reducing potential generation of metals and acidic drainage. See Mine Waste and Water Management Plan.	high	low	high	Monitor conditions. See Mine Waste and Water Management Plan, and Aquatic Environmental Management Plan.
	Dust and emissions generated from stripping of organic soils and deposition of waste rock, reaching 2PL through direct deposition or in runoff.	medium	footprint	Frequent	Short-term	All Year	low	Use of dust suppressants, watering, road preparation and/or other dust control procedures (see Air Quality and Noise Management Plan). Select appropriate explosives and charge weight. Maintain and operate equipment in an efficient manner.	medium	low	medium	See Air Quality and Noise Management Plan and Aquatic Environment Management Plan
Borrow Pit(s)	N/A (All borrow from within pit footprint)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table B.1 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Tailings Disposal Facilities	N/A (See comments on Tailings Dike construction)											
Main Site Roads & Traffic	Sedimentation, dusting, fuel and load spills from traffic affects quality in water bodies along transit route.	medium	footprint and local	Continuous/ Rare	Short-term	Summer/ All Year	medium to low	Use of dust suppressants, watering, road preparation and/or other dust control procedures (see Air Quality and noise Management Plan). Use BMP for sediment control in ditches and control of runoff. Implement Spill Contingency Plan and other emergency responses, when required.	high	low	medium	Monitor conditions. See Mine Waste and Water Management Plan, Aquatic Environmental Management Plan, Air Quality and Noise Management Plan.
Airstrip & Air Traffic	Sedimentation and dusting from construction affects water quality in 3PL.	medium	local	Continuous	Short-term	Summer	medium	Use of dust suppressants, watering, road preparation and/or other dust control procedures (see Air Quality and Noise Management Plan). Use BMP for sediment control in ditches and control of runoff. Implement Spill Contingency Plan and other emergency responses, when required. Minimize disturbed area.	high	low	medium	Monitor conditions. See Mine Waste and Water Management Plan, Aquatic Environmental Management Plan, Air Quality and Noise Management Plan.

Table B.1 Continued

		Assessment of Unmitigated Effects							Assessment of Residual Effects			
		Spatial Boundaries		Temporal Boundaries								
Project Component	Potential Effect	Magnitude	Spatial Extent	Frequency	Duration	Timing	Significance of Unmitigated Effects	Proposed Mitigation	Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Mine Plant and Associated Facilities	Sedimentation and dusting from construction, fuel and load spills from traffic effects localized water quality that drains to tailings impoundment.	medium	footprint	Continuous/ Rare	Short-term	Summer/ All Year	low	Use of dust suppressants, watering, road preparation and/or other dust control procedures (see Air Quality and Noise Management Plan). Use BMP for sediment control in ditches and control of runoff. Implement Spill Contingency Plan and other emergency responses, when required. Minimize disturbed area.	high	low	medium	Monitor conditions. See Mine Waste and Water Management Plan, Aquatic Environmental Management Plan, Air Quality and Noise Management Plan.
Freshwater Intake & Pipeline	Disruption of 3PL foreshore from construction of wet well or barge causes release of sediment to 3Pl. Blasting for wet well releases blast residues and emissions to 3PL. Construction of pipeline will release sediment to 3PL along route	low	footprint	Rare	Short-term	Summer	low	Use BMP for construction and control of sediment and dust. Minimize disturbed area. Pipeline constructed above ground surface on raised footings.	high	low	high	Monitor conditions.
Discharge Facilities & Pipeline	Disruption of 3PL foreshore from construction of diffuser station and pipeline causes release of sediment to 3Pl.	low	footprint	Rare	Short-term	Summer	low	Use BMP for construction and control of sediment and dust. Minimize disturbed area. Pipeline constructed above ground surface on raised footings.	high	low	high	Monitor conditions.

Table B.1 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Effluent Discharge	Effluent from construction disturbance released to 3PL	medium	local	Continuous	Short-term	Summer	medium	Surface waters in mine footprint collected in natural depressions in dewatered Northwest Arm of 2PL. Best Management Practices applied to reduce total suspended solids. No effluent discharge planned during construction period. See Mine Waste and Water Management Plan	high	low	high	Monitor contained water quality and filling of depressions (Mine Waste and Water Management Plan)
Non-Contact Diversion Facilities	Sedimentation from construction of ditches and sumps released to 2PL and/or 3PL; sediment losses due to degradation of permafrost associated with ditches and sumps, particularly through bogs.	medium	footprint	Frequent	Short-term	Summer	low	Use BMP for construction and control of sediment and dust.	medium	low	medium	Monitor conditions. See Mine Waste and Water Management Plan, Aquatic Environmental Management Plan.

Table B.1 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Storage (at Plant Site)	Construction of laydown areas releases sediment and blast residues which drain to tailings impoundment or 3PL.	medium	footprint	Continuous	Short-term	Summer	low	Runoff directed to tailings impoundment, or directed to sedimentation ponds and pumped to tailings impoundment.	high	low	high	Monitor conditions.
	Fuel storage area construction of area and potential leaks.	medium	footprint	Continuous/ Rare	Short-term	Summer/ All Year	medium to low	Contain runoff and trap sediments from construction area using BMP and direct water to sedimentation ponds. In the event of a spill containment should be achieved by protective liner and bermed area.	high	low	high	Mine Waste and Water Management Plan
AN/Explosives Storage & Emulsion Plant	Sedimentation and blast residues during facility construction released to local water bodies	medium	footprint	Continuous	Short-term	Summer	low	Runoff directed to tailings impoundment, or directed to sedimentation ponds and pumped to tailings impoundment.	high	low	high	Monitor conditions.
	Spills of explosives during manufacture and transport	medium	footprint	Rare	Short-term	All Year	low/medium	Implement Spill Contingency Plan and other emergency responses, when required.	medium	low	medium	Spill Contingency Plan, Emergency Response Plan, and Accidents and Malfunctions Plan

Table B.1 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Site Accommodations	Construction of site accommodations releases sediment to local water bodies and sediment ponds.	medium	footprint	Continuous	Short-term	Summer	low	Use BMP for construction and control of sediment and dust. Minimize disturbed area.	high	low	high	Monitor conditions. See Mine Waste and Water Management Plan, Aquatic Environmental Management Plan.
	Incinerated waste emissions settle in water bodies, degrading water quality	low	local	Continuous	Short-term	All Year	low	Use BMP for operation of facility and insure appropriate environmental controls for stack emissions are in place.	medium	low	high	Air Quality and Noise Management Plan
	Leachate from incineration ashes enter water bodies, degrading water quality	medium	footprint	Continuous	Short-term	Summer	medium to low	Incinerator residue will be disposed of in the tailings facility. Monitor and maintain tailings facility and ensure dust control so incinerator ash does not become airborne.	high	low	medium	Mine Waste and Water Management Plan
Sewage & Waste Disposal	Waste water and sewage discharge increases BOD and nutrient load to water bodies	medium	footprint	Continuous	Short-term	All Year	low	Sewage treatment plant to reduce effluent concentrations to legislated levels. Sewage sludge will be incinerated. Effluent from sewage treatment plant will be disposed of in the tailings facility.	high	low	medium	Mine Waste and Water Management Plan
VAULT FACILITIES												
Construction Noise & Activity	Constructed during operations (see comments in Operations Matrix)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vault Dike	Constructed during operations (see comments in Operations Matrix)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table B.1 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Vault Lake Dewatering & Drainage Facilities	Constructed during operations (see comments in Operations Matrix)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vault Pit	Constructed during operations (see comments in Operations Matrix)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vault Rock Storage Facility	Constructed during operations (see comments in Operations Matrix)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vault Area Effluent Discharge	N/A during construction	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vault Access Road & Traffic	Constructed during operations (see comments in Operations Matrix)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Access Road Culverts (Tern Lake)	Constructed during operations (see comments in Operations Matrix)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mine Shop/Office	Constructed during operations (see comments in Operations Matrix)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
OTHER FACILITIES												
Winter Road & Traffic	Spills of fuel and/or loads on ice and in close proximity to water bodies may result in water quality degradation.	medium	footprint	Rare	Short-term	All Year	low to medium	Implement Spill Contingency Plan and other emergency responses, when required.	medium	low	medium	Spill Contingency Plan, Emergency Response Plan, and Accidents and Malfunctions Plan
Baker Lake Access Road & Traffic	Sedimentation, dusting, fuel and load spills from traffic affects quality in water bodies along transit route.	low to medium	footprint	Continuous/ Rare	Short-term	All Year	low to medium	Implement Spill Contingency Plan and other emergency responses, when required. Follow BMP for storm water management and sediment control, and use dust control measures, as necessary.	medium	low	medium	Spill Contingency Plan, Emergency Response Plan, and Accidents and Malfunctions Plan

Table B.1 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Barge Landing Facility	Localized degradation of water quality along Baker Lake foreshore due to sediment loading during construction of facility. Loss of diesel during transfer.	low to medium	footprint	Continuous/ Rare	Short-term	Summer	low to medium	Implement Spill Contingency Plan and other emergency responses, when required. Follow BMP for storm water management and sediment control, and use dust control measures, as necessary.	medium	low	medium	Spill Contingency Plan, Emergency Response Plan, and Accidents and Malfunctions Plan
Barge Traffic	Dust and emissions from off-loading equipment traffic settles in Baker Lake affecting water quality	low	footprint	Continuous	Short-term	Summer	low	Use dust control, as required. Ensure proper equipment maintenance.	medium	low	medium	Air Quality and Noise Management Plan
	Fuel and load spills from traffic affects runoff quality and possibly water bodies along transit route.	low to medium	footprint	Continuous/ Rare	Short-term	All Year	low to medium	Implement Spill Contingency Plan and other emergency responses, when required. Follow BMP for storm water management and sediment control, and use dust control measures, as necessary.	medium	low	medium	Spill Contingency Plan, Emergency Response Plan, and Accidents and Malfunctions Plan
In-town Staging Facility												
Explosives Magazine	Disturbance of area with sediment entering surface water runoff during construction. Once in use if an accident, then leaks, fires or explosions from this facility could negatively impact water quality.	low to high	footprint	Continuous/ Rare	Short-term	Summer/ All Year	low to high	Construct plant on concrete foundation surrounded by a berm and drainage control structures. See Hazardous Materials Management Plan	high	low	medium	See Construction Documents and Hazardous Materials Storage Plan

Table B.1 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Tank Farm	Diesel spills to Baker Lake	low to medium	footprint	Rare	Short-term	All Year	low to medium	Lined, bermed facility	high	low	high	Spill Contingency Plan, Emergency Response Plan, and Accidents and Malfunctions Plan

Table B.2: Water Quality Impact Matrix – Operation

Project Component	Potential Effect	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
MAIN FACILITIES												
Construction Noise & Activity	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dykes												
East Dike	Leaching of metals and acidity from dike rock to 2PL Leached metals and acidity initially reach pit as seepage through dike. Metals and acidity in runoff from downstream (pit side) rock embankment report to pit (see Pit discussions)	Low	footprint to local	Continuous	Long-term	Year Round	low	Use of UM rock for capping. Use of IF for submerged rock in upstream shell.	medium	low	medium to high	Monitor water quality adjacent to dikes. See Aquatic Environment Management Plan.
West (Tailings) Dike	Metals and acidity in seepage and runoff from downstream (pit side) of rock embankment report to pit	High	Footprint	Frequent	Medium-term	Summer	Low	Use of IV and UM as construction rock. Directing all seepage and runoff to pit, and pump to attenuation pond for potential treatment. Permafrost aggradaion into dike will reduce seepage.	Medium: magnitude reduced	Low	medium	Monitor internal dike temperature using thermistors (potential seepage control).
	Metals and acidity in runoff from downstream portion of tailings dam report to tailings impoundment (See Tailings Storage Facility Discussion)	High	Footprint	Frequent	Medium-term	Summer	Low	Use of IV and UM as construction rock. Directing all seepage and runoff to tailings storage facility and eventually attenuation pond for treatment.	Medium: magnitude reduced	Low	medium	
Portage South (Bay Zone) Dike	Leaching of metals and acidity from dike rock to 3PL during open season Leached metals and acidity initially reach pit as seepage through dike. Metals and acidity in runoff from downstream (pit side) rock embankment report to pit (see Pit discussions)	Low	footprint to local	Continuous	Long-term	Year Round	low	Use of UM rock for capping. Use of IF for submerged rock in upstream shell.	medium	low	medium to high	Monitor water quality adjacent to dikes. See Aquatic Environment Management Plan.

Table B.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Goose Island & 3rd Portage Arm (South Camp Island) Dikes	Disturbance of lake sediment during rock placement, releasing TSS to 3PL	very high to high	footprint to local	Continuous	Short-term	Summer	high	Utilize silt curtains, and other sediment control practices and monitoring (BMP). See Aquatic Environment Management Plan.	high	medium to low	medium	See Aquatic Environment Management Plan.
	Release of soluble rock and/or till constituents to 2PL as material is placed into water (blasting residues, metals, TSS)	high to medium	footprint	Continuous	Short-term	Summer	medium to low	Appropriate selection of explosive type (use emulsion explosives rather than dry ANFO), and charge load. Selection of appropriate rock type for use to minimize metals loading (rocks with low leaching potential) and potential acid generation. See Aquatic Environment Management Plan.	medium	medium to low	medium to low	Monitor water quality. See Aquatic Environment Management Plan
	Seepage through dike to pit during and after drawdown (See Pit Discussion)											
	Leaching of metals and acidity from dike rock to 3PL during open season Leached metals and acidity initially reach pit as seepage through dyke. Metals and acidity in runoff from downstream shell of dam report to pit (see Pit discussions)	Low	footprint to local	Continuous	Long-term	Year Round	low	Use of UM rock for capping. Use of IF for submerged rock in upstream shell.	medium	low	medium to high	Monitor water quality adjacent to dikes. See Aquatic Environment Management Plan.
Dewatering												
2nd Portage Lake	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Portage Pit (3rd Portage Lake)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table B.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Goose Island (3rd Portage Lake)	Release of TSS to 3PL in dewatering discharge	very high to high	footprint to local	Frequent	Short-term	Summer	high	Only relatively clean water to be discharged directly to 3PL; non-compliant water to be directed to tailings storage facility or attenuation storage pond. Monitor location of suction pipe to minimize sediment disturbance. Monitor outlet pipe location an use silt curtains.	high	low	medium	Monitor conditions. See Mine Waste and Water Management Plan and Aquatic Environmental Management Plan.
	Dust and emission from construction activities may degrade water quality in 2PL and 3PL	low	footprint	Continuous	Short-term	Summer	low	Use of dust suppressants, watering, road preparation and/or other dust control procedures. See Air Quality and Noise Management Plan.	high	low	high	See Air Quality and Noise Management Plan and Aquatic Environment Management Plan
Pits												
Portage Pit	Metals, acidity and explosives residues are released in runoff from pit walls and in seepage and runoff from dikes.	Very High	Footprint	Continuous	Medium-term	Year Round	Low	Use of appropriate rock in dike construction. Remove water rapidly from pit. Encourage permafrost aggradation into dike to reduce seepage. Collect pit water and pump to attenuation pond for potential treatment.	Medium	Low	medium	Monitor conditions. See Mine Waste and Water Management Plan.

Table B.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Goose Island Pit	Metals, acidity and explosives residues are released in runoff from pit wall and seepage and runoff from dikes	Very High	Footprint	Continuous	Medium-term	Year Round	Low	Use of appropriate rock in dike construction, removal of water rapidly from pit, pit water collected and directed to attenuation pond.	Medium	Low	medium	Monitor conditions. See Mine Waste and Water Management Plan.
	Dust and emissions from haul truck traffic	Low	Footprint	Continuous	Medium-term	Year Round	Low	Use of water trucks for dust suppression	Medium	Low	High	
	Potential for blasting residues (nitrogen species) to be released to lakes in runoff or melting of lake ice	medium	fooprint to local	Frequent	Short-term	Summer	low	Appropriate selection of explosive type, and charge load. Best Management Practices to minimize spills and excess explosives loss. See AEMP	medium	Low	medium	See Aquatic Environment Management Plan
Portage Rock Storage Facility	Metals, acidity and nitrogen species are released in seepage and runoff to tundra, active layer groundwater and project lakes	High	Local	Frequent	Medium-Term	Summer	High	Seepage and runoff contained by collection facilities, and directed to sumps and the attenuation pond. Release to active layer groundwater limited by collection facilities.	High: Spatial extent reduced	Low	High	
Borrow Pit(s)	Within waste rock storage facility and/or ultimate pit footprints.											

Table B.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Assessment of Unmitigated Effects: Spatial Boundaries: Spatial Extent	Assessment of Unmitigated Effects: Temporal Boundaries: Frequency	Assessment of Unmitigated Effects: Temporal Boundaries: Duration	Assessment of Unmitigated Effects: Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Assessment of Residual Effects: Significance of Residual Impacts	Assessment of Residual Effects: Probability	Management and Monitoring
Tailings Disposal Facilities	Decant from tailings process water and runoff from exposed tailings beaches confined to tailings storage facility from Year 1 to 5. Tailings Pond and Portage Attenuation Pond are combined after Year 5 (See comments on Portage Attenuation Pond)	Very high	Footprint	Continuous	Medium-term	All Year	Low	Cyanide destruction treatment in mill. Progressive capping with UM rock to promote freezing and improve runoff quality. Recycle to mill to reduce volumes. Contained within tailings pond with in Years 1 to 5. No contribution to effluent discharge to 3PL.	High: Spatial extent confined to footprint; No contribution to effluent.	Low	High	Monitor cyanide destruction plant and reclaim to validate predictions. Monitor of internal temperatures in tailings with thermistors.
	Release of concentrated pore water when forced to surface during tailings freeze back	Very High	Footprint	Infrequent	Medium to Long term	Winter	Low	Containment in tailings disposal facility and/or attenuation pond, with treatment before discharge to environment. Progressive capping with UM rock to encourage freezing of tailings	High	Low	Medium	Monitor tailings beach and recycle
	Dust from desiccated exposed tailings transports metals and nitrogen species to local water bodies.	Medium	Footprint to Local	Infrequent	Medium-term	Year Round	Medium	Progressive placement of UM cover material to reduce erosion and wind blow dust (Abandonment & Restoration Plan)	Medium: magnitude reduced; Spatial extent reduced.	Low	Medium	Air Quality and Noise Monitoring Plan
	Tailings process water moves into the groundwater system via the talik under the former Northwest Arm of Second Poratage Lake	Very high	footprint to local	Continuous	Medium-term	Year Round	High	Promote permafrost aggradation in the tailings facility to encourage permafrost to act as a cutoff to groundwater flow.	High: Reduce magnitude, reduce spatial extent	Low	Medium	Monitor permafrost development in the underlying talik

Table B.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Main Site Roads & Traffic	Diesel spills to local water bodies	Medium	Footprint to Local	Rare	Medium to Long term	Year Round	Medium to Low	Best Management Practices and Spill Contingency Plans	Medium	Low	High	
	Dust from traffic releases metals and nitrogen species to local water bodies	Low	Footprint/Local	Frequent	Medium-term	Year round	Low	Dust control water will be drawn from the Portage Attenuation Pond (Abandonment & Restoration Plan) within Portage catchment. Dust control water for haul roads outside the Portage catchment areas will be drawn from Phase Lake in an effort to keep contact water within the mining areas. (Abandonment & Restoration Plan)	Medium	Low	High	Air Quality and Noise Monitoring Plan
	Metals, acidity and nitrogen species in runoff and seepage from road bed are released to local water bodies	Low	Footprint to Local	Frequent	Medium to Long term	Summer	Low	Majority of roadways servicing the Portage mining and milling areas are located such that their drainage will be directed at proposed contact water management infrastructure (Abandonment & Restoration Plan)	Medium	Low	medium	Mine site monitoring, and settling pond cleanout

Table B.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Airstrip & Air Traffic	Fuel spills to local water bodies	Medium	Footprint to Local	Rare	Medium to Long term	Year Round	Medium to Low	Best Management Practices and Spill Contingency Plans	Medium	Low	High	
	Dust from air traffic/ loading and unloading transports metals and nitrogen species to local water bodies	Low	Footprint/Local	Frequent	Medium-term	Year round	Low	Dust control water will be drawn from the Portage Attenuation Pond (Abandonment & Restoration Plan) within Portage catchment. Dust control water for haul roads outside the Portage catchment areas will be drawn from Phase Lake in an effort to keep contact water within the mining areas. (Abandonment & Restoration Plan)	Medium	Low	High	Air Quality and Noise Monitoring Plan
	Metals, acidity and nitrogen species in runoff and seepage from road bed are released to local water bodies	Low	Footprint to Local	Frequent	Medium to Long term	Summer	Low	Runoff collected in ditches and directed to attenuation pond	Medium	Low	Medium	Mine site monitoring, and settling pond cleanout
Mine Plant and Associated Facilities	Runoff from mine plant site contains TSS, metals, acidity and potential reagent spills.	Medium	Footprint	Infrequent	Medium-term	Summer	Medium	Plant site runoff directed to a local sump, and pumped to attenuation pond.	High	Low	High	Mine site monitoring, and settling pond cleanout
	Dust from traffic and ore handling releases metals and nitrogen species to local water bodies.	Low	Footprint/Local	Frequent	Medium-term	Year round	Low	Dust control water will be drawn from the Portage Attenuation Pond (Abandonment & Restoration Plan)	Medium	Low	High	Air Quality and Noise Monitoring Plan
	Inadvertent spill of tailings.	High	Footprint	Rare	Medium-term	Year round	Low	Tailings contained within ditch, containment sumps located in depressions, Pipeline pressure monitored	High	Low	High	Regular inspections of tailings pipeline; Monitoring of tailings line pressure.
Freshwater Intake & Pipeline	N/A											

Table B.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Portage Attentuation Pond (Discharge Facilities & Pipeline)	From Year 1 to 5, effluent from attenuation pond releases TSS, metals, acidity, explosives residues to 3PL. Effluent sources are runoff and seepage from Portage Area Pits, Portage Rock Storage Facility and Plant Site Runoff.	Medium	Local	Continuous	Medium-term	Summer	Medium	All effluents directed to Portage Attenuation Pond for settling and monitoring prior to discharge; See comments on effluent sources for additional mitigation. Effluent discharged through diffusers, only during summer months	medium	Low	Low	
	After Year 5, effluent includes tailings supernatant, releasing TSS, metals, acidity, explosives residue and cyanide species to 3PL.	High	Local	Continuous	Medium-term	Summer	High	All effluents directed to Portage Attenuation Pond for settling and treatment prior to discharge. See comments on effluent sources for additional mitigation. Effluent discharged through diffusers, only during summer months. Potable water intake located away from effluent discharge location.	medium	Medium	Low	
Non-Contact Diversion Facilities	Sediment loss to receiving waters due to degradation of permafrost associated with ditch and sump construction, particularly through bogs..	medium	Local	Infrequent	Medium to Long term	Summer	Low	Construction of diversion facility to address local permafrost conditions, and placement of erosion protection.	Medium	Low	Medium	See Aquatic Environmental Management Plan
Storage (at Plant Site)	Runoff from storage facility contains contaminants from pad, stored materials or spilled diesel and reagents.	High	Footprint	Infrequent	Medium - term	Summer	Low	Plant site runoff directed to a local sump, and pumped to attenuation pond. Spill Contingency Plan	High	Low	Medium	

Table B.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
AN/Explosives Storage & Emulsion Plant	Spills of explosives during manufacture and transport	Medium	Footprint	Rare	Medium to Long term	Summer	Low	Best Management Practices; Runoff collected and directed to settling pond.	Medium	Low	Medium	
	Site runoff releases nitrogen species to local water bodies	Medium	Footprint	Infrequent	Medium to Long term	Summer	Low	Placed on a local topographic high; runoff collected and directed to settling pond	Medium	Low	Medium	See Aquatic Environmental Management Plan
Site Accommodations	Incinerated waste emissions settle in water bodies, degrading water quality	Low	Local	Frequent	Medium-term	Year Round	Low	Best Management Practices in operation of incinerator.	High	Low	Medium	Air Quality and Noise Monitoring Plan
	Leachate from incineration ashes enter water bodies, degrading water quality							Ash from incinerated organic materials (including but not limited to paper, wood, food waste and sewage treatment sludge will be placed within the tailings impoundment (Abandonment & Restoration Plan)				
Sewage & Waste Disposal	Waste water and sewage discharge increases BOD and nutrient load to water bodies	Medium	Footprint	Continuous	Medium to Long term	Year Round	Medium	Effluent will be treated to a Level 3 standard for discharge into the pipeline tailings stream (Abandonment & Restoration Plan)	High	Low	High	
	Leachate from landfill released to water bodies	medium	Local	Frequent	Long-term	Year Round	High	All materials considered unsuitable for landfill depositions will be packaged for shipment and disposed off site (Abandonment & Restoration Plan)	High	Low	Medium	
VAULT FACILITIES												
Construction Noise & Activity	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table B.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Vault Dike	Construction in Year 1: Disturbance of lake sediment during rock placement, releasing TSS to Wally Lake and Attenuation Storage Pond	very high to high	footprint to local	Continuous	Short-term	Summer	high	Utilize silt curtains, and other sediment control practices and monitoring (BMP). See Aquatic Environment Management Plan.	high	medium to low	medium	See Aquatic Environment Management Plan and other relevant monitoring documents
	Release of soluble rock and/or till constituents as material is placed underwater (blasting residues, metals, TSS) to Wally Lake and Attenuation Storage Pond	high to medium	footprint	Continuous	Short-term	Summer	medium to low	Appropriate selection of explosive type (use emulsion explosives rather than dry ANFO), and charge load. Selection of appropriate rock type for use to minimize metals loading (rocks with low leaching potential) and potential acid generation. See Aquatic Environment Management Plan.	medium	medium to low	medium to low	Monitor water quality. See Aquatic Environment Management Plan
	Metals, acidity and nitrogen species released in seepage through dyke and runoff from downstream dike shell to Attenuation Pond during and after drawdown	high	footprint	Continuous	Short-term	Summer	low	Collect seepage water and direct to the settling pond.	high	low	high	Mine Waste and Water Management Plan
	Leaching of metals and acidity from dike rock to Wally Lake during open season	Low	footprint to local	Continuous	Long-term	Year Round	low	Use of UM rock for capping. Use of IF for submerged rock in upstream shell.	medium	low	medium to high	Monitor water quality adjacent to dikes. See Aquatic Environment Management Plan.

Table B.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Vault Lake Dewatering & Drainage Facilities	Release of TSS and metals to Turn Lake in dewatering discharge of relatively clean water from Phaser Lake	very high to high	footprint to local	Frequent	Short-term	Summer	high	Only relatively clean water to be discharged directly to Turn Lake; non-compliant water to be directed to the attenuation storage pond. Monitor location of suction pipe to minimize sediment disturbance. Monitor outlet pipe location.	high	low	medium	Monitor conditions. See Mine Waste and Water Management Plan and Aquatic Environmental Management Plan.
	Release of TSS and metals to Wally Lake in dewatering discharge of relatively clean water from Vault Lake (V1)	very high to high	footprint to local	Frequent	Short-term	Summer	high	Turbid water left in attenuation storage pond; treated for TSS removal if required. Monitor location of suction pipe to minimize sediment disturbance. Monitor outlet pipe location and water quality.	high	low	medium	Monitor conditions. See Mine Waste and Water Management Plan and Aquatic Environmental Management Plan.
	Sediment loading in attenuation pond is increased as Vault Lake bottom sediments are disturbed during drawdown, and runoff from local area increases TSS.	very high to high	footprint to local	Continuous	Short-term	Summer	high	Turbid water left in attenuation storage pond; treated for TSS removal if required	high	low	medium	Monitor conditions. See Mine Waste and Water Management Plan and Aquatic Environmental Management Plan.
	Runoff from the local area releases TSS to the Attenuation Pond.	medium	local	Continuous	Short-term	Summer	medium	A small berm will be constructed between Phaser and Vault Lake to ensure no flow is directed to Vault Lake. Non-contact water is directed away from the Attenuation Pond				

Table B.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Vault Pit	Metals, acidity and explosives residues are released in runoff from pit walls.	Medium	Footprint	Continuous	Medium-Term	Year Round	Low	Pump to Attenuation Pond	High	Low	medium	
	Dust and emissions from haul truck traffic	Low	Footprint	Continuous	Medium-term	Year Round	Low	Use of water trucks for dust suppression	Medium	Low	High	
	Potential for blasting residues (nitrogen species) to be released to lakes in runoff or melting of lake ice	medium	fooprint to local	Frequent	Short-term	Summer	low	Appropriate selection of explosive type, and charge load. Best Management Practices to minimize spills and excess explosives loss. See Aquatic Environment Management Plan.	medium	low	medium	See Aquatic Environment Management Plan
Vault Rock Storage Facility	Metals, acidity and nitrogen species are released in seepage, runoff, and active layer groundwater.	High	Footprint	Frequent	Medium-term	Summer	High	Seepage and runoff contained by collection facilities, and directed to sumps, then to Vault attenuation pond. Release to active layer groundwater limited by collection facilities.	Medium	Low	High	
Vault Area Effluent Discharge	Collected water from pits, waste rock piles are directed to the Attenuation Pond and discharge to Wally Lake	High	Local	Continuous	Medium-term	Summer	High	All effluents to be directed to the Vault Attenuation Pond for settling and monitoring prior to discharge. Effluent to be discharged through diffuser, only during summer months. Treatment of effluent prior to discharge if required (Abandonment & Restoration Plan)	medium	medium	medium	

Table B.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Vault Access Road & Traffic	Diesel spills to local water bodies	Medium	Footprint to Local	Rare	Medium to Long term	Year Round	Medium to Low	Best Management Practices and Spill Contingency Plans	Medium	Low	High	Spill Contingency Plan, Emergency Response Plan, and Accidents and Malfunctions Plan
	Dust from traffic releases metals and nitrogen species to local water bodies	Low	Footprint/Local	Frequent	Medium-term	Year round	Low	Dust control water for haul roads will be drawn from Phaser Lake (Abandonment & Restoration Plan)	Medium	Low	High	Air Quality and Noise Monitoring Plan
	Metals, acidity and nitrogen species in runoff and seepage from road bed are released to local water bodies	Low	Footprint to Local	Frequent	Medium to Long term	Summer	Low	Where possible, haul road drainage will be directed to areas serviced by contact water management infrastructure.	Medium	Low	medium	Mine site monitoring, and settling pond cleanout
Access Road Culverts (Turn Lake)	Metals, acidity and nitrogen species in runoff and seepage from road bed are released to Turn Lake	Medium	Footprint to Local	Rare	Medium to Long term	Year Round	Medium to Low	Select rock with low ARD and metal leaching potential will be used for construction. Best Management Practices for sediment and erosion control	Medium	Low	High	Mine site monitoring, and settling pond cleanout
Mine Shop/Office	Runoff from mine plant site contains TSS, metals, acidity and potential reagent spills.	Medium	Footprint	Continuous	Medium-term	Summer	Low	Runoff collected in ditches and directed to attenuation pond	medium	Low	High	Mine Site monitoring.
OTHER FACILITIES												
Winter Road & Traffic	Diesel spills released to local water bodies	Medium	Local	Rare	Medium to Long term	Winter	Medium	Best Practices; Spill Contingency Plan	Medium	Low	medium	See Aquatic Environment Management Plan.
Baker Lake Access Road & Traffic	Diesel spills released to local water bodies	Medium	Local	Rare	Medium to Long term	Year Round	Medium	Best Practices; Spill Contingency Plan	Medium	Low	medium	See Aquatic Environment Management Plan.
Barge Landing Facility	Spills from transferred materials	Medium	Local	Rare	Medium to Long term	Summer	Medium	Best Practices; Spill Contingency Plan	Medium	Low	medium	See Aquatic Environment Management Plan.
Barge Traffic	Diesel spills	Medium	Local	Rare	Medium to Long term	Summer	Medium	Best Practices (Abandonment & restoration Plan)	Medium	Low	medium	See Aquatic Environment Management Plan.
Staging Facility (approx. 1.5 km east of town)	Runoff contains reagent spills	Medium	Footprint	Infrequent	Medium to Long term	Year Round	Low	Best Practices; Spill Contingency Plan	Medium	Low	medium	See Aquatic Environment Management Plan.

Table B.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Explosives Magazine	Runoff contains nitrogen species	Medium	Footprint	Rare	Medium to Long term	Year Round	Low	Best Practices; Spill Contingency Plan	Medium	Low	medium	See Aquatic Environment Management Plan.
Tank Farm	Diesel spills during transfer.	High	Footprint	Infrequent	Medium to Long term	Year Round	Low	Best Practices - The tank farm will be contained within a secondary containment facility approximately 15,200 m2 comprising a geomembrane liner overlying soil containment berms and access ramps, a storm water sump and grease trap. (Abandonment & Restoration Plan).	Medium	Low	medium	See Aquatic Environment Management Plan.

Table B.3: Water Quality Impact Matrix – Closure & Post Closure

Project Component	Potential Effect	Assessment of Unmitigated Effects					Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries					Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
MAIN FACILITIES												
Construction Noise & Activity	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dykes												
East Dike	Flooding will release soluble components from downstream (pit side) rock fill embankment to Pit Lake (See Comments on Pit Lake)											
	Leaching of metals and acidity from dike rock to 2PL	Low	Footprint to local	Continuous	Long-term	Year Round	Low	Use of UM rock for exposed surface rock. Use of IF for submerged rock in upstream shell.	medium	low	medium	Monitor water quality adjacent to dikes. See Aquatic Environment Management Plan.
West (Tailings) Dike	Flooding will release soluble components from downstream (pit side) rock fill embankment to Pit Lake (See Comments on Pit Lake)											
Portage South (Bay Zone) Dike	Flooding will release soluble components from downstream (pit side) rock fill embankment to Pit Lake (See Comments on Pit Lake)											
	Leaching of metals and acidity from dike rock to 2PL	Low	Footprint to local	Continuous	Long-term	Year Round	Low	Use of UM rock for exposed surface rock. Use of IF for submerged rock in upstream shell.	medium	low	medium	Monitor water quality adjacent to dikes. See Aquatic Environment Management Plan.
Goose Island & 3rd Portage Arm (South Camp Island) Dikes	Flooding will release soluble components from downstream (pit side) rock fill embankment to Pit Lake (See Comments on Pit Lake)											
	Leaching of metals and acidity from dike rock to 2PL	Low	Footprint to local	Continuous	Long-term	Year Round	Low	Use of UM rock for exposed surface rock. Use of IF for submerged rock in upstream shell.	medium	low	medium	Monitor water quality adjacent to dikes. See Aquatic Environment Management Plan.
Dewatering												
2nd Portage Lake	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table B.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects					Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries					Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Portage Pit (3rd Portage Lake)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Goose Island (3rd Portage Lake)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pits												
Portage Pit	Flooding releases soluble metals from pit walls and dikes to Pit Lake	Medium	Footprint	Continuous	Short to medium term	Summer	Low	Flood slowly over five summer seasons to minimize TSS release. Pit Lake water not to be released to project lakes until of acceptable quality	Low	Low	low	Water quality will be monitored and managed until pit water is acceptable to be mixed with surrounding lake water.
Goose Island Pit	Flooding creates a single Pit Lake from North Portage, Third Portage and Goose Pits (see Pit Lake comments)											

Table B.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects					Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries					Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Pit Lake	Pit Lake water released to 3PL	Medium	Local to regional	Continuous	Medium-term to Long term	All year	High	Effluent will be managed, such that water quality will not be released until it reached acceptable levels (Abandonment & Restoration Plan). Removal of portions of the Goose Island Dike will not occur until the pit lake elevation achieves static conditions and the water quality monitoring results are considered acceptable for discharge without treatment to the environment. (Abandonment & Restoration Plan)	Medium: Magnitude reduced	Low	Low	Water quality will be monitored and managed until pit water is acceptable to be mixed with surrounding lake water.
	Pit Lake water moves into underlying talik to impact underlying deep regional groundwater.	Medium	Footprint	Continuous	Long-term	All year	Low	Low differential head between Pit Lake and surrounding lakes limits driving head, such that downward contaminant transport limited to diffusion.	Low: reduction of spatial extent below pit floor.	Low	moderate	Water quality monitored in pit lake and minimal driving head confirmed.
	Pit Lake itself becomes permanent part of receiving environment	Medium	Local	Continuous	Long-term	All Year	High	Pit Lake will not become part of 3PL until water quality reaches acceptable levels.	Medium	Medium	Low	Water quality will be monitored and managed until pit water is acceptable to be mixed with surrounding lake water.

Table B.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects					Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries					Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Portage Rock Storage Facility	Release of metals and acidity from active layer to tundra and local lakes	Very high	Footprint	Frequent	Long-term	Summer	High	Regrading to promote runoff and use of UM rock in active layer to minimize release of acidity and metals (Abandonment & Restoration Plan). Seepage to be directed to Portage Attenuation Pond until quality and volumes are shown suitable for uncontrolled discharge.	High	Medium	Low	Monitoring to validate predictions (see Aquatic Environment Management Plan)
Borrow Pit(s)	N/A											
Tailings Disposal Facilities	Combined with Portage Attentuation Pond (see comments below)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Main Site Roads & Traffic	Continued leaching of metals and acidity from active layer rock	Medium	Footprint	Frequent	Long-term	Summer	Medium	Selection of appropriate construction rock. (see Water and Waste Management Plan). Contingency (where monitoring indicates unanticipated metal leaching or acidic drainage) capping with nominal 2 m layer of UM rock.	High	Low	moderate	

Table B.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Airstrip & Air Traffic	Continued leaching of metals and acidity from active layer rock	Medium	Footprint	Frequent	Long-term	Summer	Medium	Selection of appropriate construction rock. (see Water and Waste Management Plan). Contingency (where monitoring indicates unanticipated metal leaching or acidic drainage) capping with nominal 2 m layer of UM rock.	High	Low	moderate	
Mine Plant and Associated Facilities	Continued leaching of metals and acidity from active layer rock	Medium	Footprint	Frequent	Long-term	Summer	Medium	Selection of appropriate construction rock. (see Water and Waste Management Plan). Contingency (where monitoring indicates unanticipated metal leaching or acidic drainage) capping with nominal 2 m layer of UM rock.	High	Low	moderate	
Freshwater Intake & Pipeline	N/A (removed)											

Table B.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects					Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries					Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Portage Attenuation Pond	Drainage/runoff from rock storage facility continues to discharge to attenuation pond.	High	Footprint	Frequent	Long-term	Summer	High	See comments on Portage Rock Storage Facilities for mitigation. Portage Attenuation Pond provides additional settling and aging of runoff.	High	Medium	Moderate	
	Release of concentrated pore water when forced to surface during tailings freeze back; Release of metals and acidity from active layer of frozen tailings to attenuation pond	Very high	Footprint	Infrequent	Long-term	Summer	High	Placement of UM cover material to allow pore water to move into rock voids and minimize release of acidity andmetals from tailigns by promoting freezing in the tailings (Abandonment & Restoration Plan). Tailings placement to be managed to promote a naturally graded, sloping beach surface prior to freezing to promote runoff. Tailings runoff permanently directed to Portage Attenuation Pond for settling and aging.	High	Medium	Moderate	
	Dust from desiccated exposed tailings releases metals and nitrogen species deposited in local water bodies.	Medium	Footprint to local	Frequent	Long-term	Year Round	High	Placement of UM cover material to reduce erosion and wind blow dust (Abandonment & Restoration Plan)	High: reduces magnitude and spatial extent	Low	High	See Air Quality and Noise Monitoring Plan

Table B.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects					Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries					Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Discharge Facilities & Pipeline	Portage Attenuation Pond connected to 3PL	Medium	Local	Continuous	Long-term	Summer	High	Treatment plant continues in operation until all mime operations and closure activities are completed in the Portage mining and milling areas, the attenuation pond is drained and covered, and the monitoring results can demonstrate that the water quality from this watershed is acceptable for discharge without treatment to the environment (Abandonment & Restoration Plan)	Medium	Low	Low	See Aquatic Environment Management Plan
Non-Contact Diversion Facilities	Remain as per operations.											
Storage (at Plant Site)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AN/Explosives Storage & Emulsion Plant	N/A after removal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Site Accommodations	N/A after removal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sewage & Waste Disposal	N/A after removal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
VAULT FACILITIES												
Construction Noise & Activity	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table B.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects					Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries					Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Vault Dike	Flooding will release soluble components from dyke downstream shell materials to Attenuation Pond. (see comments on Vault Pit)							Selection of appropriate construction rock to minimize buildup of metals and acidity prior to flooding. Dike can be removed entirely if required.				
	Leaching of metals and acidity from dike rock to Wally Lake during open season	Low	Footprint to local	Continuous	Long-term	Year Round	Low	Use of UM rock for exposed surface rock. Use of IF for submerged rock in upstream shell. Dike can be removed entirely if required.	medium	low	medium	Monitor water quality adjacent to dikes. See Aquatic Environment Management Plan.
Vault Lake Dewatering & Drainage Facilities	Increased TSS as non-contact diversion above Phase Lake returned to natural path and flow to pit	Medium	Footprint	Frequent	Short to medium term	Summer	Low	Use of erosion protection and best management practices for sediment control until flows are reestablished	Medium	Low	High	On-site monitoring at closure

Table B.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significanc e of Residual Impacts	Probabilit y	Management and Monitoring
Vault Pit Lake/Attenuation Pond	Flooding releases soluble metals from previously exposed pit walls and suspended sediments from former lake bed to Attenuation Pond	Medium	Footprint	Continuous	Short to medium term	Summer	Medium	Flooding conducted over five summer seasons to minimize impacts to lake elevations.	low	Medium	Low	Water quality will be monitored and managed until pit water is acceptable to be mixed with surrounding lake water.
	At steady state, both exposed and submerged pit walls and dike materials continue to leach to Vault Pit/Attenuation Pond. Dike removed to connect Vault Attenuation Pond with Wally Lake.	Low	Local	Continuous	Long-term	Year Round	Low	Effluent will be managed, such that water quality will not be released until it reached acceptable levels (Abandonment & Restoration Plan). Removal of Vault Dike will not occur until the pit lake water levels achieve static conditions and the water quality monitoring results from pit lake are considered acceptable for discharge without treatment to the environment. (Abandonment & Restoration Plan)	Medium	Low	Low	Water quality will be monitored and managed until pit water is acceptable to be mixed with surrounding lake water.
	Pit Lake water moves into talik that develops under Attenuation Pond and flooded pit, and may be released to underlying deep regional groundwater system.	Medium	Footprint	Continuous	Long-term	All year	Low	Analyse suggests that the talik will not develop a connection to the underlying regional groundwater system. In addition, low differential head between Pit Lake and surrounding lakes limits driving head, such that downward contaminant transport would primarily be limited to diffusion.	Low	Low	moderate	Water quality monitored in pit lake, and minimal driving head confirmed.

Table B.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects					Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries					Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Vault Rock Storage Facility	Continued release of metals and acidity from active layer to local water bodies and Attenuation Pond	Medium to High	Footprint	Frequent	Long-term	Summer	Medium	Regrading to promote runoff. Use of appropriate construction rock.	Medium	Medium	Low	
Vault Access Road & Traffic	Continued release of metals and acidity from active layer to local water bodies and Attenuation Pond	Low	Local to footprint	Frequent	Long-term	Summer	Low	Regrading to promote runoff. Contingency (where monitoring indicates unanticipated metal leaching or acidic drainage) capping with nominal 2 m layer of UM rock.	Medium	Low	High	
Access Road Culverts (Tern Lake)	N/A after removal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mine Shop/Office	N/A after removal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
OTHER FACILITIES												
Winter Road & Traffic	N/A after final closure	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Baker Lake Access Road & Traffic	N/A after final closure	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Barge Landing Facility	N/A after final closure	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Barge Traffic	N/A after final closure	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
In-town Staging Facility	N/A after final closure	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Explosives Magazine	N/A after final closure	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tank Farm	N/A after final closure	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

APPENDIX C

Permafrost

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Table C.1: Permafrost Impact Matrix – Construction

Project Components	Potential Effects	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Monitoring/ Management
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
MAIN FACILITIES												
Construction Noise & Activity	Noise N/A; activity related to specific structures dealt with below	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dykes												
East Dike	Permafrost aggradation and formation of new active layer in portion of dike above 2PL level, including abutments - POSITIVE	gain	local	infrequent	Permanent	all year	enhancement	none	N/A	N/A	certain	Commence ground temperature monitoring in dikes and dike foundation as soon as possible. Commence slope monitoring as soon as structures are completed.
Tailings Dike	Permafrost aggradation and formation of new active layer - POSITIVE	gain	local	infrequent	Permanent	all year	enhancement	none	N/A	N/A	certain	Commence ground temperature monitoring in dikes and dike foundation as soon as possible. Commence slope monitoring as soon as structures are completed. Commence sub permafrost pore pressure monitoring as soon as the structure is completed.
Bay Zone Dike	Permafrost aggradation and formation of new active layer in portion of dike above 3PL level, including abutments - POSITIVE	gain	local	infrequent	Permanent	all year	enhancement	none	N/A	N/A	certain	Commence ground temperature monitoring in dikes and dike foundation as soon as possible. Commence slope monitoring as soon as structures are completed.
Goose Island & South Camp Island Dikes	Constructed during operations - see comments in operations matrix	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table C.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Monitoring/ Management
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Dewatering												
Second Portage Lake	A - Permafrost aggradation in talik under former 2PL NW arm and formation of a new active layer - POSITIVE; B - lowering of water table in nearby bogs and in bogs along tributary streams will cause temporary deepening of the active layer, minor warming of permafrost, melting of ground ice, thaw subsidence and sediment loss	A – gain B - loss	A – local B - footprint	infrequent	A – permanent B - short-term	A - all year B - summer	A - enhanc. B - high	B only: Silt fences to restrict movement of sediment into diked off portion of 2PL; adjust pumping rate to deal with possible high TSS; use NW corner as clarification pond, as required; in last phase of drawdown use locally isolated clarification pond(s) inside diked off area, as required	none	B only: High, although the condition is of limited concern because the polygons affected will ultimately be covered by tailings	High, assuming excess ground ice is present	B only: Only required during dewatering in so far as the condition influences TSS build-up in pumped discharge from pond
Portage Pit (Third Portage Lake)	A - Permafrost aggradation in talik under former 3PL north central shoreline area and formation of a new active layer - POSITIVE; B - lowering of water table in nearby possibly ice rich areas may cause temporary deepening of the active layer, minor warming of permafrost, melting of ground ice, thaw subsidence and sediment loss	A – gain B - loss	A – local B - footprint	infrequent	A – permanent B - short-term	A - all year B - summer	A - enhanc. B - high	B only: Silt fences to restrict movement of sediment into diked off portion of 3PL; adjust pumping rate to deal with possible high TSS; in last phase of drawdown use locally isolated clarification pond(s) inside diked off area, as required	none	B only: High, and relatively more important than the 2PL dewatering (above) because polygon that may be affected will become shoreline of 3PL at closure	Moderate because likelihood of widespread excess ground ice is very limited	B only: Only required during dewatering in so far as the condition influences TSS build-up in pumped discharge from pond
Goose Island (Third Portage Lake)	Dewatered during operations - see comments in operations matrix	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table C.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Monitoring/ Management
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Pits												
Portage Pit	A - Loss of permafrost, cooling of remaining permafrost, and development of a new active layer in terrestrial areas; B - aggradation of permafrost and development of a new active layer in talik under former 2PL NW arm	A – loss B - gain	local	infrequent	A - short-term B - medium-term	all year	A – low B - enhance.	none	N/A	low	certain	none recommended
Goose Island Pit	Constructed during operations - see comments in operations matrix	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	none recommended
Portage Rock Storage Facility	A - Fall, winter and spring construction activity will bury the natural ground surface and permafrost will aggrade into the waste rock where a new active layer will form - POSITIVE; B - Placement of lifts on natural ground in the summer may cause temporary deepening of the active layer, warming of near-surface permafrost, and possible subsidence, particularly in low lying bog areas	A – gain B - loss	A – local B - footprint	infrequent	A – permanent B - short-term	A – winter B - summer	A - enhanc. B - high	B only: Schedule placement of waste rock on thaw-sensitive polygons during winter months, possibly in conjunction with proactive measures to enhance ground chilling prior to placement (e.g. snow removal and/or compaction); use flatter side slopes	none	B only: Low	moderate	Internal and foundation temperatures to be monitored
Borrow Pit(s) (All borrow material is currently planned to be taken from the ultimate pit boundaries.)	Loss of permafrost, cooling of remaining permafrost, and development of a new active layer	loss	local	infrequent	Short-term	all year	low	none	N/A	low	certain	none recommended

Table C.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Monitoring/ Management
Tailings Storage Facilities	Permafrost aggradation and development of a new active layer in talik under former 2PL NW Arm - POSITIVE	gain	local	infrequent	Short-term	all year	enhancement	none	N/A	N/A	certain	N/A
Main Site Roads & Traffic	A - Loss of permafrost, cooling of remaining permafrost, and development of a new active layer in cut sections; B - permafrost aggradation, warming of underlying natural permafrost, and formation of new active layer in fill sections - POSITIVE	negligible	local	infrequent	A – permanent B - medium-term	all year	low	none	N/A	low	certain	none recommended
Airstrip & Air Traffic	A - Loss of permafrost, cooling of remaining permafrost, and development of a new active layer in cut sections; B - permafrost aggradation, warming of underlying natural permafrost, and formation of new active layer in fill sections - POSITIVE	negligible	local	infrequent	A – permanent B - medium-term	all year	low	none	N/A	low	certain	none recommended

Table C.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Monitoring/ Management
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Ditches (Roads, Airstrip & Contact Water)	A - Loss of permafrost, warming of remaining permafrost, and development of a new active layer in cut sections; B - where ditches are excavated through bogs, there is potential for deepening of the active layer, warming of permafrost, ground ice degradation and related thaw subsidence, slumping and sediment losses	loss	A – local B - footprint	infrequent	A – permanent B - permanent	A - all year B - summer	A - low B - high	B only: Where thaw sensitive polygons are crossed, avoid using cut sections for ditches, ensure positive drainage away from fill sections, avoid concentrating runoff waters, or use rock aprons to slow the rate of thaw penetration and stabilize the underlying soils	none	B only: Low	high	B only - Further assessment of susceptible locations along proposed ditch centrelines is required
Mine Plant & Associated Facilities	A - Loss of permafrost, cooling of remaining permafrost, and development of a new active layer in cut sections; B - permafrost aggradation, warming of underlying natural permafrost, and formation of new active layer in fill sections - POSITIVE	negligible	local	infrequent	A – permanent B - medium-term	all year	low	none	N/A/	low	certain	none recommended

Table C.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Monitoring/ Management
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Freshwater Intake & Pipeline	A - Loss of permafrost at wet well excavation, warming of remaining permafrost around the excavated wet well, and local re-establishment of active layer ; B - potential warming of permafrost and deepening of active layer associated with pipeline	loss	local	infrequent	A – permanent B - short-term	all year	low	none	N/A	low	certain	none recommended
Discharge Facilities & Pipeline	A - Subaqueous discharge facility construction has no affect on permafrost; B - potential warming of permafrost and deepening of active layer associated with pipeline	negligible	local	infrequent	A - N/A B - short-term	A - N/A B - all year	low	none	N/A	low	certain	none recommended

Table C.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Monitoring/ Management
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Non-Contact Diversion Facilities	A - Loss of permafrost, warming of remaining permafrost, and deepening of the active layer along ditches; B - where ditches are excavated through bogs, there is potential for deepening of the active layer, warming of permafrost, ground ice degradation and related thaw subsidence, slumping and sediment losses	loss	A – local B - footprint	infrequent	Short-term	A - all year B - summer	A – low B - high	B only: Where thaw sensitive polygons are crossed, avoid using cut sections for ditches, ensure positive drainage away from fill sections, avoid concentrating runoff waters, or use rock aprons to slow the rate of thaw penetration and stabilize the underlying soils	none	B only: High	certain	B only - Further assessment of susceptible locations along proposed ditch centrelines is required; selection of materials used as rock aprons, if required, must be done in keeping with the "non-contact" zonation
Laydown Storage (at Plant Site)	A - Loss of permafrost, cooling of remaining permafrost, and development of a new active layer in cut sections; B - permafrost aggradation, warming of underlying natural permafrost, and formation of new active layer in fill sections - POSITIVE	negligible	local	infrequent	A – permanent B - medium-term	all year	low	none	N/A	low	certain	none recommended

Table C.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Monitoring/ Management
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
AN/Explosives Storage & Emulsion Plant	A - Loss of permafrost, cooling of remaining permafrost, and development of a new active layer in cut sections; B - permafrost aggradation, warming of underlying natural permafrost, and formation of new active layer in fill sections - POSITIVE	negligible	local	infrequent	A – permanent B - medium-term	all year	low	none	N/A	low	certain	none recommended
Site Accommodations	A - Loss of permafrost, cooling of remaining permafrost, and development of a new active layer in cut sections; B - permafrost aggradation, warming of underlying natural permafrost, and formation of new active layer in fill sections - POSITIVE	negligible	local	infrequent	A – permanent B - medium-term	all year	low	none	N/A	low	certain	none recommended
Sewage & Waste Disposal	A - Loss of permafrost, cooling of remaining permafrost, and development of a new active layer in cut sections; B - permafrost aggradation, warming of underlying natural permafrost, and formation of new active layer in fill sections - POSITIVE	negligible	local	infrequent	A – permanent B - medium-term	all year	low	none	N/A	low	certain	none recommended

Table C.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Monitoring/ Management
VAULT FACILITIES												
Construction Noise & Activity	Noise N/A; activity related to specific structures dealt with below	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vault Dike	Constructed during operations - see comments in operations matrix	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vault Lake Dewatering & Drainage Facilities	Dewatered during operations - see comments in operations matrix	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vault Lake-Phaser Lake Berm	Constructed during operations - see comments in operations matrix	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Phaser Lake Operation	Constructed during operations - see comments in operations matrix	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vault Pit	Constructed during operations - see comments in operations matrix	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vault Waste Dump	Constructed during operations - see comments in operations matrix	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vault Access Road & Traffic												
Access Road Culverts (Tern Lake)	Constructed during operations - see comments in operations matrix	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Shop/Office	Constructed during operations - see comments in operations matrix	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
OTHER FACILITIES												
Winter Road & All Terrain Vehicle Traffic	Chilling of permafrost and decrease in active layer thickness beneath winter roads - POSITIVE	gain	local	infrequent	Medium-term	winter	low	none	N/A	low	certain	none recommended

Table C.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Proposed Mitigation	Assessment of Residual Effects: Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	Monitoring/ Management
Baker Lake Access Road & Traffic	A - Loss of permafrost and development of a new active layer in cut sections; B - permafrost aggradation and formation of new active layer in fill sections - POSITIVE	negligible	local	infrequent	A – permanent B - medium-term	A - all year B - winter	low	none	N/A	low	certain	none recommended
Barge Landing Facility	A - Loss of permafrost and development of a new active layer in cut sections; B - permafrost aggradation and formation of new active layer in fill sections - POSITIVE	negligible	local	infrequent	A – permanent B - medium-term	A - all year B - winter	low	none	N/A	low	certain	none recommended
Barge Traffic	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
In-town Staging Facility (approx. 1.5 km east of town)	A - Loss of permafrost and development of a new active layer in cut sections; B - permafrost aggradation and formation of new active layer in fill sections - POSITIVE	negligible	local	infrequent	A – permanent B - medium-term	A - all year B - winter	low	none	N/A	low	certain	none recommended
Explosives Magazine	A - Loss of permafrost and development of a new active layer in cut sections; B - permafrost aggradation and formation of new active layer in fill sections - POSITIVE	negligible	local	infrequent	A – permanent B - medium-term	A - all year B - winter	low	none	N/A	low	certain	none recommended

Table C.1 Continued

Project Components	Potential Effects	Assessment of Unmitigated Effects						Proposed Mitigation	Assessment of Residual Effects			Monitoring/ Management
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Residual Effects/ Influence of Mitigation	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Tank Farm (40 million litres)	A - Loss of permafrost and development of a new active layer in cut sections; B - permafrost aggradation and formation of new active layer in fill sections - POSITIVE	gain	local	infrequent	A – permanent B - medium-term	A - all year B - winter	low	none	N/A	low	certain	none recommended

Table C.2: Permafrost Impact Matrix – Operation

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
MAIN FACILITIES												
Construction Noise & Activity	Noise N/A; activity related to specific structures dealt with below	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dikes												
East Dike	Continued permafrost aggradation and stabilization of new active layer in upstream portion of dike above 2PL level, across top, all of downstream side, and all sides of the abutments - POSITIVE	gain	local	infrequent	medium-term	all year	enhancement	none	N/A	N/A	certain	Monitoring of ground temperatures to ensure permafrost aggradation into the dike. This will facilitate optimum closure planning. Monitoring of slopes.
Tailings Dike	Continued permafrost aggradation and stabilization of new active layer - POSITIVE	gain	local	infrequent	medium-term	all year	enhancement	none	N/A	N/A	certain	Monitor ground temperatures and sub permafrost pore pressures to ensure permafrost aquitard can be relied upon as an effective barrier against contaminant movement from the tailings facility eastward toward the Portage Pit.

Table C.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Bay Zone Dike	Continued permafrost aggradation and stabilization of new active layer in upstream portion of dike above 3PL level, across top, all of downstream side, and all of abutments - POSITIVE; later, after construction of Goose Island & 3PL dikes and dewatering of pond, permafrost aggradation into upstream side and development of a new active layer - POSITIVE; finally, loss of this permafrost and development of a new active layer where portions of the dike are removed for completion of the Portage Pit	gain	local	infrequent	medium-term	all year	enhancement	none	N/A	N/A	certain	Monitoring of ground temperatures to ensure permafrost aggradation into the dike. This will facilitate optimum closure planning. Monitoring of slopes.
Goose Isl. & South Camp Isl. Dikes	Permafrost aggradation and formation of new active layer in portion of dike above 3PL level on upstream side, across top, all of downstream side, and all of abutments - POSITIVE	gain	local	infrequent	medium-term	all year	enhancement	none	N/A	N/A	certain	Commence ground temperature monitoring in dike and dike foundation as soon as possible. Continue monitoring to ensure permafrost aggradation into the dike. This will facilitate optimum closure planning. Commence slope monitoring as soon as the structure is completed.

Table C.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Dewatering												
Second Portage Lake	Continued permafrost aggradation in talik under former 2PL NW arm and stabilization of new active layer as long as subaerial exposure persists - POSITIVE; loss of this permafrost when levels of reclaim and attenuation ponds rise and flood former lake bottom; re-establishment of permafrost and development of a new active layer in conjunction with subaerial tailings deposition	gain	local	infrequent	permanent	all year	low	none	N/A	low	certain	Representative monitoring of ground temperatures to ensure permafrost aggradation into the talik beneath 2PL. Assessment of anticipated ice entrapment (i.e. ground ice development) in conjunction with permafrost aggradation. Assessment of suspected ground ice development in conjunction with permafrost aggradation (ie. outside of tailings area). These initiatives will facilitate optimum closure planning of the tailings facility.
Portage Pit (Third Portage Lake)	Continued permafrost aggradation in talik under former 3PL north central shoreline area and stabilization of new active layer as long as subaerial exposure persists; loss of a portion of this permafrost and formation of a new active layer as the Portage pit walls are pushed back	gain	local	infrequent	medium-term	all year	low	none	N/A	low	certain	Assessment of suspected ground ice development in conjunction with permafrost aggradation. Assessment of ground ice content of select shoreline polygons.

Table C.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Potential Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Goose Island (Third Portage Lake)	A - Permafrost aggradation in talik under former 3PL NE arm and formation of a new active layer; B - lowering of water table in nearby possibly ice rich areas may cause temporary deepening of the active layer, minor warming of permafrost, melting of ground ice, thaw subsidence and sediment loss	A – gain B - loss	A – local B - footprint	infrequent	medium-term	A – winter B - summer	A - enhanc. B - high	B only: Silt fences to restrict movement of sediment into diked off portion of 3PL; adjust pumping rate to deal with high TSS; in last phase of drawdown use locally isolated clarification pond(s) inside diked off area	none	B only: High and relatively more important than the 2PL dewatering because polygon affected will become shoreline of 3PL at closure	Moderate because likelihood of widespread excess ground ice is very limited	B only: Only required during dewatering in so far as the condition influences TSS build-up in pumped discharge from pond. Assessment of suspected ground ice development in conjunction with permafrost aggradation. Assessment of ground ice content of select shoreline polygons. These initiatives will facilitate optimum closure planning.
Pits												
Portage Pit	A - Loss of permafrost and development of a new active layer in terrestrial areas as pit slopes are pushed back; B - aggradation of permafrost and development of a new active layer in talik under former 2PL NW arm after mining of benches is completed	A - loss B - gain	local	infrequent	medium-term	all year	A - low B - enhance.	none	N/A	low	certain	Assessment of suspected ground ice development in conjunction with permafrost aggradation.

Table C.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Goose Island Pit	A - Loss of permafrost and development of a new active layer in terrestrial areas as pit slopes are pushed back; B - aggradation of permafrost and development of a new active layer in talik under former 2PL NW arm and 3PL NE arm after mining of benches is completed	A - loss B - gain	local	infrequent	medium-term	all year	A - low B - enhance.	none	N/A	low	certain	none recommended

Table C.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Potential Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Portage Rock Storage Facility	A - Fall, winter and spring placement will continue to bury the natural ground surface and permafrost will aggrade into the waste rock where a new and temporary active layer will form - POSITIVE; B - placement of lifts on natural ground in the summer may continue to cause temporary and localized deepening of the active layer, warming of near-surface permafrost and possible subsidence, particularly in low-lying areas; C - where new lifts are added to older lifts, permafrost will continue to aggrade into both new and older waste rock and new active layers will form, although summer placement conditions will include temporary and localized loss of new permafrost, the net effect will be permafrost aggradation and general ground cooling - NET POSITIVE	A – gain B – loss C - gain	A – local B – footprint C - local	infrequent	A – permanent B - medium-term C - permanent	A – winter B – summer C - all year	A - enhanc. B – high C - enhanc.	B only: Schedule placement of waste rock on thaw-sensitive polygons during winter months, possibly in conjunction with proactive measures to enhance ground chilling prior to placement (e.g. snow removal and/or compaction); use flatter side slopes	none	B only: Low	moderate	Internal and foundation temperatures to be monitored. These initiatives will facilitate optimum cap rock design and closure planning of the Portage waste rock pile.

Table C.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Borrow Pit(s) (All borrow material is currently planned to be taken from the ultimate pit boundaries)	Loss of permafrost, cooling of remaining permafrost, and development of a new active layer where pits continue to be operated; stabilization of permafrost temperatures and active layer thickness soon after operations cease	loss	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended

Table C.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Tailings Storage Facilities	Permafrost aggradation into subaerial tailings and ice entrapment. Entrapped ice originates from in situ freezing of transport water as interstitial ground ice and burial of reclaim/attenuation pond ice during winter operations. The large quantity of ice that forms in the long and cold winter months together with the high latent heat barrier it represents to melting in the short summer season accounts for the net accumulation of entrapped ice. The preliminary tailings facility design report provides volume elevation curves for 0%, 10%, 20% and 30% net volume entrapment scenarios	gain	local	infrequent	permanent	all year	Aggradation of permafrost is an enhancement , however, ice entrapment in the permafrost is assessed as a high unmitigated effect.	Ice entrapment can be managed in one of three ways: First, by subaqueous discharge during the winter months; second, by minimizing the thickness of winter placement to what will thaw the following summer season, which is usually 1 to 1.5 metres; and third, by thicker subaerial deposition where the entrapped ice content of the new permafrost is monitored so as to keep the net volume of entrapped ice within the design tolerance, which is less than or equal to 30% of the total unfrozen tailings volume. Choosing the first option requires relatively more reclaim / attenuation pond volume. Choosing the second or third options requires careful monitoring and regular relocation of the spigot points.	none	high	high	Ice entrapment is poorly constrained at this time, although there is momentum in the Northern Mining Industry toward valuable research and development (e.g. Diavik Diamond Mines water license).
Main Site Roads & Traffic	Stabilization of permafrost temperatures and active layer thickness	negligible	local	infrequent	medium-term	all year	low	none	N/A	low	certain	none recommended

Table C.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Airstrip & Air Traffic	Stabilization of permafrost temperatures and active layer thickness	negligible	local	infrequent	medium-term	all year	low	none	N/A	low	certain	none recommended
Ditches (Roads, Airstrip & Contact Water)	Stabilization of permafrost temperatures and active layer thickness; stabilization of thaw subsidence and sediment loss in bog areas	negligible	local	infrequent	permanent	all year	medium	Silt fences as required to manage sediment loss; rock aprons as required to slow the rate of thaw penetration and stabilize the underlying soils	none	low	moderate	none recommended
Mine Plant & Associated Facilities	A - Stabilization of permafrost temperatures and active layer thickness in outside areas; B - loss of permafrost under heated structures and potential settlement where ground ice is present and degrades under imposed ground temperatures	A – negligible B - loss	local	infrequent	medium-term	all year	A – low B - high	B only: Locate heated structures (at the design phase) where ground ice is not present in the subgrade materials. Alternatively, insulate foundations to retard thaw; artificially chill foundations to prevent thaw; and/or elevate structures on piles or insulated gravel pads to prevent thaw.	none	low	moderate	B only: Ground temperature measurements will be taken during operations where there is a need to monitor foundation temperatures
Freshwater Intake & Pipeline	Stabilization of permafrost temperatures and active layer thickness in the vicinity of the wet well and beneath the pipeline	negligible	local	infrequent	medium-term	all year	low	Use insulated pipe with heat tracing; elevate pipeline across thaw sensitive terrain	none	low	moderate	Monitor pipeline alignment for potential permafrost degradation. Monitoring may include one or both of ground surveys or ground temperature measurements.

Table C.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Discharge Facilities & Pipeline	Stabilization of permafrost temperatures and active layer thickness beneath the pipeline	negligible	local	infrequent	medium-term	all year	low	Use insulated pipe with heat tracing; elevate pipeline across thaw sensitive terrain	none	low	moderate	Monitor pipeline alignment for potential permafrost degradation. Monitoring may include one or both of ground surveys or ground temperature measurements.
Non-Contact Diversion Facilities	Stabilization of permafrost temperatures and active layer thickness; stabilization of thaw subsidence and sediment loss in bog areas	negligible	local	infrequent	permanent	all year	medium	Silt fences as required to manage sediment loss; gravel aprons as required to slow the rate of thaw penetration and stabilize the underlying soils	none	low	moderate	none recommended
Laydown Storage (at Plant Site)	Stabilization of permafrost temperatures and active layer thickness	negligible	local	infrequent	medium-term	all year	low	none	N/A	low	certain	none recommended
AN/Explosives Storage & Emulsion Plant (assumes buildings are not heated)	Stabilization of permafrost temperatures and active layer thickness	negligible	local	infrequent	medium-term	all year	low	none	N/A	low	certain	none recommended
Site Accommodations	A - Stabilization of permafrost temperatures and active layer thickness in outside areas; B - loss of permafrost under heated structures and potential settlement where ground ice is present and degrades under imposed ground temperatures	A - negligible B - loss	local	infrequent	medium-term	all year	A – low B - high	B only: Locate heated structures (at the design phase) where ground ice is not present in the subgrade materials. Alternatively, insulate foundations to retard thaw; artificially chill foundations to prevent thaw; and/or elevate structures on piles or insulated gravel pads to prevent thaw.	none	low	moderate	B only: Ground temperature measurements will be taken during operations where there is a need to monitor foundation temperatures

Table C.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Sewage & Waste Disposal	A - Stabilization of permafrost temperatures and active layer thickness in outside areas; B - loss of permafrost under heated structures and potential settlement where ground ice is present and degrades under imposed ground temperatures	A – negligible B - loss	local	infrequent	medium-term	all year	A - low B - high	B only: Locate heated structures (at the design phase) where ground ice is not present in the subgrade materials. Alternatively, insulate foundations to retard thaw; artificially chill foundations to prevent thaw; and/or elevate structures on piles or insulated gravel pads to prevent thaw.	none	low	moderate	B only: Ground temperature measurements will be taken during operations where there is a need to monitor foundation temperatures
VAULT FACILITIES												
Construction Noise & Activity	Noise N/A; activity related to specific structures dealt with below	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vault Dike	Permafrost aggradation and formation of new active layer in portion of dike above Vault Lake level on upstream side, across top, all of downstream side, and all of abutments - POSITIVE	gain	local	infrequent	medium-term	all year	enhancement	none	N/A	N/A	certain	N/A

Table C.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Vault Lake Dewatering & Drainage Facilities	A - Permafrost aggradation in talik under former Vault Lake and formation of a new active layer; B - lowering of water table in nearby possibly ice rich areas may cause temporary deepening of the active layer, minor warming of permafrost, melting of ground ice, thaw subsidence and sediment loss	A – gain B - loss	A – local B - footprint	infrequent	medium-term	A - all year B - summer	A - enhanc. B - high	B only: Silt fences to restrict movement of sediment into diked off portion of Vault Lake; adjust pumping rate to deal with high TSS	none	B only: Medium because affected shoreline polygons are expected to quickly stabilize and Vault attenuation pond has high clarification capacity	A – certain B - moderate because likelihood of widespread excess ground ice is very limited	B only: Only required during initial drawdown in so far as the effect influences TSS build-up in pumped discharge from Vault Lake. Assessment of suspected ground ice development in conjunction with permafrost aggradation into former lake bottom.
Vault Lake-Phaser Lake Berm	A - Permafrost aggradation and formation of new active layer in berm; B - lowering of water table in Vault and Phaser lakes may cause temporary deepening of the active layer, warming of permafrost, melting of ground ice, thaw subsidence and sediment loss in local areas near structures, particularly in low lying bog areas	A – gain B - loss	A – local B - footprint	Infrequent	medium-term	A - all year B - summer	A - enhanc. B - high	B only: Schedule placement of fill on thaw-sensitive polygons during winter months, possibly in conjunction with proactive measures to enhance ground chilling prior to placement (e.g. snow removal and/or compaction); flatter sideslopes in affected areas; and/or subexcavate thaw sensitive soils.	none	B only: High	moderate	Further site investigations, geothermal modelling and slope stability analyses are needed during the next phase of study. These initiatives will facilitate optimum berm design and closure planning; and, are expected to reduce the residual impacts to a "low".

Table C.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Phaser Lake Operation	A - Permafrost will begin to aggrade into the subaerial portion of lake bottom during the first winter following dewatering; permafrost will be maintained in any portion of the former lake bottom that is not re-flooded with non-contact runoff and a new active layer will stabilize; B - lowering of water table in nearby bogs and in bogs along tributary streams may cause temporary deepening of the active layer, warming of permafrost, melting of ground ice, thaw subsidence and sediment loss	A – gain B - loss	A – local B - footprint	infrequent	medium-term	A - all year B - summer	A - enhanc. B - high	B only: Silt fences to restrict movement of sediment into Phaser Lake; adjust pumping rate to deal with high TSS	none	B only: High	moderate	Further work needed to assess ground ice content of shoreline polygons at next phase of study. Assessment of suspected ground ice development in conjunction with permafrost aggradation into former lake bottom during operation.
Vault Pit	A - Loss of permafrost and development of a new active layer in terrestrial areas as pit slopes are pushed back; B - aggradation of permafrost and development of a new active layer in talik under former Vault Lake after mining of benches is completed	A – loss B - gain	local	infrequent	medium-term	all year	A – low B - enhance.	none	N/A	low	certain	none recommended

Table C.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Vault Waste Dump	A - Fall, winter and spring placement will bury the natural ground surface and permafrost will aggrade into the waste rock where a new and temporary active layer will form - POSITIVE; B - placement of lifts on natural ground in the summer will cause temporary and localized deepening of the active layer, warming of near-surface permafrost, and possible subsidence, particularly in low lying bog areas; C - where new lifts are added to older lifts, permafrost will aggrade into both new and older waste rock and new active layers will form, although summer placement conditions will include temporary and localized loss of new permafrost, the net effect will bepermafrost aggradation and general ground cooling - NET POSITIVE	A – gain B – loss C - gain	A – local B – footprint C - local	infrequent	A – permanent B - medium-term C - permanent	A - all year B – summer C - all year	A - enhanc. B – high C - enhanc.	B only: Schedule placement of waste rock on thaw-sensitive polygons during winter months, possibly in conjunction with proactive measures to enhance ground chilling prior to placement (e.g. snow removal and/or compaction); use flatter side slopes	none	B only: Low	moderate	Internal and foundation temperatures to be monitored. These initiatives will facilitate optimum cap rock design and closure planning of the Vault waste rock pile.

Table C.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Vault Access Road & Traffic												
Access Road Culverts (Turn Lake)	Loss of permafrost, warming of remaining permafrost, and deepening of the active layer where runoff is concentrated through culverts; possible subsidence, particularly in low lying bog areas	loss	local	infrequent	medium-term	summer	low	Maintenance, as required, to restore smooth grade where thaw settlement is a problem; avoid culverts in areas susceptible to thaw settlement	none	low	moderate	Maintenance, as required, to restore smooth grade where thaw settlement is a problem
Shop/Office	A - Loss of permafrost, cooling of remaining permafrost, and development of a new active layer in cut sections followed by stabilization of new ground temperature regime; B - permafrost aggradation, warming of underlying natural permafrost, and formation of a new active layer in fill sections followed by stabilization of new ground thermal regime; C - loss of permafrost under heated structures and potential settlement where ground ice is present and degrades under imposed ground temperatures	A – negligible B – negligible C - loss	local	infrequent	medium-term	all year	A – low B – low C - high	C only: Locate heated structures (at the design phase) where ground ice is not present in the subgrade materials. Alternatively, insulate foundations to retard thaw; artificially chill foundations to prevent thaw; and/or elevate structures on piles or inulated gravel pads to prevent thaw.	none	low	moderate	C only: Ground temperature measurements will be taken during operations where there is a need to monitor foundation temperatures

Table C.2 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
OTHER FACILITIES												
Winter Road & All Terrain Vehicle Traffic	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	medium-term	all year	enhancement	none	N/A	N/A	certain	N/A
Baker Lake Access Road & Traffic	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	medium term	all year	low	none	N/A	low	certain	none recommended
Barge Landing Facility	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	medium term	all year	low	none	N/A	low	certain	none recommended
Barge Traffic	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Staging Facility (approx. 1.5 km east of town)	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	medium-term	all year	low	none	N/A	low	certain	none recommended
Explosives Magazine	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	medium term	all year	low	none	N/A	low	certain	none recommended
Tank Farm (40 million litres)	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	medium term	all year	low	none	N/A	low	certain	none recommended

Table C.3: Permafrost Impact Matrix – Closure & Post-Closure

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
MAIN FACILITIES												
Construction Noise & Activity	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dikes												
East Dike	Degradation of recently developed permafrost and loss of active layer in submerged downstream (west) side of dike; slight warming of recently developed permafrost and deepening of the active layer in the portion of the dike above the level of 2PL and 3PL	loss	local	infrequent	permanent	all year	low	none	N/A	low	certain	Representative monitoring of ground temperatures to ensure permafrost characteristics are understood at closure and for the short-term after re-flooding of the remaining NW arm of 2PL.
Tailings Dike	Degradation of recently developed permafrost and loss of active layer in submerged downstream (east) side of dike; slight warming of recently developed permafrost and deepening of the active layer in the portion of the dike above the level of 3PL	loss	local	infrequent	permanent	all year	medium	none	N/A	medium	high	Monitor ground temperatures and sub permafrost pore pressures to confirm permafrost aquitard remains an effective barrier against contaminant movement from the tailings facility into 3PL

Table C.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Potential Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Bay Zone Dike	Degradation of recently developed permafrost and loss of active layer in breached portions of the dike as well as the submerged downstream (north) side of remaining dike; slight warming of recently developed permafrost and deepening of the active layer in the remaining portion of the dike above the level of 3PL	loss	local	infrequent	permanent	all year	low	none	N/A	low	certain	Representative monitoring of ground temperatures to ensure permafrost characteristics are understood at closure and for the short-term after re-flooding of the remaining NW arm of 2PL.
Goose Island & South Camp Island Dikes	Degradation of recently developed permafrost and loss of active layer in breached portions of the dike as well as the submerged downstream side of the remaining dike; slight warming of recently developed permafrost and deepening of the active layer in the remaining portion of the dike above the level of 3PL	loss	local	infrequent	permanent	all year	low	none	N/A	low	certain	Representative monitoring of ground temperatures to ensure permafrost characteristics are understood at closure and for the short-term after re-flooding of the remaining NW arm of 2PL.

Table C.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Dewatering												
Second Portage Lake	Stabilization of permafrost temperatures and depth of active layer in tailings cover and tailings infilling of the reclaim and attenuation ponds, and downward movement of permafrost into the remaining talik beneath 2PL NW arm where these structures are located; loss of permafrost and active layer as remaining portion of original 2PL basin is flooded by waters from 3PL; increased elevation of 3PL level in relation to 2PL will result in small net loss of permafrost around remaining portion of original 2PL shoreline; degradation of ground ice, where present on the lake bottom and around the remaining shoreline, accompanied by thaw subsidence and possible sediment release	loss	footprint	infrequent	permanent	all year	high	Silt fences to restrict movement of sediment into re-flooded section from affected shoreline; however, sediment release from melting ground ice on the re-flooded lake bottom cannot be contained.	none	High	Moderate because likelihood of widespread excess ground ice is expected to be limited	Only a concern during re-flooding. The potential significance of ground ice along the shoreline and across the former lake basin will be assessed during the next phase of study, and ongoing assessment will be carried out through operation in order to prepare for closure.

Table C.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Potential Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Portage Pit (Third Portage Lake)	Loss of permafrost and active layer beneath original 3PL basin after it is flooded by 3PL; degradation of ground ice, where present on the lake bottom and around the new shoreline, accompanied by thaw subsidence and possible sediment release	loss	footprint	infrequent	permanent	all year	medium	Silt fences to restrict movement of sediment into re-flooded section from affected shoreline; however, sediment release from melting ground ice on the re-flooded lake bottom cannot be contained.	none	medium	Moderate because likelihood of widespread excess ground ice is expected to be limited	Only a concern during re-flooding. The potential significance of ground ice along the shoreline and across the former lake basin will be assessed during the next phase of study, and ongoing assessment will be carried out through operation in order to prepare for closure.
Goose Island (Third Portage Lake)	Loss of permafrost and active layer beneath original 3PL basin after it is flooded by 3PL; degradation of ground ice, where present on the lake bottom and around the new shoreline, accompanied by thaw subsidence and possible sediment release	loss	footprint	infrequent	permanent	all year	medium	Silt fences to restrict movement of sediment into re-flooded section from affected shoreline; however, sediment release from melting ground ice on the re-flooded lake bottom cannot be contained.	none	medium	Moderate because likelihood of widespread excess ground ice is expected to be limited	Only a concern during re-flooding. The potential significance of ground ice along the shoreline and across the former lake basin will be assessed during the next phase of study, and ongoing assessment will be carried out through operation in order to prepare for closure.
Pits												
Portage Pit	Loss of permafrost and active layer as pit is flooded by 3PL	loss	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
Goose Island Pit	Loss of permafrost and active layer as pit is flooded by 3PL	loss	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
Portage Rock Storage Facility	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	gain	local	infrequent	permanent	all year	medium	none	N/A	medium	certain	Cover and internal temperature regimes will be monitored for several years after closure to ensure predicted performance is achieved.

Table C.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Potential Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Borrow Pit(s) (All borrow material is currently planned to be taken from the ultimate pit boundaries.)	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
Tailings Storage Facilities	Stabilization of permafrost temperatures and active layer thickness, and downward movement of permafrost into the remaining talik beneath 2PL NW arm - POSITIVE	gain	local	infrequent	permanent	all year	medium	none	N/A	medium	certain	Cover, internal and former talik temperature regimes will be monitored for several years after closure to ensure predicted performance is achieved.
Main Site Roads & Traffic	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
Airstrip & Air Traffic	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
Ditches (Roads, Airstrip & Contact Water)	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
Mine Plant & Associated Facilities	Recovery of any degraded permafrost from beneath heated structures; stabilization of permafrost temperatures and active layer thickness - POSITIVE	gain	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended

Table C.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects: Spatial Boundaries: Magnitude	Spatial Boundaries: Spatial Extent	Temporal Boundaries: Frequency	Temporal Boundaries: Duration	Temporal Boundaries: Timing	Significance of Unmitigated Effects	Potential Mitigation	Assessment of Residual Effects: Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	Management and Monitoring
Freshwater Intake & Pipeline	Recovery of any degraded permafrost from beneath disturbed areas; stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
Discharge Facilities & Pipeline	Recovery of any degraded permafrost from beneath disturbed areas; stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
Non-Contact Diversion Facilities	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
Laydown Storage (at Plant Site)	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
AN/Explosives Storage & Emulsion Plant	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
Site Accommodations	Recovery of any degraded permafrost from beneath heated structures; stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended

Table C.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Sewage & Waste Disposal	Recovery of any degraded permafrost from beneath heated structures; stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
VAULT FACILITIES												
Construction Noise & Activity	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vault Dike	Degradation of recently developed permafrost and loss of active layer in breached portion of the Vault dike as well as the submerged downstream (south) side of dike; warming of recently developed permafrost and deepening of the active layer in the portion of the dike above the level of Vault-Wally lakes.	loss	local	infrequent	permanent	all year	low	none	N/A	low	certain	Representative monitoring of ground temperatures to ensure permafrost characteristics are understood at closure and for the short-term after re-flooding of Vault Lake.
Vault Lake Dewatering & Drainage Facilities	Loss of permafrost and active layer beneath subaerial portion of original Vault Lake basin after it is flooded; degradation of ground ice, where present on the lake bottom and around the new shoreline, accompanied by thaw subsidence and possible sediment release	loss	Footprint	infrequent	permanent	all year	medium	Silt fences to restrict movement of sediment into re-flooded section from affected shoreline; however, sediment release from melting ground ice on the re-flooded lake bottom cannot be contained.	none	medium	Moderate because likelihood of widespread excess ice is expected to be limited.	Only a concern during re-flooding. The potential significance of ground ice along the shoreline and across the former lake basin will be assessed during the next phase of study, and ongoing assessment will be carried out through operation in order to prepare for closure.

Table C.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Vault Lake-Phaser Lake Berm	Stabilization of permafrost temperatures and active layer thickness - POSITIVE; except loss of permafrost and establishment of a new active layer where berm is removed to facilitate re-establishment of drainage between Phaser and Vault lakes.	loss	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
Phaser Lake Operation	Loss of permafrost and active layer beneath subaerial portion of original Phaser Lake basin after it is flooded; degradation of ground ice, where present, accompanied by thaw subsidence and possible sediment release	loss	Footprint	infrequent	permanent	all year	medium	Silt fences to restrict movement of sediment into re-flooded section from affected shoreline; however, sediment release from melting ground ice on the re-flooded lake bottom cannot be contained.	none	medium	Moderate because likelihood of widespread excess ice is expected to be very limited.	Only a concern during re-flooding. The potential significance of ground ice along the shoreline and across the former lake basin will be assessed during the next phase of study, and ongoing assessment will be carried out through operation in order to prepare for closure.
Vault Pit	Loss of permafrost and active layer as pit is flooded by Vault Lake	loss	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
Vault Waste Dump	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	gain	local	infrequent	permanent	all year	medium	none	N/A	medium	certain	Cover and internal temperature regimes will be monitored for several years after closure to ensure predicted performance is achieved.
Vault Access Road & Traffic												
Access Road Culverts (Turn Lake)	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	loss	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended

Table C.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Shop/Office	Recovery of any degraded permafrost from beneath heated structures; stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
OTHER FACILITIES												
Winter Road & All Terrain Vehicle Traffic	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
Baker Lake Access Road & Traffic	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
Barge Landing Facility	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
Barge Traffic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Staging Facility (approx. 1.5 km east of town)	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended
Explosives Magazine	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended

Table C.3 Continued

Project Component	Potential Effect	Assessment of Unmitigated Effects						Potential Mitigation	Assessment of Residual Effects			Management and Monitoring
		Spatial Boundaries		Temporal Boundaries			Significance of Unmitigated Effects		Influence of Mitigation on Effects Assessment	Significance of Residual Impacts	Probability	
		Magnitude	Spatial Extent	Frequency	Duration	Timing						
Tank Farm	Stabilization of permafrost temperatures and active layer thickness - POSITIVE	negligible	local	infrequent	permanent	all year	low	none	N/A	low	certain	none recommended