APPENDIX I

GLOSSARY OF TERMS AND DEFINITIONS

GLOSSARY

The following terminology is utilized in this document following the definitions provided in the Mine Site Reclamation Guidelines for the Northwest Territories (INAC 2007) and the DDMI Class “A” Water License [License Number: W2007L2-0003])

“A154 Pit”: The developed open pit and underground mine workings for the mining of the A154 North and South Kimberlite Pipes.

“A21 Pit”: The developed open pit for the mining of the A21 Kimberlite Pipe.

“A418 Pit”: The developed open pit and underground mine workings for the mining of the A418 Kimberlite Pipe.

Abandonment: The permanent dismantlement of a facility so it is permanently incapable of its intended use. This includes the removal of associated equipment and structures.

Abiotic: Non-living factors that influence an ecosystem, such as climate, geology and soil characteristics.

Acid Rock Drainage: The production of acidic leachate, seepage or drainage from underground workings, pits, ore piles, rockwaste, tailings, and overburden that could lead to the release of metals to groundwater and surface water during the life of the mine and after closure.

Active Layer: The layer of ground above the permafrost which thaws and freezes annually.

Adsorption: The surface retention of solid, liquid or gas particles by a solid or a liquid.

Alkalinity: A measure of the buffering capacity of water, or the capacity of bases to neutralize acids.

Ambient: The conditions surrounding an organism or area.

Ambient: The air in the surrounding atmosphere.

Anthropogenic: Caused by human activity.

“Aquatic Effects Monitoring Program”: A monitoring program designed to determine the short and long-term effects in the water environment resulting from the Project, to evaluate the accuracy of impact predictions, to assess the effectiveness of impact mitigation measures and to identify additional impact mitigation measures to reduce or eliminate environmental effects.

Aquitard: A material of low permeability between aquifers. An aquitard allows some measure of leakage between the aquifers it separates.

Backfill: Material excavated from a site and reused for filling the surface or underground void created by mining.

Background: An area near the site under evaluation not influenced by chemicals released from the site, or other impacts created by onsite activity.

Baseline: A surveyed condition and reference used for future surveys.

Bathymetry: Measurement of the depth of an ocean or large waterbody.

Bedrock: The body of rock that underlies gravel, soil or other subregion material.

Benthic Invertebrate: Invertebrate organisms living at, in or in association with the bottom (benthic) substrate of lakes, ponds and streams. Examples of benthic invertebrates include some aquatic insect species (such as caddisfly larvae) that spend at least part of their lifestages dwelling on bottom sediments in the waterbody. These organisms play several important roles in the aquatic community. They are involved in the mineralization and recycling of organic matter produced in the water above, or brought in from external sources, and they are important second and third links in the trophic sequence of aquatic communities. Many benthic invertebrates are major food sources for fish.

Berm: A mound of rock or soil used to retain substances or to prevent substances from entering an area.

Biodiversity: The variety of plants and animals that live in a specific area.

Biotic: The living organisms in an ecosystem.

Biotite schist: A metamorphic rock containing a significant proportion of biotite (black) mica flakes, which are aligned in one main direction.

Board: The Mackenzie Valley Land and Water Board established under Part 4section 57.1 of the *Mackenzie Valley Resource Management Act*.

Boreal Forest: The northern hemisphere, circumpolar, tundra forest type consisting primarily of black spruce and white spruce with balsam fir, birch and aspen.

Canadian Dam Safety Guidelines: The Canadian Dam Association's Dam Safety Guidelines (January 1999) or subsequent approved editions. The scope and applicability of the DSG referred to in this Licence, is presented in Section 1 of the DSG.

Carat: A unit weight for precious stones: 1 carat = 200 mg.

Care and maintenance: A term to describe the status of a mine when it undergoes a temporary shutdown.

Closure: When a mine ceases operations without the intent to resume mining activities in the future.

Closure Criteria: Detail to set precise measures of when the objective has been satisfied.

Conductivity: A measure of the ability of water to pass an electrical current, which is affected by the presence of inorganic dissolved solids and organic compounds.

Construction: Activities undertaken to construct or build any components of, or associated with, the development of the Diavik Diamond Mine.

Contaminant: Any physical, chemical, biological or radiological substance in the air, soil or water that has an adverse effect. Any chemical substance with a concentration that exceeds background levels or which is not naturally occurring in the environment.

Contouring: The process of shaping the land surface to fit the form of the surrounding land.

County Rock: The rock surrounding an intrusive igneous rock such as kimberlite.

Criteria: Detail to set precise measures of when an objective has been satisfied.

Cryoconcentration: Concentration of solutes due to exclusion by ice.

Cryosols: An order of mineral or organic soils that generally have permafrost within 1 m of the ground surface and soil layers that are frequently disrupted by freezing.

Cryoturbation: Mixing of soil due to freezing and thawing.

Decommission: The process of permanently closing a site and removing equipment, buildings and structures. Reclamation and plans for future maintenance of affected land and water are also included.

Dewatering: The removal or draw down of water from any water body or from ground water table by pumping or draining.

Diabase: A dark-gray to black, fine-textured igneous rock composed mainly of feldspar and pyroxene.

Dike: Temporary water-retaining structure designed for water control to enable safe open-pit and underground mining.

Dike Seepage: Any water which passes through a dike.

Discharge: The release of any water or waste to the receiving environment.

Disposal: The placement, containment, treatment or processing of unwanted materials. This may involve the removal of contaminants or their conversion to less harmful forms.

Drainage: Excess surface or ground water runoff from land.

Drainage Basin: A region of land that eventually contributes water to a river or lake.

Dredging: Excavating and moving lake-bottom sediments and glacial till below the high watermark and from the bottom of Lac de Gras in the area of the footprints of the dikes.

"East Island": The large eastern-most island in Lac de Gras.

Ecodistrict: A subdivision of an ecoregion which is characterized by distinctive assemblages of relief, geology, landforms, soils, vegetation, water and fauna.

Ecoregion: A subdivision of an ecozone which is characterized by distinctive regional ecological factors, including physiography, climate, soil, vegetation, water and wildlife.

Ecosystem: An ecological unit consisting of both biotic (living) and abiotic (nonliving) environment that interacts within a defined physical location.

Ecozone: An area at the earth's surface representative of large and very generalized ecological units characterized by various abiotic (nonliving) and biotic (living) factors.

Edaphic: Referring to the soil. The influence of the soil on plant growth is referred to as an edaphic factor.

Effluent: Treated or untreated liquid waste material that is discharged into the environment from a treatment plant.

Electrical Conductivity: The capability of a solution to transmit an electrical current. A capability closely related to the concentration of salts in soils.

End Land Use: The allowable use of disturbed land following reclamation. Municipal zoning and/or approval may be required for specific land uses.

Engineered Structures: Any constructed facility which was designed and approved by a Professional Engineer registered with the Association of Professional Engineers, Geologists, and Geophysicists of the Northwest Territories.

Environment: The components of the Earth, and includes: land, water and air, including all layers of the atmosphere; all organic and inorganic matter and living organisms; and the interacting natural systems that include the aforementioned components.

Environmental Assessment (EA): An assessment of the environmental effects of a project that is conducted in accordance with the Canadian Environmental Assessment Act and its regulations.

Erosion: The wearing away of rock, soil or other surface material by water, rain, waves, wind or ice.

Esker: Glaciofluvial landform that occurs when meltwater deposits are left behind after glacier melts, resulting in long winding ridges of sediment.

Evaporation: The process by which water is changed from a liquid to a vapour.

Extensometer: An instrument used to monitor ground displacements.

Fish: Fish as defined in the *Fisheries Act*, includes parts of fish, shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals and the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals.

Fish Habitat: Areas used by fish for spawning, nursery, rearing, foraging and overwintering.

Footprint: The proposed development area that directly affects the soil and vegetation components of the landscape.

Freeboard: The vertical distance between the water line and the effective water containment crest on a dam's or dike's upstream slope.

Freshet: An increase in surface water flow during the late winter or spring as the result of rainfall, and snow and ice melt.

Geotechnical Engineer: A professional engineer registered with the Association of Professional Engineers, Geologists and Geophysicists of the Northwest Territories and whose principal field of specialization is the design and construction of earthworks in a permafrost environment.

Glacial Till: Unsorted and unlayered rock debris deposited by a glacier.

Glaciofluvial Deposits: Material moved by glaciers and subsequently sorted and deposited by flowing glacial meltwater. Consist primarily of course to medium grained sands, gravels, cobbles, and boulders.

Glaciolacustrine Deposits: Material moved by glaciers and deposited in glacial lakes. Consist primarily of fine sands, silts and clay.

Groundwater: All subsurface water that occurs in rocks, soil and other geologic formations that are fully saturated.

Groundwater Recharge: Water that enters the saturated zone by a downward movement through soil and contributes to the overall volume of groundwater.

Habitat: The place where an animal or plant naturally lives and grows.

Habitat Unit: Generally, used in Habitat Suitability Index models. A habitat is ranked in regards to its suitability for a particular wildlife species. This ranking is then multiplied by the area (hectares) of the particular habitat type to give the number of habitat units (HU) available to the wildlife species in question.

Home Range: The area within which an animal normally lives, and traverses as part of its annual travel patterns.

Hummock: A bulging mound of soil having a silty of clay core that often develops in wet and/or permafrost conditions and shows evidence of movement due to regular frost action.

Hydrogeology: The study of the factors that deal with subsurface water (groundwater) and the related geologic aspects of surface water. Groundwater as used here includes all water in the zone of saturation beneath the earth’s surface, except water chemically combined in minerals.

Hydrology: The science that deals with water, its properties, distribution and circulation over the Earth’s surface.

Hydraulic Conductivity: Measure of the capacity of an aquifer to transmit water.

Igneous Rock: Rock formed when molten rock cools and solidifies.

Inclinometer: A tilt sensor used to monitor the angle of an object with respect to gravity.

In Situ Treatment: A method of managing, treating or disposing of material "in place" in a manner that does not require the material to be physically removed or excavated from where it is located.

Inspector: An Inspector designated by the Minister under Section 35(1) of the Northwest Territories *Water Act*.

Kame: An irregularly shaped hill or mound composed chiefly of poorly sorted sand and gravel deposited by a sub-glacial stream as an alluvial fan or delta.

Kimberlite: A type of ancient rock that travelled up to the earth's surface where it formed mini-volcanoes.

Kimberlite Pipes: Volcanic deposits contained in steep-walled, cone-shaped cylinders.

Landfill: An engineered waste management facility at which waste is disposed of by placing it on or in land in a manner that minimizes adverse human health and environmental effects.

Leachate: Water or other liquid that has washed (leached) from a solid material, such as a layer of soil or water; leachate may contain contaminants.

Leaching: The removal, by water, of soluble matter from any solid material lying on top of bedrock (e.g., soil, alluvium or bedrock).

Lithology: The systematic description of sediment and rocks, in terms of composition and texture.

Littoral Zone: The zone in a lake that is closest to the shore. It includes the part of the lake bottom, and its overlying water, between the highest water level and the depth where there is enough light (about 1% of the surface light) for rooted aquatic plants and algae to colonize the bottom sediments.

Local Study Area: Defines the spatial extent directly or indirectly affected by the project.

Metal Leaching: The mobilization and migration of metals from underground workings, pitwalls, ore piles, waste rock, tailings, and overburden.

Meteoric Water: Groundwater that has recently originated from the atmosphere.

Migration: The movement of chemicals, bacteria, and gases in flowing water or vapour.

Mine Design: The detailed engineered designs for all mine components stamped by a design engineer

Mine Plan: The plan for development of the mine, including the sequencing of the development.

Mine Water: Any water that accumulates in any underground working or open pits.

Mitigation: The process of rectifying an impact by repairing, rehabilitating or restoring, the affected environment, or the process of compensating for the impact by replacing or providing substitute resources or environments.

Monitoring: Observing the change in geophysical, hydrogeological or geochemical measurements over time.

Nitrogen Dioxide: One of the component gases of oxides of nitrogen which also includes nitric oxide. In burning natural gas, coal, oil and gasoline, atmospheric nitrogen may combine with molecular oxygen to form nitric oxide, an ingredient in the brown haze observed near large cities. Nitric oxide is converted to nitrogen dioxide in the atmosphere. Cars, trucks, trains and planes are the major source of oxides of nitrogen in Alberta. Other major sources include oil and gas industries and power plants.

No Net Loss: A term found in Canada's Fisheries Act. It is based on the fundamental principle of balancing unavoidable losses of fish habitat with habitat replacement on a project-by-project basis in order to prevent depletion of Canada's fisheries resources.

"North Inlet Facility": The containment facility that is constructed within the North Inlet of East Island of Lac de Gras.

"North Inlet Treatment Facility: Includes the treatment plant designated for the treatment of waters associated with the North Inlet Facility and mine workings.

Nutrient Regime: The relative supply of nutrients available for plant growth at a given site.

Objectives: Objectives describe what select activities are aiming to achieve.

Oligotrophic: Trophic state classification for lakes characterized by low productivity and low nutrient inputs (particularly total phosphorus).

Outliers: A data point that falls outside of the statistical distribution defined by the mean and standard deviation.

Parent Material: Material (generally bedrock) from which soils typically obtain structure and minerals. Consolidated (rock) or unconsolidated (e.g., river deposits) material that has undergone some degree of physical or chemical weathering.

Particulate Matter: A mixture if small particles and liquid droplets, often including a number of chemicals, dust and soil particles.

Passive Treatment: Treatment technologies that can function with little or no maintenance over long periods of time.

Pegmatite: A very coarse-grained igneous rock that has a grain size of 20 mm or more;

Permafrost: Ground that remains at or below zero degrees Celsius for a minimum of two consecutive years.

Permafrost Aggradation: A naturally or artificially caused increase in the thickness and/or area extent of permafrost.

Permeability: The ease with which gases or liquids penetrate or pass through a soil or cover layer.

pH: A measure of the alkalinity or acidy of a solution, related to hydrogen ion concentration; a pH of 7.0 being neutral.

Piezometer: An instrument used to monitor pore water pressure.

Pit water: Water that seeps into and/or is collected within the pit.

Pore Water Pressure: The pressure of groundwater held within the spaces between sediment particles.

Pore Water: The groundwater present within the spaces between sediment particles.

Post-Closure: The period of time after closure of the mine.

Processed Kimberlite (PK): Processed material rejected from the process plant after the recoverable minerals have been extracted.

Processed Kimberlite Containment (PKC): A storage area for the kimberlite remaining after diamonds have been removed during processing.

Progressive Reclamation: Actions that can be taken during mining operations before permanent closure, to take advantage of cost and operating efficiencies by using the resources available from mine operations to reduce the overall reclamation costs incurred. Progressive reclamation enhances environmental protection and shortens the timeframe for achieving the reclamation objectives and goals.

Project: The Diavik Diamond Mines Project, a joint venture between Harry Winston Diamond Corporation and Diavik Diamond Mines Inc.

Quaternary Glaciation: Glaciation that occurred during Quaternary period or the geologic time period from the end of the Pliocene Epoch roughly 1.8-1.6 million years ago to the present.

Rare Plants: A native plant species found in restricted areas, at the edge of its range or in low numbers within a province, state, territory or country.

Reclamation: The process of returning a disturbed site to a condition consistent with the original natural state or one for other productive uses that minimizes any adverse effects on the environment or threats to human health and safety.

Regional Study Area: Defines the spatial extent related to the cumulative effects resulting from the project and other regional developments.

Rehabilitation: Activities to ensure that the land will be returned to a form and productivity in conformity with a prior land use plan, including a stable ecological state that does not contribute substantially to environmental deterioration and is consistent with surrounding aesthetic values.

Relative Humidity: The ratio of the amount of water vapour in the atmosphere to the amount necessary for saturation at the same temperature. Relative humidity is expressed in terms of percent and measures the percentage of saturation.

Remediation: The removal, reduction, or neutralization of substances, wastes or hazardous material from a site in order to minimize any adverse effects on the environment and public safety now or in the future.

Restoration: The renewing, repairing, cleaning-up, remediation or other management of soil, groundwater or sediment so that its functions and qualities are comparable to those of its original, unaltered state.

Revegetation: Replacing original ground cover following a disturbance to the land.

Riparian: Refers to streams, channels, banks and the habitats associated with them.

Risk assessment: Reviewing risk analysis and options for a given site, component or condition. Risk assessments consider factors such as risk acceptability, public perception of risk, socio-economic impacts, benefits, and technical feasibility. It forms the basis for risk management.

Runoff: Water that is not absorbed by soil and drains off the land into bodies of water.

Scarification: Preparation of a site to make it more amenable to plant growth.

Security deposit: Funds held by the Crown that can be used in the case of abandonment of an undertaking to reclaim the site, or carry out any ongoing measures that may remain to be taken after the abandonment of the undertaking.

Sedge: Any plant of the genus *Carex*, perennial herbs, often growing in dense tufts in marshy places. They have triangular jointless stems, a spiked inflorescence and long grass-like leaves which are usually rough on the margins and midrib. There are several hundred species.

Sediment: Solid material, both mineral and organic, that has been moved by air, water, gravity, or ice and has come to rest on the earth's surface either above or below sea level.

Seepage: Slow water movement in subsurface. Flow of water from constructed retaining structures. A spot or zone, where water oozes from the ground, often forming the source of a small spring.

Sewage: All toilet wastes and greywater.

"Sewage Treatment Plants": Comprises the engineered structures that are designed to contain and treat sewage at the North and South Camps during the construction period, and the main accommodations complex during operations,

Sentinel Species: Species that can be used as an indicator of environmental conditions.

Shoals: A shallow but submerged area isolated from the shorelines of a body of water.

Shoreline Habitat: Area extending from the high water mark to the low water mark of a given water body.

Slurry: A mixture of fine rock and water that can be pumped.

Soil: The naturally occurring, unconsolidated mineral or organic material at least 10 cm thick that occurs at the earth's surface and is capable of supporting plant growth.

Soil Horizon: A layer of mineral or organic soil material approximately parallel to the land surface that has characteristics altered by processes of soil formation. A soil mineral horizon is a horizon with 17% or less total organic carbon by weight. A soil organic horizon is a horizon with more than 17% organic carbon by weight.

Solar Radiation: The principal portion of the solar spectrum that spans from approximately 300 nanometres (nm) to 4,000 nm in the electromagnetic spectrum. It is measured in W/m^2, which is radiation energy per second per unit area.

Solifluction: The slow creeping of soil down a slope promoted by the presence of permafrost and caused by a combination of frost creep and the downslope movement of wet, unfrozen soil.

Spawning Habitat: A particular type of area where a fish species chooses to produce and deposit its eggs.

Spillway: An engineered structure to facilitate the release of water from a water retention facility, often in an emergency. The spillway elevation is the elevation at which water begins to flow through the spillway structure.

Substrate: The material that comprises the bottom of a water body.

Sulphur Dioxide: Sulphur dioxide is a colourless gas with a pungent odour. In Alberta, natural gas processing plants are responsible for close to half of the emissions of this gas. Oil sands facilities and power plants are also major sources. Others include gas plant flares, oil refineries, pulp and paper mills and fertilizer plants.

Surficial material: Deposits on/at the earth's surface.

Sump: A catch basin where water accumulates before being pumped elsewhere for storage, treatment or release.

Surface Waters: Natural water bodies such as rivers, streams, brooks, ponds and lakes, as well as artificial watercourses, such as drainage ditches and collection ponds.

Sustainable Development: The design, development, operation and closure of all mining activities so as to ensure the optimisation of post closure outcomes in terms of social, environmental and economic development needs and expectations.

Tailings: Material rejected from a mill after most of the recoverable valuable minerals have been extracted.

Taliks: Unfrozen zones that can exist within, below, or above permafrost layers. They are usually located below deep water bodies.

Temporary Shutdown: The cessation of mining and diamond recovery for a finite period due to economic or other operational reasons, with the intent to resume operations under more favourable conditions.

Thermistor: An instrument used to monitor temperature change.

Thermokarst: A landscape characterized shallow pits and depressions caused by selective thawing of ground ice, or permafrost.

Till: Sediments laid down by glacial ice.

Total Dissolved Solids (TDS): A measure of the amount of dissolved substances in a waterbody:

Total Organic Carbon: Total organic carbon is composed of both dissolved and particulate forms. Total organic carbon is often calculated as the difference between Total Carbon (TC) and Total Inorganic Carbon (TIC). Total organic carbon has a direct relationship with both biochemical and chemical oxygen demands, and varies with the composition of organic matter present in the water. Organic matter in soils, aquatic vegetation and aquatic organisms are major sources of organic carbon.

Total Suspended Particulate: A measure of the total particulate matter suspended in the air. This represents all airborne particles with a mean diameter less than 30 µm (microns) in diameter.

Total Suspended Solids (TSS): A measure of the particulate matter suspended in the water column.

Traditional Knowledge: A cumulative, collective body of knowledge, experience, and values built up by a group of people through generations of living in close contact with nature. It builds upon the historic experiences of a people and adapts to social, economic, environmental, spiritual and political change.

Trophic: Pertaining to part of a food chain, for example, the primary producers are a trophic level just as tertiary consumers are another trophic level.

Turbidity: The degree of clarity in the water column typically reflected as the amount of suspended particulate matter in a waterbody.

Understorey: Trees or other vegetation in a forest that exist below the main canopy level.

Waste Rock: All unprocessed rock materials produced as a result of mining operations that have no economic value.

Waste Rock Storage Facilities: Includes the engineered facilities for the disposal of rock and till, which are designated as the North and South Wasterock piles.

Waterbody: A general term that refers to ponds, bays, lakes, estuaries and marine areas.

Waterfowl Staging Area: Waterbodies used by waterfowl to gather, rest and feed before or during migration.

Watershed: A region or area bordered by ridges of higher ground that drains into a particular watercourse or body of water.

Wetland: A swamp. Marsh, bog, fen or other land that is covered by water during at least three consecutive months of the year.

Wildlife: Under the *Species at Risk Act*, wildlife is defined as a species, subspecies, variety or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus that is wild by nature and is native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.

APPENDIX II

LIST OF ACRONYMS

ACRONYMS

Acronym	Description
AEMP	Aquatics Effects Monitoring Program
ARD	acid rock drainage
BHPB	BHP Billiton
Ca	Calcium
CCME	Canadian Council of Ministers of the Environment
Cl	Chloride
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPK	Course Processed Kimberlite
DDMI	Diavik Diamond Mines Inc.
DFO	Department of Fisheries and Oceans (Fisheries and Oceans Canada)
DIAND	Department of Indian Affairs and Northern Development (Indian and Northern Affairs Canada)
DTC	Diavik Technical Committee
EA	Environmental Assessment
EER	Environmental Effects Report
EMAB	Environmental Monitoring Advisory Board
EMPR	Department of Energy Mines and Petroleum Resources
ESWG	Ecological Stratification Working Group
FeSi	Ferro-Silicon
FPK	Fine Processed Kimberlite
HADD	Harmful alteration, disruption or destruction (of fish habitat)
HCO_3	Bicarbonate
HSEQMS	Health, Safety and Environment Quality Management Systems
HW	Harry Winston Diamond Limited Partnership
ICRP	Interim Closure and Reclamation Plan
INAC	Indian and Northern Affairs Canada
LSA	Local Study Area
Mg	Magnesium

Acronym	Description
MLch	Metal Leaching
MVLWB	Mackenzie Valley Land and Water Board
Na	Sodium
NI	North Inlet
NIWTP	North Inlet Water Treatment Plant
NKSL	Nishi Khon-SNC Lavalin
NTU	Nephelometric Turbidity Unit
NWT	Northwest Territories
PK	Processed Kimberlite
PKC	Processed Kimberlite Containment
RA	Regulatory Authorities
ROM	Run of Mine
RSA	Regional Study Area
SARA	*Species at Risk Act*
SGP	Slave Geological Province
SNP	Surveillance Network Program
TDS	total dissolved solids
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TSP	Total Suspended Particulate
TSS	total suspended solids
UCAF	Underhand cut and fill
VLC	vegetation/land cover
WLWB	Wek’èezhìi Land and Water Board
WTA	Waste Transfer Area
WWF	World Wildlife Fund
ZOI	Zone of Influence

APPENDIX III

LIST OF ABBREVIATIONS

ABBREVIATIONS

Abbreviation	Description
EBA	EBA Engineering Consultants Ltd.
Golder	Golder Associates Ltd.
Kennecott	Kennecott Canada Inc.
The Mine	Diavik Diamond Mine

APPENDIX IV

LIST OF UNITS AND SYMBOLS

UNITS

Unit	Description
%	percent
<	less than
>	greater than
° '	degrees, minutes
°C	degrees Celsius
µg/m^3	microgram per cubic metre
µS/cm	micro Siemens per centimetre
BTU	British Thermal Units
cm	centimetre
FeSi	ferro-silicon
ha	Hectare
kg $CaCO_3$/tonne	kilograms calcium carbonate per tonne
km	kilometre
km/hr	kilometres per hour
km^2	square kilometres
kV	kilovolts
m	metre
m/s	metres per second
m^3	cubic metres
m^3/day	cubic metres per day
m^3/s	cubic metres per second
masl	metres above sea level
mg/dm^2/yr	milligrams per square decimetre per year
mg/kg	milligrams per kilogram
mg/L	milligrams per litre
ML	Million litres
mm	millimetre
Mm^3	Million cubic metres
Mt	Million tonnes (1 tonne = 1,000 kilograms)
MW	Megawatts
NTU	Nephelometric Turbidity Units
wt%	percent by weight

APPENDIX V

CLOSURE OBJECTIVES AND CRITERIA

Appendix V-1 Detailed Tabulation of Objectives and Criteria

Appendix V-2 Graphical Comparison of Criteria and Research Data

Appendix V-3 Site Specific Risk Based Closure Criteria

Appendix V-1 Detailed Tabulation of Objectives and Criteria

Appendix V-1 Detailed Tabulation of Closure Objectives and Criteria - NCRP

1. Introduction

This Appendix describes the approach DDMI has used to develop proposed closure criteria. DDMI recognizes the challenges in developing closure criteria. The most recent WLWB sponsored Closure Criteria Workshop (December 2016) confirms that this challenge is recognized by all Parties. DDMI's intent here is to be as clear as possible about what is proposed and why.

It is recognized that the ultimate decision on closure criteria rests with the WLWB. It is DDMI's understanding that the WLWB will ultimately draft specific regulatory language and conditions that will form part of a future Water License. In the interim DDMI is seeking a reasonable level of regulatory certainty with regard to the criteria that will be used to determine the acceptability of this WRSA closure plan. This certainty is necessary for DDMI to support financial expenditures of this magnitude. Where appropriate, DDMI has attempted to describe criteria in a way that they can be incorporated into a future Water License.

Guidance with regard to closure criteria is taken from the MVLWB/AANDC (2013) "*Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories*". Here closure criteria are defined as:

> *"standards that measure the success of selected closure activities in meeting closure objectives. Closure criteria may have a temporal component (e.g., a standard may need to be met for a pre-defined number of years). Closure criteria can be site-specific or adopted from territorial/federal or other standards and can be narrative statements or numerical values."* (definitions page 6).

MVLWB/AANDC (2013) go further at page 16 to state that criteria "*must be meaningful, measurable and achievable*".

In addition to guidance from MVLWB/AANDC (2013), DDMI has also taken guidance from MVLWB (2011) "Water and Effluent Quality Management Policy" in developing the proposed approach to water quality closure criteria.

Section 2 below focuses on the approach used by DDMI to develop numeric closure criteria for water that would apply at the point of release to Lac de Gras analogous to an EQC grab limit. DDMI anticipates that once approved these could form a key condition of a future water License.

Section 3 below describes the approach used by DDMI to develop numeric human health and wildlife closure criteria related to water quality. DDMI expects these criteria will most likely be used in the interpretation of monitoring results but are less likely to form regulatory limits. While some of the "other" criteria proposed in Section 4 are numeric, many are narrative. It is unclear how or if these other narrative criteria would be included in a future Water License. Section 5 summarizes in table format the closure criteria for each of the closure objectives applicable to the NCRP-WRSA.

2. Criteria Approach – Water Quality and Protection of Aquatic Life

Water Quality Standards for the protection of aquatic life in Lac de Gras form the base for the closure criteria. DDMI proposes to use the approved AEMP Benchmark values as Water Quality Standards. These are listed in Column N of Table V1. At this time DDMI has not proposed the use of the Site Specific Risk Based Closure Criteria (Appendix V-3) for protection of aquatic life as there seems to be significant reluctance to this approach for water quality given the existence of the AEMP Benchmarks.

A back calculation approach was used to estimate the runoff/seepage concentration of each water quality parameter required to anticipate receiving water concentrations below the AEMP benchmark in Lac de Gras at the assessment boundary. The calculation used is:

CC=EM*(DF+1)-(REFO*DF) where:

CC = Closure Criteria (mg/L) (Column T)

EM=Effects Magnitude (mg/L) (Column O)

REFO = Reference Condition – Median Open Water (mg/L) (Column Q)

DF = DF=Dilution Factor (dimensionless)

The Effect Magnitude (Column O) is defined as being 20 percent greater than current AEMP Benchmark (Column N) in Table V1. This is the defined High Effects Magnitude from Canada (1999).

Background water quality (REFO) for the calculation was assumed to be the median open water concentration as defined in the AEMP Reference Condition Report (DDMI 2015). These values are listed in Table V1 for both open-water (Column Q) and ice-cover (Column P).

The dilution factor (DF) has been assumed at 85. This value is from the Environmental Assessment (DDMI 1998- Table A7) and was determined based on modelling of runoff to Lac de Gras and represents the expected level of dilution that would occur within 1 km^2. The 1 km assessment boundary is also from the Environmental Assessment (DDMI 1998 Figure 1-4) and is defined as the "local" assessment area in Canada (1999). The area is shown in Figure V1.

The resulting back calculated closure criteria are shown in Column T.

Table V1. Values used in the derivation of water quality closure criteria for protection of aquatic life.

B	C	D	E	M	N	O	P	Q	T	U
							Median LDG Reference			
		Smith (2013) Mean	Smith (2013) Max	EA Prediction	DDMI AEMP Benchmark Aquatic Life	Effects Magnitude	Ice	Open	Back Calculated Criteria	Criteria Note
Silver	mg.L-1	0.011	0.064	0.0003	0.0001	0.00012	0.0000025	0.0000025	0.010	Calculated
Aluminum	mg.L-1	0.054	0.302	0.05	0.087	0.1044	0.0029	0.0044	8.6	Calculated
Arsenic	mg.L-1	0.0060	0.0317	0.0063	0.005	0.006	0.0002	0.00017	0.5	Calculated
Boron	mg.L-1	0.071	0.398		1.5	1.8	0.0025	0.0025	155	Calculated
Barium	mg.L-1	4.02	22.68		1.0	1.2	0.00193	0.00181	103	Calculated
Cadmium	mg.L-1	0.0003	0.0019	0.0094	0.0001	0.00012	0.0000025	0.0000025	0.01	Calculated
Chloride	mg.L-1	38.1	214.9	0.6	120	144	0.8	1	12299	Calculated
Copper	mg.L-1	0.073	0.413	0.0085	0.002	0.0024	0.0003	0.00030	0.18	Calculated
Iron	mg.L-1	0.071	0.401	0.0155	0.3	0.36	0.0025	0.0025	31	Calculated
Nitrite	mg.L-1	0.004	0.022	0.003	0.06	0.072	0.001	0.001	6	Calculated
Nitrate	mg.L-1	1.1	6.3	0.2	3	3.6	0.0034	0.001	310	Calculated
Ammonia	mg.L-1			0.015	4.73	5.676	0.0178	0.005	488	Calculated
Sodium	mg.L-1	70.7	398.8	16.8	52	62.4	0.64	0.63	5313	Calculated
Nickel	mg.L-1	0.070	0.394	0.0523	0.025	0.03	0.00097	0.00095	2.5	Calculated
Lead	mg.L-1	0.0024	0.0134	0.0029	0.001	0.0012	0.0000025	0.0000025	0.10	Calculated
Sulphate	mg.L-1	158.9	896.0	3.2	100	120	2.2	1.9	10159	Calculated
Selenium	mg.L-1	0.0032	0.0181	0.0006	0.001	0.0012	0.00002	0.00002	0.10	Calculated
Silicon	mg.L-1	2.9	16.6		2.1	2.52	0.025	0.025	215	Calculated
Strontium	mg.L-1	0.95	5.34		30	36	0.0076	0.0073	3095	Calculated
Uranium	mg.L-1	1.35	7.61	0.0171	0.015	0.018	0.000028	0.000028	1.5	Calculated
Zinc	mg.L-1	0.070	0.398	0.0479	0.03	0.036	0.00090	0.00075	3.0	Calculated
Chromium	mg.L-1	0.00032	0.00178	0.0206	0.001	0.0012	0.00003	0.00003	0.10	Calculated
Molybdenum	mg.L-1	0.016	0.089		0.073	0.0876	0.00007	0.00009	7.5	Calculated
Antimony	mg.L-1	0.00031	0.00141	0.0214	0.033	0.0396	0.00001	0.00001	3.4	Calculated
Tin	mg.L-1	0.00063	0.00356		0.073	0.0876	0.000005	0.000005	7.5	Calculated
Thallium	mg.L-1	0.00020	0.00114	0.0031	0.0008	0.00096	0.000001	0.000001	0.08	Calculated
pH	units		6.18						5-8.4	EQC (H26)

Achievability

The next step in the approach was to consider "achievability". Achievability is a specified consideration in both MVLWB/AANDC (2013) and MVLWB (2011). DDMI evaluated achievability by reviewing the back calculated closure criteria against both the predicted NCRP runoff/seepage quality (Smith 2013) and a graphical compilation of measured seepage results from Diavik's research program. Appendix V-2 contains the figures presenting the research data sets in comparison to a) back calculated closure criteria (Column T), b) EA predicted seepage/runoff (Column M), c) range (min/max) of runoff/seepage predictions (Smith 2013) and d) the AEMP Benchmark (Column N).

From this visual assessment DDMI noted two parameters where the back calculated closure criteria appear to present substantive "achievability" concerns; silver and copper.

Silver

The back calculated closure criteria for silver of 0.01 mg/L is lower than maximum predicted in Smith (2013) of 0.064 mg/L (Column E) and is within the measured range shown in Appendix V-2. DDMI proposes to increase the closure criteria for silver to 0.06 mg/L, the maximum predicted in Smith (2013) to improve achievability. It should be noted that the 0.06 mg/L closure criteria is still within the range of measured seepage from Diavik's test pile research.

Copper

The back calculated closure criteria for copper of 0.18 mg/L is lower than maximum predicted in Smith (2013) of 0.413 mg/L (Column E) and is within the measured range shown in Appendix V-2. DDMI proposes to increase the closure criteria for silver to 0.4 mg/L the maximum predicted in Smith (2013) to improve achievability. It should be noted that the 0.4 mg/L closure criteria is still within the range of measured seepage from Diavik's test pile research.

Other Exceptions

Nickel and Zinc

The back calculated closure criteria for nickel and zinc are greater than the current grab limits specified in the Metal Mining Effluent Regulations (MMER). DDMI is recommending that the proposed closure criteria for these two parameters be reduced to equal the MMER grab limits.

Nitrogen compounds

The nitrogen compounds (ammonia, nitrate, nitrite) present a unique challenge with regard to achievability. These are not geochemical parameters where runoff/seepage concentrations are influenced by rock type. Nitrogen compounds are the result of explosives residue. While they are expected to be present in early NCRP runoff/seepage, concentrations are expected to decline to very low values quickly relative to metals. For this reason nitrogen compounds have not been evaluated for achievability in the same way as metal parameters. Like nickel and zinc the proposed MMER limit for un-ionized ammonia is likely lower than the back calculated closure criteria and DDMI is recommending the closure criteria for ammonia be equal to the proposed MMER grab limit for un-ionized ammonia once it has been finalized.

pH

The back calculation approach described above is not appropriate for pH as it does not mass balance the same way as the other water quality parameters. DDMI proposes that the closure criteria for pH remain as per Part H Item 26 (W2015L2-0001) at between 5 and 8.4.

Criteria not Proposed

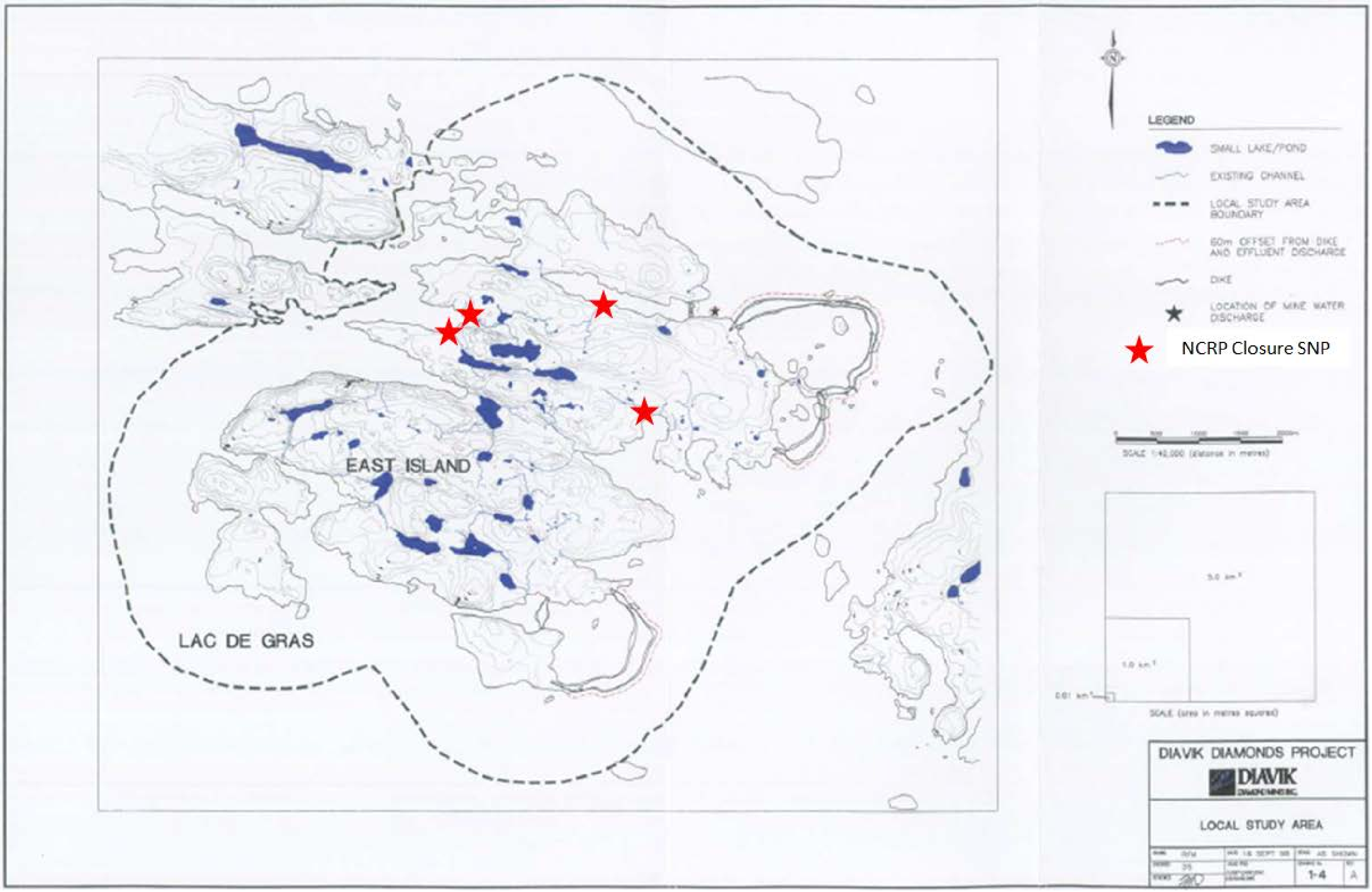
MVLWB (2011) includes the principle of waste minimization in setting criteria including setting levels that are lower than what is necessary to meet water quality standards in the receiving environment. DDMI has identified nine parameters where closure criteria could be either lowered following the waste minimization principle or eliminated as being unnecessary for closure. These parameters are boron, barium, chloride, iron, molybdenum, sodium, silicon, sulphate and strontium. For each the back calculated closure criteria are much greater than the expected runoff/seepage water quality from either Smith (2013) or the Diavik research measurements (Appendix V-2). DDMI proposes that there be no closure criteria for boron, barium, chloride, iron, molybdenum, silicon, sulphate or strontium on the basis that criteria are not necessary.

Table V2 below list the proposed surface runoff/seepage closure criteria for protection of aquatic life in Lac de Gras and the Coppermine River as grab limits.

Table V2. Proposed surface runoff/seepage closure criteria for protection of aquatic life. All as grab limits.

		Proposed Closure Criteria	Criteria Note
Silver	mg.L-1	0.06	Achievable
Aluminum	mg.L-1	8.6	Back Calculated
Arsenic	mg.L-1	0.5	Back Calculated
Cadmium	mg.L-1	0.01	Back Calculated
Copper	mg.L-1	0.4	Achievable
Nitrite	mg.L-1	6.1	Back Calculated
Nitrate	mg.L-1	310	Back Calculated
Unionized Ammonia	mg.L-1	1.0	MMER (proposed)
Nickel	mg.L-1	1.0	MMER
Lead	mg.L-1	0.1	Back Calculated
Selenium	mg.L-1	0.1	Back Calculated
Uranium	mg.L-1	1.5	Back Calculated
Zinc	mg.L-1	1.0	MMER
Chromium	mg.L-1	0.10	Back Calculated
Antimony	mg.L-1	3.4	Back Calculated
Tin	mg.L-1	7.5	Back Calculated
Thallium	mg.L-1	0.1	Back Calculated
pH	units	5-8.4	EQC (H26)

Figure V1. Assessment Areas – Protection of Aquatic Life (from DDMI 1998 – Figure 1-4).



3. Criteria Approach – Water Quality and Human Health/Wildlife

Water quality closure criteria for human health and wildlife are those defined as Site-Specific Risk-Based Closure Criteria (SSRBCC) in Appendix V-3.

Human Health

Closure criteria for human drinking water are those specified in Appendix J (of Appendix V-3) with application of the notes listed for each parameter. Table V3 below summarizes these values for convenience but the reader should go to Appendix V-3 for an explanation of the basis for these criteria. These criteria are applicable where water could be consumed by people. For the NCRP this would include direct consumption of seepage/runoff or consumption of Lac de Gras water in proximity to where the seepage/runoff was released.

Table V3. Drinking water closure criteria from Appendix V-3 (Appendix J).

		SSRBCC (App J with Notes)	
		Adult	Toddler
Antimony	mg.L-1	0.113	0.00662
Arsenic	mg.L-1	0.01	0.01
Chromium	mg.L-1	0.05	0.05
Manganese	mg.L-1	0.59	0.301
Mercury	mg.L-1	0.0011	0.0007
Nitrate	mg.L-1	30.2	17.6
Nitrite	mg.L-1	1.89	1.0
Selenium	mg.L-1	0.05	0.05
Sulphate	mg.L-1	266	669
Uranium	mg.L-1	0.02	0.02

Achievability is a specified consideration in MVLWB/AANDC (2013). Achievability was considered for the criteria listed in Table V3. DDMI evaluated achievability by reviewing SSRBCC against both the predicted NCRP runoff/seepage quality (Smith 2013) and a graphical compilation of measured seepage results from Diavik's research program. Appendix V-2 contains the figures presenting the research data sets and the range (min/max) of runoff/seepage predictions (Smith 2013).

From this visual assessment it appears that with the exception of uranium all of the SSRBCC will be achieved locally within Lac de Gras but it is unlikely that all SSRBCC would be achieved for direct consumption of the NCRP runoff/seepage based on these predictions. Human health SSCRCC for sulphate and manganese are within the range of expected NCRP runoff/seepage concentrations. Nitrate and nitrite SSRBCC are also within the predicted range for runoff/seepage, but as discussed above these concentrations are not expected to remain long term. Note that achievability has not been assessed for mercury as expected runoff/seepage concentrations are not currently available.

The human health SSRBCC for uranium of 0.02 mg/L is lower that the AEMP Benchmark for the protection of aquatic life (0.015 mg/L). The human health SSRBCC is unlikely to me met in the runoff/seepage water itself. In Lac de Gras the human health SSRBCC for uranium would be achieved before the edge of the local assessment area (Figure 1 above). If the human health SSRBCC of 0.02 mg/L is approved and runoff/seepage with this quality materializes, measures may be required to restrict human access to the runoff/seepage to avoid direct consumption.

Wildlife - Birds

Water closure criteria for birds are those specified in Appendix I (of Appendix V-3). Table V4 below summarizes these values for convenience but the reader should go to Appendix V-3 for an explanation of the basis for these criteria. These criteria are applicable where birds would be exposed to water. For the NCRP this would include direct exposure to seepage/runoff and in Lac de Gras in proximity to where the seepage/runoff was released.

Table V4. Water closure criteria for birds from Appendix V-3 (Appendix I).

		SSRBCC (App I)				
		Sandpiper	Duck	Ptarmigan	Falcon	Eagle
Chromium	mg.L-1	2.9	9.31	8.41	47.7	83.2
Cobalt	mg.L-1	8.28	26.6	24.1	137	238
Manganese	mg.L-1	1.95	626	566	3213	5598
Molybdenum	mg.L-1	3.81	12.2	11.1	62.8	109
Nickel	mg.L-1	7.3	23.5	21.2	120	210
Uranium	mg.L-1	17.4	56	50.6	287	500

Achievability is a specified consideration in MVLWB/AANDC (2013). Achievability was considered for the criteria listed in Table V4. DDMI evaluated achievability by reviewing SSRBCC against both the predicted NCRP runoff/seepage quality (Smith 2013) and a graphical compilation of measured seepage results from Diavik's research program. Appendix V-2 contains the figures presenting the research data sets and the range (min/max) of runoff/seepage predictions (Smith 2013). From this visual assessment it appears unlikely that any of the SSRBCC in Table V4 would be realized even with direct exposure to the seepage/runoff.

Wildlife - Mammals

Water closure criteria for mammals are those specified in Appendix H (of Appendix V-3) with application of the notes listed for molybdenum. Table V5 below summarizes these values for convenience but the reader should go to Appendix V-3 for an explanation of the basis for these criteria. These criteria are applicable where mammals would be exposed to water. For the NCRP this would include direct exposure to seepage/runoff and in Lac de Gras in proximity to where the seepage/runoff was released.

Table V5. Water closure criteria for mammals from Appendix V-3 (Appendix H).

		SSRBCC (App H)			
		Caribou	Bear	Fox	Vole
Chromium	mg.L-1	8	9.25	5.58	3.51
Cobalt	mg.L-1	24.4	28.3	17.1	10.7
Manganese	mg.L-1	172	199	120	75.4
Molybdenum	mg.L-1	1	1	1	1
Nickel	mg.L-1	5.67	6.55	3.95	2.49
Uranium	mg.L-1	10.2	11.8	7.14	4.5

Achievability is a specified consideration in MVLWB/AANDC (2013). Achievability was considered for the criteria listed in Table V5. DDMI evaluated achievability by reviewing SSRBCC against both the predicted NCRP runoff/seepage quality (Smith 2013) and a graphical compilation of measured seepage results from Diavik's research program. Appendix V-2 contains the figures presenting the research data sets and the range (min/max) of runoff/seepage predictions (Smith 2013). From this visual assessment it appears unlikely that any of the SSRBCC in Table V5 would be realized even with direct exposure to the seepage/runoff.

4. Criteria Approach – Other

The mitigation of poor quality runoff/seepage from the NCRP-WRSA is a key consideration in the closure plan and cover design. As such runoff/seepage water quality closure criteria will likely be the key closure criteria as discussed above. Additional criteria are proposed to describe how the success of other, non-water quality closure objectives could be measured. Many of these proposed criteria are appropriately narrative rather than numeric. DDMI understands that different criteria may be proposed by others. DDMI is willing to fully consider alternative proposals for these criteria now and/or in conjunction with the consideration of similar closure criteria for other areas of the mine site.

DDMI understands closure criteria to be different from design criteria. Where available, design criteria can be used in the process of developing a closure design to more clearly express a closure objective. Take for example one of the NCRP landscape objectives:

> *W2 - Rock and till pile features (shape and appearance) that match aesthetics of the surrounding natural area*

Conceptually, design criteria could have been developed for this objective. An example of a design criteria could be that the top of NCRP must be no higher than 500 m above sea level. Design criteria have been developed for some aspects of the closure design, for example till thickness, but not all. In many cases, including the example of landscape, the design has been developed with general consideration of an objective (i.e. aesthetics input from people) rather than designing to specified design criteria like elevation no greater than 500m. One of the purposes of developing this Plan and DDMI's Engagement is for reviewers to confirm the acceptability of the design, including the acceptability of how well the design aligns with objectives like W2. Once approved, the design itself can and should become the better definition of an objective like W2. With the design as the better definition of the W2 objective the closure criteria can then be to demonstrate that the closure landscape has been constructed following the approved design.

DDMI does not believe that it is necessary or helpful try to ascribe subjective metrics to an approved design expressly for the purpose of having numeric closure criteria. Using the example above, we do not see value in now stating that the NCRP should be no higher than 500m ASL, just so that there is metric to use as a closure criteria. DDMI is asking that the NCRP be approved as designed and for the example of an objective like W2 the NCRP height, the standard to measure success will be for DDMI to provide evidence that the NCRP final landscape conforms to the approved design.

Some of the closure criteria in Tables V6 and V7 below have been developed based on the rationale described above.

5. Proposed Criteria

Tables V6 and V7 present the proposed closure criteria for the site wide closure objectives applicable to the NCRP and the objectives that are specific to the NCRP. Descriptions or references are also provided for where or how the criteria are to be "measured" and where a description of the monitoring program can be found.

Table V6 Closure Objectives and Criteria – Site Wide Applicable to North Country Rock Pile Closure

Closure Objective	Closure Criteria	Measurements	Monitoring Reference
SW1. Surface runoff and seepage water quality that is safe for humans and wildlife.	Tables V3,V4 and V5 or the result of a detailed Risk Assessment.	Surface water affected by runoff/seepage.	Appendix VI-2
SW2 Surface runoff and seepage water quality that will not cause adverse effects on aquatic life or water uses in Lac de Gras or the Coppermine River.	Table V2 No acute toxicity (96 hr Rainbow Trout, 48 hr *Daphnia Magna*).	NCRP surface runoff/seepage at point of discharge to Lac de Gras	Appendix VI-2
SW3. Dust levels safe for people, vegetation, aquatic life, and wildlife.	Mean TSP concentrations less than 60 ug/m^3 annual and 120 ug/m^3 24 hr maximum acceptable (Canadian Ambient Air Quality Objectives and NWT Ambient Air Quality Standards).	Ambient TSP.	Appendix VI-2
SW4. Dust levels do not affect palatability of vegetation to wildlife.	Monitoring evidence of post-closure wildlife use of area.	Post-closure monitoring of wildlife use in area.	Appendix VI-2
SW6. Ground surface designed to drain naturally follow pre-development drainage patterns.	NCRP As-Built Report conforms adequately with Golder (2016)	Reclamation Completion Report.	Appendix VI-2
SW7. Areas in and around the site that are undisturbed during operation of the mine should remain undisturbed during and after closure.	NCRP As-Built Report conforms adequately with Golder (2016)	Reclamation Completion Report.	Appendix VI-2
SW8. No increased opportunities for predation of caribou compared to pre-development conditions.	No monitoring evidence of recurring predation directly associated with an aspect of the NCRP.	Post-closure monitoring of wildlife use in area.	Appendix VI-2
SW9. Landscape features (topography and vegetation) that match aesthetics and natural conditions of the surrounding natural area.	NCRP As-Built Report conforms adequately with Golder (2016)	Post-closure Completion Report	Appendix VI-2
SW10. Safe passage and use for caribou and other wildlife.	No repeated harm to caribou as a direct result of passage through or use of the NCRP. (i.e. if a feature of NCRP is confirmed as being a hazard based on	Post-closure monitoring of caribou use in area. Post-closure monitoring of caribou use in area.	Appendix VI-2

Closure Objective	Closure Criteria	Measurements	Monitoring Reference
	more than one incident then objective is not met for that feature)		

Table V7 Closure Objectives and Criteria – North Country Rock Pile

Closure Objective	Closure Criteria	Actions - Measurements	Monitoring Reference
W1 Physically stable slopes to limit risk of failure that would impact the safety of people or wildlife.	NCRP As-Built Report conforms adequately with Golder (2016). Final Geotechnical Inspection by Engineer of Record.	Reclamation Completion Report Geotechnical Inspections	Appendix VI-2
W2 Rock and till pile features (shape and appearance) that match aesthetics of the surrounding natural area.	NCRP As-Built Report conforms adequately with Golder (2016).	Reclamation Completion Report.	Appendix VI-2
W3 Contaminated soils and waste disposal areas that cannot contaminate land and water.	NCRP As-Built Report conforms adequately with Golder (2016).	Reclamation Completion Report.	Appendix VI-2

Appendix V-2 Graphical Comparison of Criteria and Research Data

Technical Memorandum

To	Gord Macdonald, Diavik Diamond Mines (2012) Inc.
From	Lianna Smith, M.Sc., P.Geo (NWT), Principal, Lianna Smith Consulting
cc	
Reference	Waste Rock Storage Area Final Closure and Reclamation Plan, WLWB request #6 for additional data from the Type I test pile (letter dated 16 Dec 2016)_R2
Date	3 Mar 2017

1 Background

DDMI received a letter dated 16 Dec 2016 that included a request for times-series data from the Type 1 test pile:

Additional Data - Provide the complete set of water quality results graphed over time for the Type 1 test pile, to provide a better indication of geochemical performance, as requested by WLWB staff (WLWB Staff Comment # 14). DDMI agreed in principle to providing the data but did not submit it with their responses.

2 Time-series plots

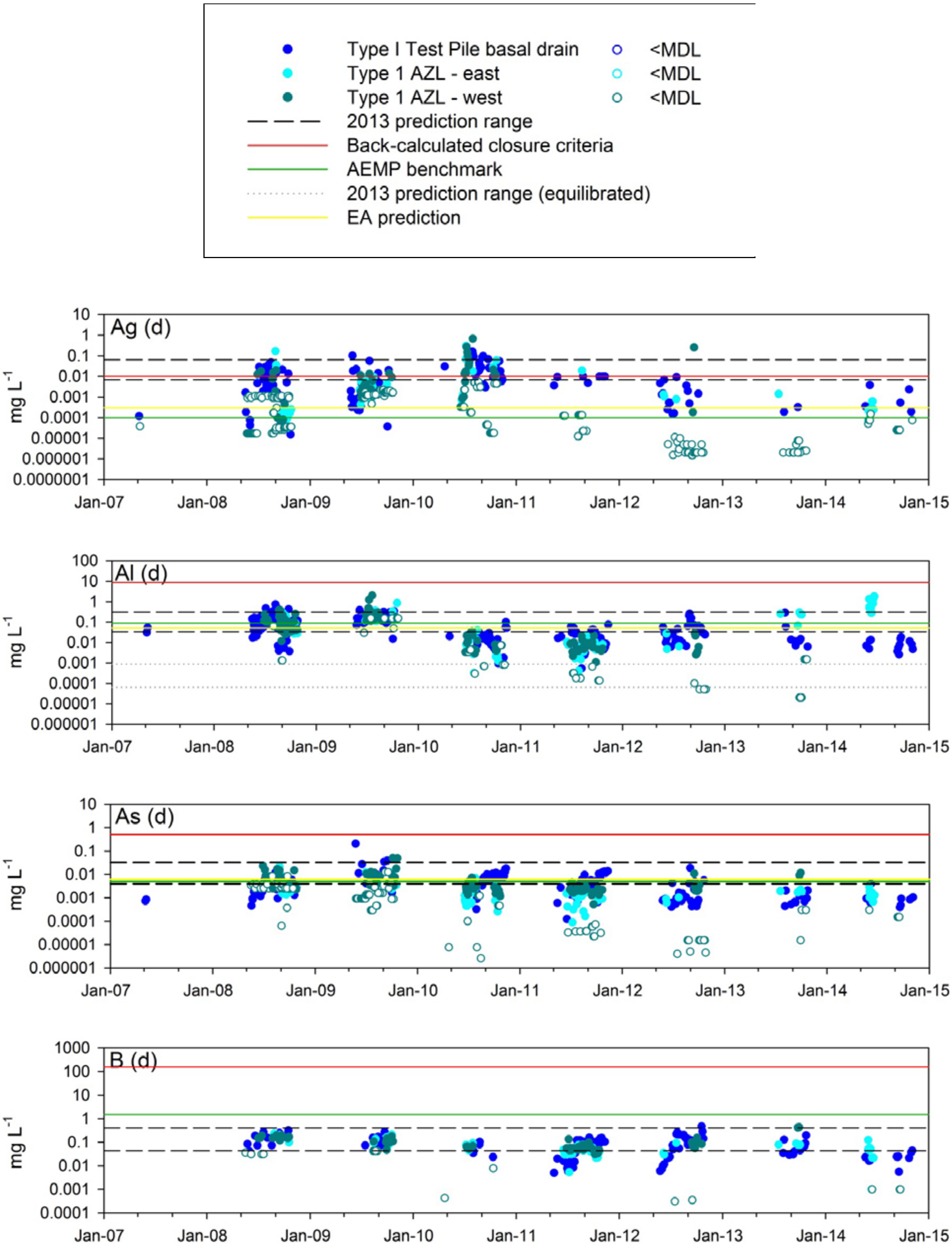
Data from the Type I basal drain and the two Type I active zone lysimeters (AZLs) were compiled and plotted over time. For samples with concentrations measured at less than the method detection limit (<MDL), the sample point was plotted at one half the MDL as an open symbol. All sample concentrations are for dissolved parameters.

In addition to the Type I Test Pile basal drain and AZL concentrations, the plots illustrate the back-calculated closure criteria (red line), the AEMP benchmark (green line), the Environmental Assessment (EA) prediction (yellow line), the range of concentrations from the 2013 North Country Rock Pile seepage predictions (dashed lines; Smith, 2013), and, for relevant parameters the equilibrated concentration from the 2013 North Country Rock Pile seepage predictions (dotted lines; Smith, 2013).

The low-concentration line from the 2013 predictions was taken from the 3 m cover scenario at the 75th percentile of precipitation for the QUAR basin (i.e. highest water:rock ratio calculated, and the basin with the lowest calculated concentrations); the high-concentration line was taken from the 7 m active zone with +10% matrix fraction at the 25th percentile precipitation for the NWR-west basin (i.e. the lowest water:rock ratio calculated, and the basin with the highest calculated concentrations). For Al, Ba, Fe and SO_4, the calculated equilibrated concentration range is also plotted as dotted lines because concentrations of these parameters may be influenced by secondary mineral precipitation (Smith et al., 2013).

3 References

Smith, L. 2013. Predictions of seepage quality from the North Country Rock Pile at closure. Prepared for Diavik Diamond Mines Inc. December 2013.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Type 1 AZL - east
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Type 1 AZL - west
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2013 prediction range
Back-calculated closure criteria
AEMP benchmark
2013 prediction range (equilibrated)
EA prediction
Ag (d)
Al (d)
As (d)
B (d)
mg L-1
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
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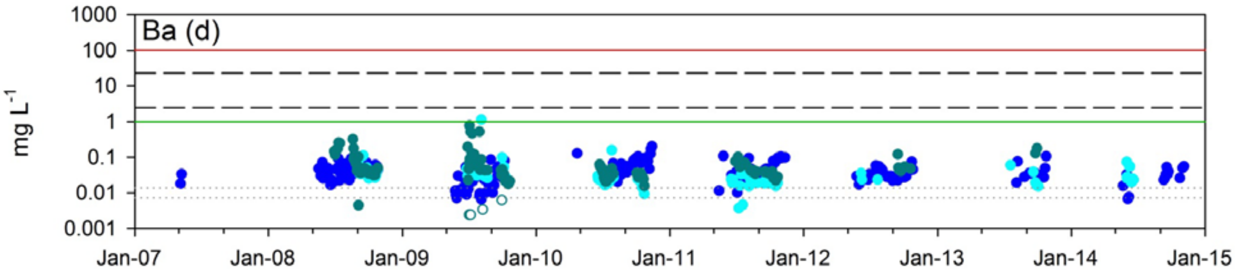
Jan-13
Jan-14
Jan-15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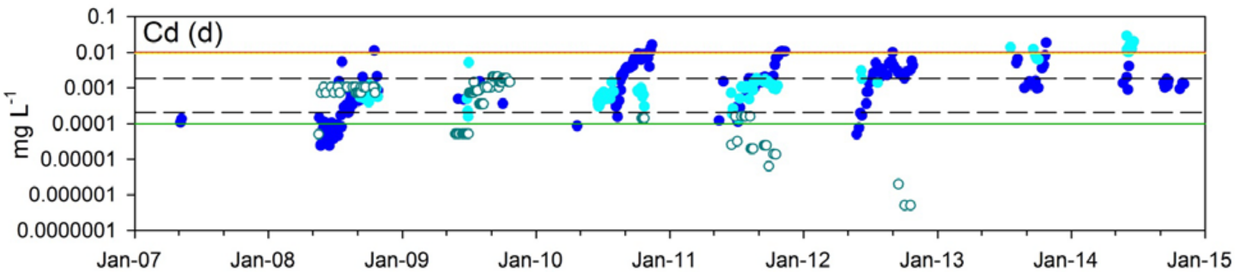
Cd (d)
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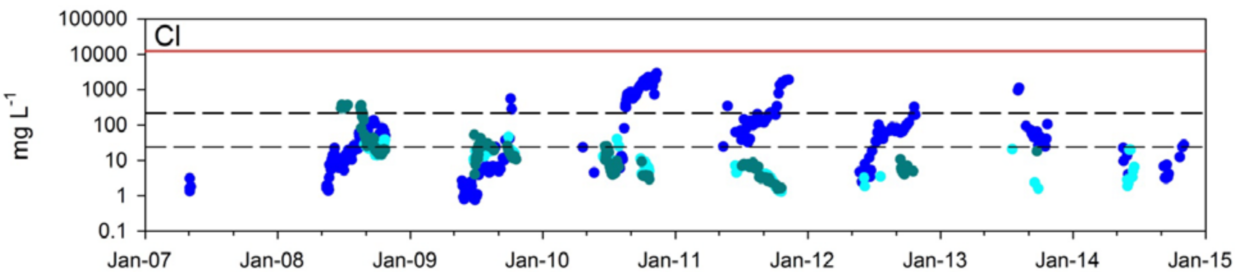
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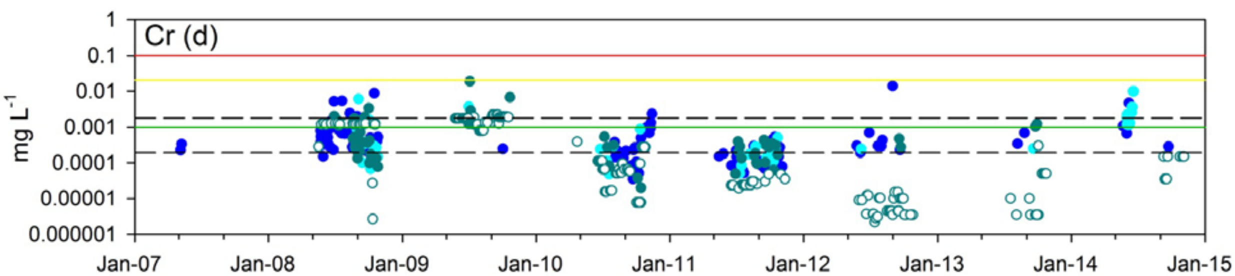
Jan-07 Jan-08 Jan-09 Jan-10 Jan-11 Jan-12 Jan-13 Jan-14 Jan-15


Cr (d)
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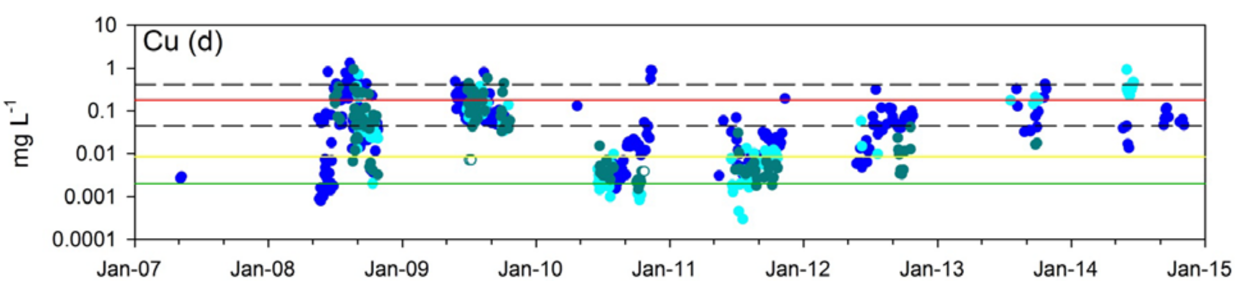
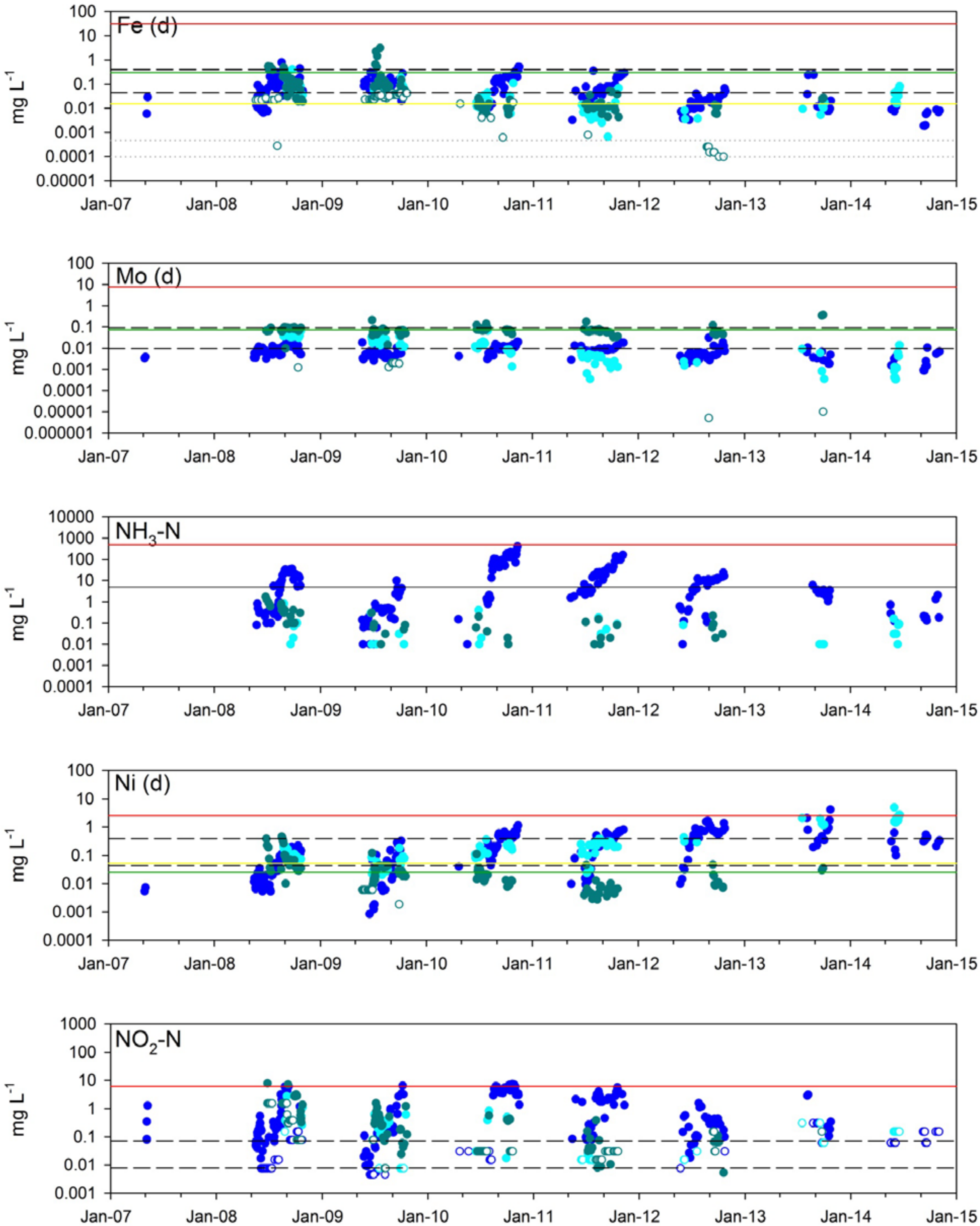
0.001
0.0001
0.00001
0.000001
Jan-07 Jan-08 Jan-09 Jan-10 Jan-11 Jan-12 Jan-13 Jan-14 Jan-15


Cu (d)
mg L-1
10
1
0.1
0.01
0.001
0.0001
Jan-07 Jan-08 Jan-09 Jan-10 Jan-11 Jan-12 Jan-13 Jan-14 Jan-15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Mo (d)
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0.1
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0.001
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0.00001
0.000001
NH3-N
mg L-1
10000
1000
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10
1
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Ni (d)
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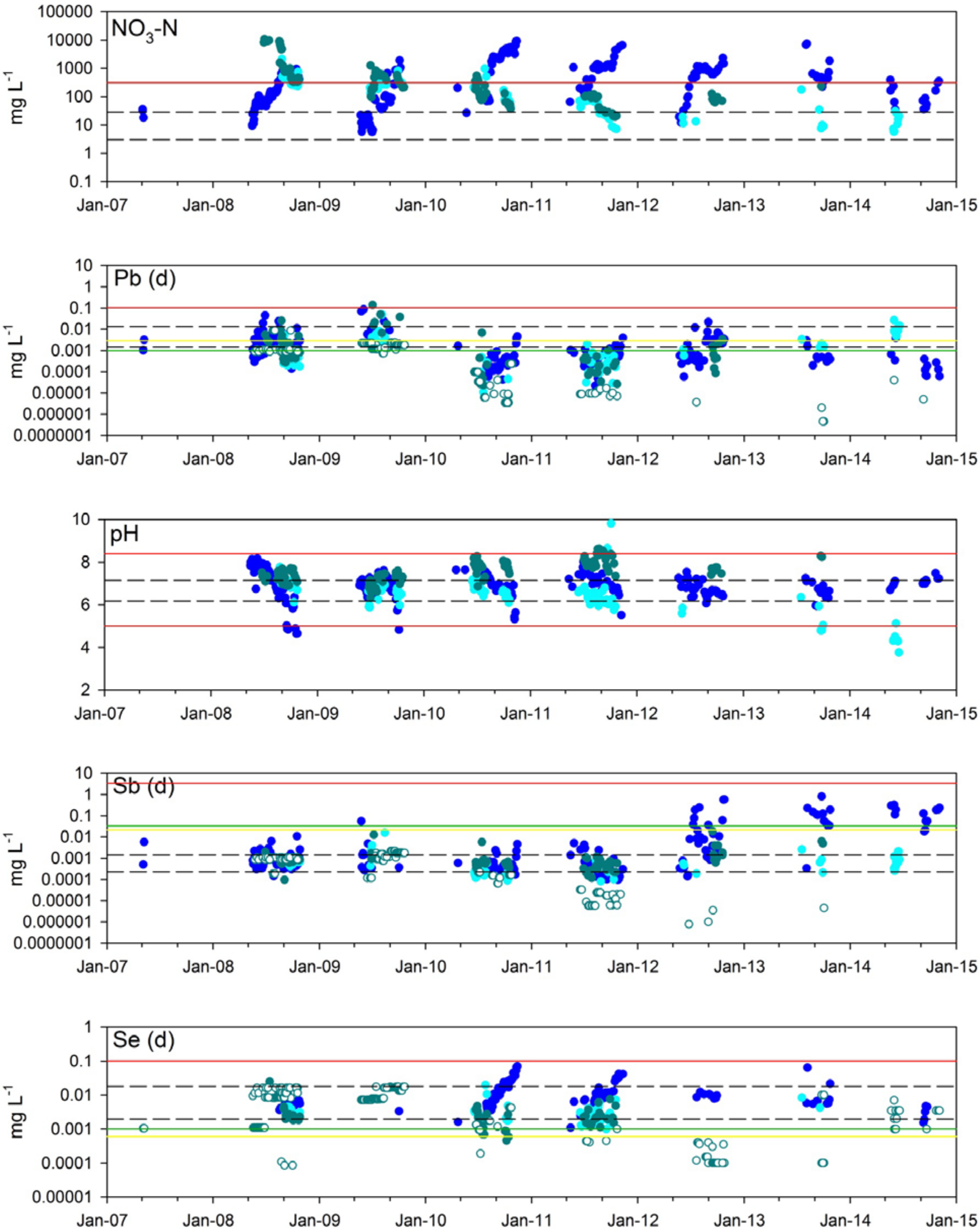
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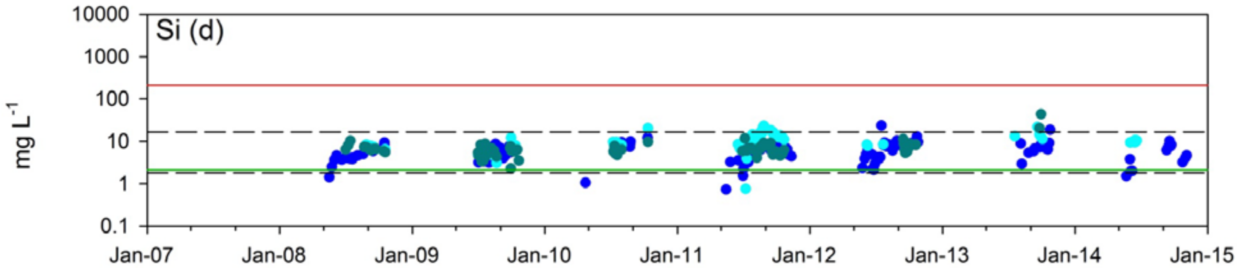
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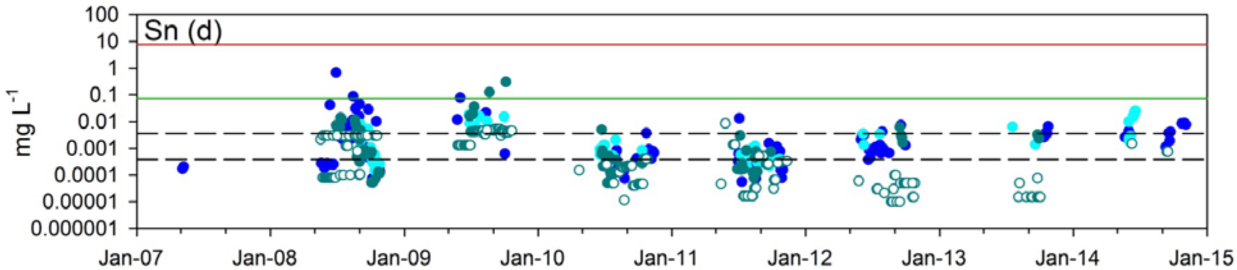
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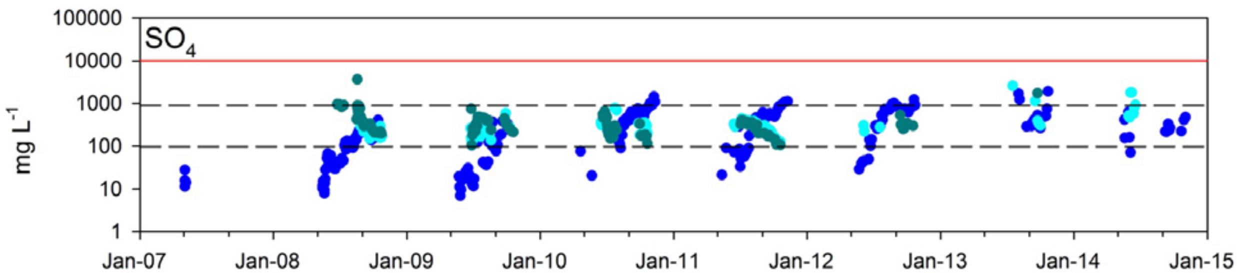
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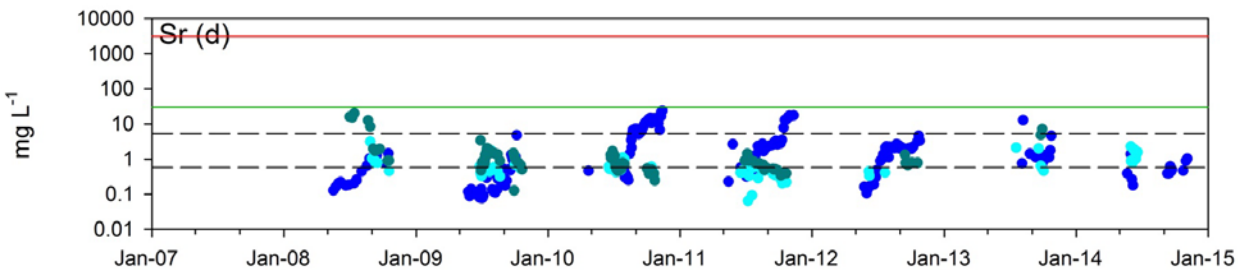
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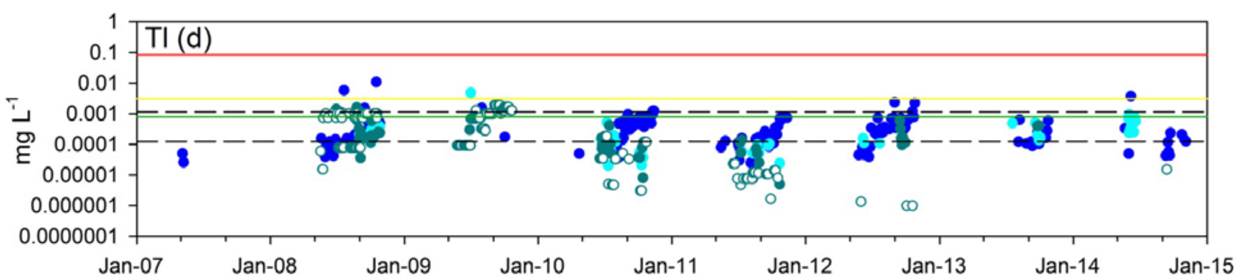
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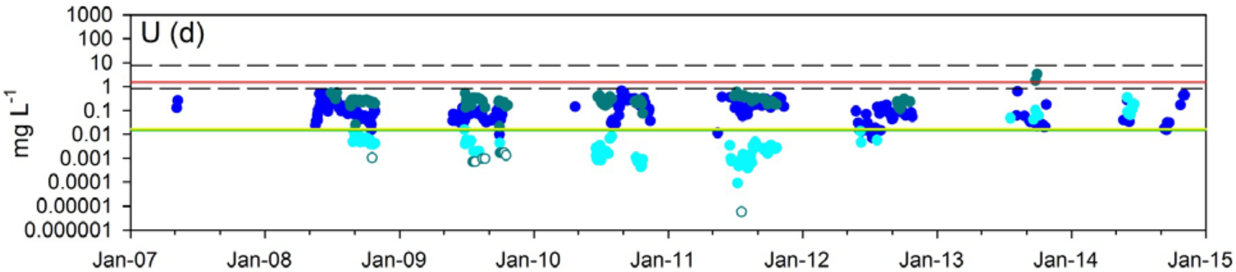
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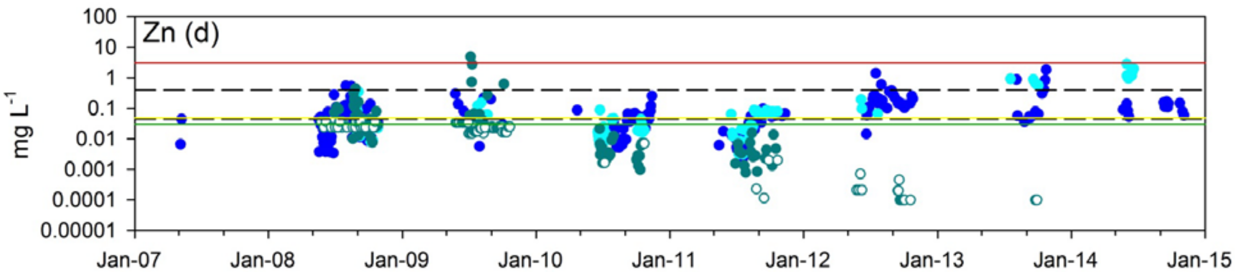
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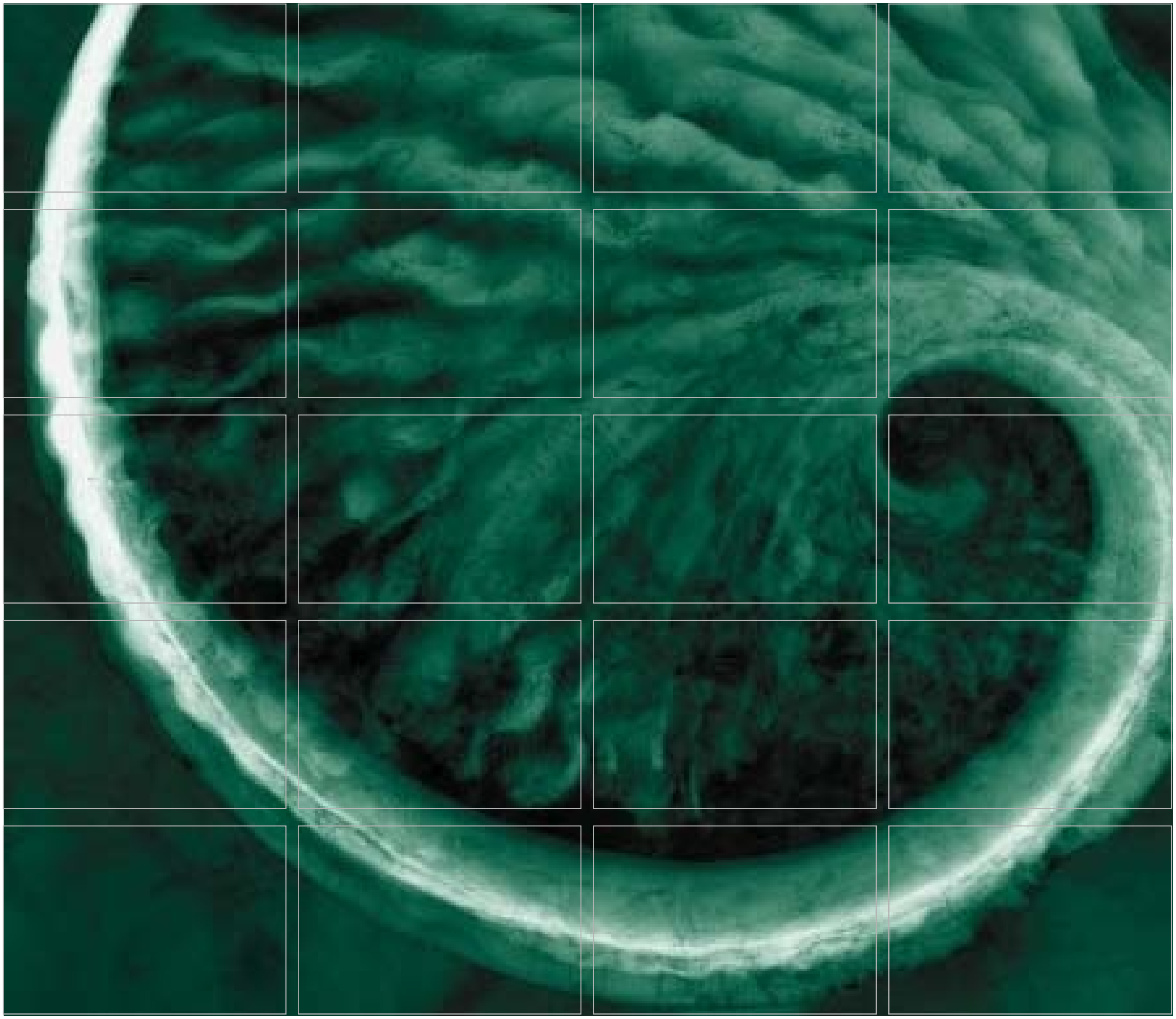
Appendix V-3 Site Specific Risk Based Closure Criteria



Prepared for:

Diavik Diamond Mines (2012) Inc.

DIAVIK DIAMOND MINE

Site-specific Risk-based Closure Criteria Phase I Report

January 2016

ERM

Diavik Diamond Mines (2012) Inc.

DIAVIK DIAMOND MINE

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January 2016

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

ARD	Acid rock drainage
BC MOE	British Columbia Ministry of Environment
CCME	Canadian Council of Ministers of the Environment
COPC	Contaminants of potential concern
ECO SSL	Ecological Soil Screening Level
EDI	Estimated daily intake
ICPR	Interim Closure and Reclamation Plan
ISQG	Interim sediment quality guidelines
KIA	Kitikmeot Inuit Association
LKDFN	Łutselk'e Dene First Nation
NCRP	North Country Rock Pile
NIWTP	North Inlet Water Treatment Plant
NSMA	North Slave Métis Alliance
PEL	Probable effects level
PKCA	Processed Kimberlite Containment Area
ROC	Receptor of concern
SNP	Surveillance Network Program
SSRBCC	Site-specific Risk-based Risk Closure Criteria
TDS	Total dissolved solids
TG	Tłı̨chǫ Government
TOC	Total organic carbon
TRV	Toxicity reference value
TSS	Total suspended solids

US EPA	United States Environmental Protection Agency
WLWB	Wek'èezhìi Land and Water Board
YKNFA	Yellowknives Dene First Nation

1. INTRODUCTION

1.1 OVERVIEW

Diavik Diamond Mines (2012) Inc. (DDMI) has requested Environmental Resource Management Consultants Canada Ltd. (ERM)'s assistance in developing closure criteria as set out in the Interim Closure and Reclamation Plan (ICRP) for Diavik Diamond Mine (the Project), using a risk-based approach that incorporates site-specific information (DDMI 2011). Specifically, DDMI has requested that ERM assist with the derivation of Site-specific Risk-based Closure Criteria (SSRBCC) as part of the development of the Final Closure and Reclamation Plan for the Project.

1.2 FRAMEWORK FOR DERIVING SITE-SPECIFIC RISK-BASED CLOSURE CRITERIA

Although the derivation of SSRBCC is not the same as a risk assessment, risk assessment principles can be used in developing safe closure criteria. The standard ecological risk assessment framework used in Canada (Health Canada 2010d; Environment Canada 2012) has the following key components:

- **Problem Formulation:** define the scope and context for the risk assessment;
- **Exposure Assessment:** define the amount of exposure of ecological or human receptors to the Contaminants of Potential Concern (COPCs);
- **Effects Assessment:** define the toxicity reference values (TRV) which are the acceptable amount of exposure for ecological or human receptors to COPCs such that adverse effects are unlikely to occur; and
- **Risk Characterization:** define the existing or predicted level of risk to ecological or human receptors.

The Problem Formulation consists of identifying potential receptors, sources of contaminants in the receiving environment, exposure pathways, and project-specific COPCs. This sets the stage for development of SSRBCC that are relevant for the Project, taking into consideration site-specific characteristics. The Exposure Assessment identifies the extent to which receptors will be exposed to COPCs. The Effects Assessment consists of the derivation of SSRBCC based on relevant TRVs and other available toxicological data. Once adopted, SSRBCC become the TRV that would be used as the maximum acceptable concentration of a COPC that is unlikely to cause adverse effects in ecological or human receptors in any future risk assessment. Uncertainties that may affect confidence in the conclusions of the risk assessment are considered at every stage.

1.3 OBJECTIVES

The overall objective of this work is to develop SSRBCC for soil, water, and sediment for the Project that will be protective of the health of both ecological and human receptors during Closure through the execution of the Problem Formulation and Effects Assessment components described above.

Exposure Assessment and Risk Characterization components have not been included at the request of DDMI because the objective of the proposed work is to determine safe concentrations (i.e., TRVs) rather than calculate the risk due to exposure to environmental concentrations during closure.

The derivation of SSRBCC is being conducted in two phases. The first phase consists of the Problem Formulation as described in the previous section. The focus of the first phase is on identifying representative human and ecological receptors, which contaminants of potential concern (COPCs) require SSRBCCs, and identification of uncertainties associated with the development of SSRBCCs. The second phase consists of the derivation of the SSRBCC once any data gaps identified in the first phase have been addressed. This report summarizes the outcome of the first phase.

2. PROBLEM FORMULATION

The Problem Formulation describes the context and scope of the subsequent derivation of SSRBCCs. It identifies a representative set of receptors that may be present, potential sources of contaminants in the receiving environment, potential pathways by which receptors may be exposed to COPCs, and project-specific COPCs. A conceptual model is one of the primary outcomes of the Problem Formulation Stage. The conceptual model is a narrative and/or pictorial representation of the COPC sources, environmental fate and transport, and exposure pathways for receptors associated with the Project (Environment Canada 2012).

The approach to Problem Formulation was similar for both ecological and human health, with both approaches based on risk assessment principles, and is consistent with Environment Canada and Health Canada's guidelines for assessing potential risks to ecological and human health (Health Canada 2010c, 2010b, 2010a, 2010d; Environment Canada 2012).

2.1 POTENTIAL RECEPTORS OF CONCERN

2.1.1 Potential Ecological Receptors

There are numerous aquatic and terrestrial wildlife species present in the sub-Arctic environment. As it is not practical to evaluate all species that may be present at or around the Project site, representative aquatic and terrestrial wildlife receptors were selected for consideration in the derivation of SSRBCCs.

Receptor types were identified in accordance with Environment Canada guidance for selection of ecological receptors of concern (ROCs) for ecological risk assessment (Environment Canada 2012) and considered the following factors:

- several receptor types were included in the assessment to ensure representation of various trophic levels, habitats, and feeding guilds within the environments appropriate for the Project site;
- wildlife species were considered as a potential ROC if they are found at the Project site or in close proximity to the Project site;
- some wildlife species may reside at the Project site all year round while others may be expected to be present during particular times or seasons and both were considered in the assessment; and
- different potential ROCs may be present at the site based on future closure scenarios and land uses.

Representative ROCs were selected using the following guidance from Environment Canada (Environment Canada 2012) with consideration of the wildlife Valued Environmental Components (VECs) identified during the Project's Environmental Assessment (EA):

- the species is representative of the local ecosystem;
- the species has the greatest potential for exposure;
- the species is considered sensitive to the COPCs;
- the species is of relative social, economic, and/or cultural importance;
- the species plays a key role in the food chain or could be representative of a trophic level within the food chain;
- the species has sufficient characterization data to facilitate the calculation of exposure and risk; and
- the species is of intrinsic ecological significance (e.g., endangered species).

Potential ROCs were identified based on available information on aquatic and terrestrial wildlife at the Project site and nearby developments (DDMI 2015; Golder Associates Ltd. 2015b). General site characteristics, regional and local habitat surveys, records of environmental conditions, species inventories, and a list of species at risk were considered in the selection of potential ROCs, as recommended by the Environment Canada guidelines (Environment Canada 2012; Golder Associates Ltd. 2015b, 2015a). A brief description of the potential ecological receptors of concern, as well as the rational for selection of the ROCs is provided in Table 2.1-1.

Table 2.1-1. Potential Ecological Receptors of Concern and Rational for Selection

Receptor Group	Receptor Type	Potential Ecological Receptor	Rational for Selection
Primary Producers	Aquatic primary producers	Phytoplankton, periphyton communities, algal and aquatic plant community	Aquatic primary producer communities are the building blocks of the aquatic food web. The primary exposure pathway for this group of receptors is direct contact with water. A large body life history and toxicity data is available for these organisms.
	Terrestrial plants	Plant community	The plant community consists of primary producers at the lowest trophic level of the terrestrial food chain. The primary exposure pathway for this group of receptors is direct contact with soil and water. Some data on life history and toxicity data are available for these organisms.
Invertebrates	Zooplankton and Benthic Invertebrates	Zooplankton and benthic community	The primary exposure pathway for the zooplankton and benthic community is direct contact with water. A large body of life history and toxicity data is available for zooplankton and benthic organisms.
	Terrestrial Invertebrates	Terrestrial invertebrate community	The primary exposure pathway for the terrestrial invertebrate community is direct contact with soil and soil ingestion. Some data on life history and toxicity data are available for these communities.
Fish	Benthivore	Slimy Sculpin (*Cottus cognatus*)	The primary exposure pathway for slimy sculpin is contact with sediment and water. Slimy sculpin could also be exposed through trophic effects if a bioaccumulative COPC (e.g., selenium, mercury, some hydrocarbons) were present. Some life history and water toxicity data is available for Slimy Sculpin.

(continued)

Table 2.1-1. Potential Ecological Receptors of Concern and Rational for Selection (continued)

Receptor Group	Receptor Type	Potential Ecological Receptor	Rational for Selection
Fish *(cont'd)*	Planktivore/ Benthivore	Longnose Sucker (*Catostomus catostomus*)	The primary exposure pathway for longnose sucker is contact with sediment and water. Longnose sucker could also be exposed through trophic effects if a bioaccumulative COPC (e.g., selenium, mercury, some hydrocarbons) were present. Limited life history and water toxicity data is available for longnose sucker.
	Piscivore	Lake Trout (*Salvelinus namaycush*)	The primary exposure pathway for lake trout is contact with water. Lake Trout could also be exposed through trophic effects if a bioaccumulative COPC (e.g., selenium, mercury, some hydrocarbons) were present. A large amount of life history and water toxicity data is available for Lake Trout. Some food web toxicological studies may also be available for this species.
Mammals	Terrestrial Herbivore	Caribou (*Rangifer tarandus*)	Caribou can be exposed to contaminants via water, soil, food (vegetation), and air. However, similar to most terrestrial mammals, the greatest exposure is via soil ingestion. A reasonable amount of data is available on caribou life history. Some toxicological data is available for caribou. Caribou are an important cultural and socioeconomic species to the people in the Northwest Territories. Caribou are not good indicators of localized anthropogenic effects because of their large home range size. However, caribou are of cultural and subsistence importance. Therefore, they were included as a ROC.
	Aquatic/ Terrestrial Omnivore	Grizzly bear (*Ursus arctos*)	Grizzly bear can be exposed to contaminants via water, soil, food, and air. Grizzly bears feed on large and small mammals, aquatic and terrestrial plants, and fish. Grizzly bear could also be exposed through trophic effects if a bioaccumulative COPC (e.g., selenium, mercury, some hydrocarbons) were present. A reasonable amount of grizzly bear life history data is available. Limited to no toxicological data is available for grizzly bear. Grizzly bears are not good indicators of localized anthropogenic effects because of their large home range size However, grizzly bears are listed as a *Species of Special Concern* by COSEWIC and they are considered *Sensitive* by the Government of NT (COSEWIC 2015; Government of NWT 2015) so they were included as ROCs.
	Terrestrial Carnivore	Red fox (*Vulpes vulpes*)	Red fox can be exposed to contaminants via water, soil, food, and air. Red fox mostly feed on small mammals; therefore, red fox could also be exposed through trophic effects if a bioaccumulative COPC (e.g., selenium, mercury, some hydrocarbons) were present. A reasonable amount red fox life history data is available. Limited to no toxicological data is available on red fox.

(continued)

Table 2.1-1. Potential Ecological Receptors of Concern and Rational for Selection (completed)

Receptor Group	Receptor Type	Potential Ecological Receptor	Rational for Selection
Mammals *(cont'd)*	Terrestrial Omnivore	Northern red-backed vole (*Myodes rutilus*)	Northern red-backed vole can be exposed to contaminants via water, soil, food, and air. Plants constitute the diet of Northern red-backed vole although this species occasionally feeds on insects as well. Some life history data is available for Northern red-backed vole. Limited to no toxicological data is available for Northern red-backed vole.
Birds	Aquatic Insectivore	Semi-palmated sandpiper (*Calidris pusilla*)	Semi-palmated sandpipers are present at Diavik and can be exposed to contaminants via water, sediment, and food (aquatic invertebrates). Some life history data is available for semi-palmated sandpiper. Some toxicological data is available for sandpipers.
	Aquatic Omnivorous	Oldsquaw (*Clangula hyemalis*)	Oldsquaw or long-tailed duck may be present at Diavik during the breeding season and can be exposed to contaminants via water, sediment, food (aquatic plants, invertebrates, bivalves, fish eggs, and fish). Some life history data is available for oldsquaw, but limited to no toxicological data is available.
	Terrestrial Herbivore	Ptarmigan (*Lagopus spp.*)	Ptarmigan may be present at Diavik during the breeding season and can be exposed to contaminants via water, soil and food (plants). Some life history data is available for ptarmigan, but limited to no toxicological data is available.
	Terrestrial Carnivore	Peregrine falcon (*Falco peregrinus*)	Peregrine falcon may be present at Diavik during the breeding season and can be exposed to contaminants via water, and food (birds and small mammals), especially if a bioaccumulative COPC were to be identified. Some life history data is available for peregrine falcon, but limited to no toxicological data is available. Peregrine falcons are listed as *Species of Special Concern* by COSEWIC (2015).
	Aquatic/ terrestrial Carnivore	Bald eagle (*Haliaeetus leucocephalus*)	Bald eagle may migrate and breed at Diavik. They can be exposed to contaminants via food (aquatic and terrestrial prey and birds), especially if a bioaccumulative COPC were to be identified. Some life history data is available for bald eagle; some toxicological data is also available.
Amphibians and Reptiles	Carnivores and omnivores	-	The Project is outside of the *Northwest Territories Protected Areas Strategy* for amphibian and reptiles (NWPAS 2013). Species ranges of all known amphibians of the Northwest Territories are located to the south and west of the Project site and, therefore, are not expected to be present at the Project site. No amphibians were included in this report.

2.1.2 Potential Human Receptors of Concern

2.1.2.1 Potential Land Users in the Area around the Project

The Project is located within the lands traditionally used by Inuit, Dene, and Métis people (Golder Associates Ltd. 2015c). The Project is within the Tłı̨chǫ Mowfi and Tłı̨chǫ Wek'eezhii final land claim boundaries and is also within the Akaitcho Dene and chief Drygeese asserted territories (see

Map 1.3-1 in Golder Associates Ltd. 2015c). The following are the potentially affected Aboriginal communities as identified by DDMI:

- the Yellowknives Dene First Nation (YKDFN);
- the Łutselk'e Dene First Nation (LKDFN);
- the North Slave Métis Alliance (NSMA);
- the Tłįchǫ Government (TG); and
- Kitikmeot Inuit Association (KIA).

The YKDFN and LKDFN are members of the Akaitcho Dene (Golder Associates Ltd. 2015c). The closest communities to the Project are Wekweeti and Gameti to the west the Project, and Fort Reliance and Lutsel K'e to the south (Golder Associates Ltd. 2015c).

Aboriginal groups, including Inuit, Dene, and Métis have traditionally depended on clean drinking water throughout the Northwest Territories (NT). While travelling, Dene people would use ice or deeper layers of snow as a source of drinking water. Hunting and fishing camps were often set up on nearby islands and the mainland (Weledeh Yellowknives Dene 1997 in Golder Associates Ltd. 2015c).

Aboriginal people may use Lac de Gras and other parts of the barren land that may be affected by the Project during different seasons for the year (Golder Associates Ltd. 2015c). Small islands close to the narrow land between Lac de Gras and Lac de Salvage may be set up for hunting caribou, fishing, or hunting other country foods during spring, summer, fall, and winter (Golder Associates Ltd. 2015c).

2.1.2.2 Types of Human Receptors

Toddlers are often most susceptible to chemicals with a threshold response due to their ratio of body size to ingestion rates (IRs) compared to other life stages (Health Canada 2010c, 2010b). Therefore, if COPC concentrations in media are unlikely to pose a health risk to toddlers, all other life-stages would be considered protected. Thus, toddlers (1 year up to 4 years old) were selected as human health receptors (Richardson and Stantec Consulting Ltd. 2013).

An adult receptor (greater than 20 years of age) was also selected for both threshold and non-threshold response chemicals based on guidance provided by Health Canada (Health Canada 2010d). For assessing exposure to mercury (in the form of methylmercury), women of child-bearing age were also included as a sensitive group.

2.1.3 Summary

The following ecological ROCs were identified:

- Primary producer community (e.g., phytoplankton, periphyton);
- Terrestrial plant community;

- Zooplankton and benthos community;
- Terrestrial invertebrate community;
- Slimy Sculpin;
- Longnose Sucker;
- Lake Trout;
- Caribou;
- Grizzly bear;
- Red fox;
- Northern red-backed vole
- Semi-palmated sandpiper;
- Oldsquaw;
- Ptarmigan;
- Peregrine falcon; and
- Bald eagle.

Toddlers (1 year up to 4 years) and adults were selected represent human health receptors. Women of child-bearing age were also included as a sensitive group with respect to potential exposure to mercury.

2.2 POTENTIAL EXPOSURE PATHWAYS

2.2.1 Potential Exposure Pathways for Ecological Health

Ecological exposure pathways are the routes by which ecological receptors are exposed to chemicals. Exposure pathways were selected based on the potential for the following:

- ingestion of soil or sediment;
- dermal contact with sediment (aquatic species only);
- gill uptake (fish and benthic invertebrates);
- ingestion of water;
- ingestion of terrestrial prey that have taken up metals through the ingestion of soil, vegetation, and surface water;
- ingestion of aquatic prey that have taken up metals from their diet and surrounding water; and
- ingestion of plants that have taken up metals from the soil and water.

Terrestrial wildlife exposure to contaminants via the inhalation and dermal contact pathways were not considered in the assessment. Wildlife TRVs for inhalation and dermal contact are unavailable, and inhalation and dermal exposures are expected to be very small contributors compared to the ingestion pathway (Sample et al. 1997; BC MOE 2015). Thus, wildlife exposure to contaminants via inhalation and dermal contact are not pathways usually considered (Environment Canada 2012).

The exposure pathways that may exist between COPCs and ecological receptors depend on many factors which may be direct, indirect, or both. Terrestrial wildlife, aquatic birds, and aquatic life receptors could be exposed to COPCs directly by ingesting water, soil/sediment, and vegetation or indirectly through the ingestion of prey items in the food web.

Freshwater fish and freshwater benthic invertebrates could take up COPCs by consuming primary producers containing COPCs, through incidental consumption of sediment particles, and through gill uptake. Gill uptake is the uptake of COPCs by fish and some benthic invertebrates through the epithelium of the gills or other respiratory surfaces. Gills are not only involved in dissolved oxygen and carbon dioxide exchange but they are also important organs for ion- and osmoregulation. In some invertebrates gills are only used for feeding, whereas other organisms also use them for oxygen uptake. Therefore, COPCs may accumulate in fish and invertebrates, making them bioavailable to other animals in the food chain. Any COPCs incorporated into the biomass of primary producers and benthic invertebrates would be available for ingestion by fish (i.e., Slimy Sculpin and Lake Trout).

2.2.2 Potential Exposure Pathways for Human Health

Human exposure pathways are the routes by which human receptors are exposed to chemicals. The exposure routes that may exist between COPCs and human receptors depend on many factors which may be direct, indirect, or both. Human receptors could be exposed to COPCs directly by dermal contact with soil, ingesting water, soil, and country foods.

Exposure pathways were selected based on potential for the following:

- dermal contact with soil;
- ingestion of soil;
- ingestion of water; and
- ingestion of country foods.

Human exposure to contaminants via inhalation is not a pathway considered as dust levels at Closure are expected to be minimal and air inhalation is not expected to be a significant exposure route for humans at Closure.

2.2.2.1 Country Foods

Country foods are animals, plants, or fungi used for humans for medicinal, nutritional purposes that are harvested through hunting, trapping, gathering, or fishing. The land situated between Lac de Gras and Lac du Sauvage is used for hunting a variety of country foods. Country foods hunted from the land between Lac de Gras and Lac du Sauvage by YKDFN include caribou, birds, foxes, wolves, wolverines, weasels, Arctic hares, grizzly bear, and fish (Golder Associates Ltd. 2015c).

Caribou has traditionally been an important source for county food, shelter, clothing and tools for Aboriginal groups including Inuit, Dene, and Métis (Golder Associates Ltd. 2015c). The land between Lac de Gras and Lac du Sauvage is an important caribou migration route. Moose have also been found around Lac de Gras. Moose are often found in areas that contain willow and wetlands with old grass (Sadownik and Harris 1995; Golder Associates Ltd. 2015c).

Among birds, Ptarmigan and grouse are most commonly used as country foods. Geese and ducks were also a staple for some Inuit, Dene, and Métis communities (Golder Associates Ltd. 2015c). Tłįchǫ have also traditionally hunted ducks (Golder Associates Ltd. 2015c).

Rabbit, Arctic hare, marten, ground squirrel, lynx, muskrat, beaver, mink, otter, wolverine, wolf, and Arctic fox can also be hunted for both food as well as fur (Golder Associates Ltd. 2015c). Although grizzly bears are respected and rarely hunted by Dene, other Aboriginal groups, such as Inuit, hunt bears from eskers for their fur and fat (Golder Associates Ltd. 2015c).

Fish are an important source of food for Aboriginal groups including Inuit, Dene, and Métis (Golder Associates Ltd. 2015c). Whitefish, Lake Trout, Arctic Grayling, and Northern Pike are among fish species that are found in Lac de Gras.

Blackberries, blueberries, raspberries, crowberries, cranberries, and cloudberries are collected for food and may be eaten fresh or are used in juice, jams, or be dried by Aboriginal groups, including Dene and Métis (Golder Associates Ltd. 2015c). Métis use berries also in preparation of food made from dried bison, caribou or moose meat in combination with berries and pounded fat (Golder Associates Ltd. 2015c). Mosses and lichens may be used in food preparations as well.

Representative Country Foods

The concentration of contaminants in country foods is directly related to the quality of the surrounding environmental media (e.g., soil, water, and vegetation).

When considering potential exposures to contaminants present in country foods, one species is selected from the following groups of food: large mammal, small mammal, birds, fish, and vegetation. The different groups are selected because the relative exposure of each these groups to the environmental media would vary with specific habitat and foraging behaviour.

A species that represents the highest consumption level is assumed to result in the most exposure to COPCs. Therefore, the species representing the highest consumption level in each country foods group is selected to represent that particular country foods group. Theoretically, if foods that represent the highest rate of exposure are safe for consumption, then all other foods within the given group would also be considered safe for consumption.

Caribou, Arctic hare, lake trout, grouse, and berries representing the above food groups are used by all Aboriginal groups, including Inuit, Dene, and Métis, and were therefore used as country foods in this assessment. Additional details on these country foods are provided below.

Caribou

Although caribou migrate over large areas well outside of the Project, their importance to Aboriginal groups, including Dene and Métis diet, supports their inclusion in this study. However, any changes in metal concentrations in caribou tissue, while useful to inform and protect local human health, may or may not be related to the Project due to their potential to exposure from other sources across their vast home range size.

Artic Hare

Arctic hare home range is relatively small and is estimated to be about 2.5 km^2 (Canadian Museum of Nature 2004). Thus, it is possible that an Arctic hare could spend its entire lifetime at the Project site. Arctic hare are herbivores that may exist in isolation or live in groups and do not hibernate. As metal exposure from the country foods study area would be relevant to non-migratory foraging small mammals, consumption of Arctic hare would likely represent the highest exposure to metals in small mammals harvested from the country foods study area.

Lake Trout

Lake trout are desirable eating fish and are among the largest freshwater piscivorous fish species at Diavik. These fish could experience increased metal bioaccumulation in tissue relative to non-piscivorous fish and therefore are an important fish species in the derivation of SSRBSSs for protection of both humans and wildlife populations from contaminants that may bioaccumulate in fish.

Grouse

Most grouse have a relatively small home range and, with the exception of sage grouse, are not known to migrate (Parks Canada 2011). It was assumed that grouse have a home range of 0.4 km^2 (spruce grouse; Ellison 1971). As metal exposure from the country foods study area would be relevant for non-migratory foraging birds, consumption of grouse would likely represent the highest exposure to metals in birds harvested from the country foods study area.

Berries

Berries are also a desirable food by the Aboriginal groups, Inuit, Dene, and Métis. People may consume berries fresh during the warmer months of the year when berries are in season or berries may be frozen and consumed throughout the year.

2.3 POTENTIAL SOURCES OF CONTAMINANTS

Potential sources of contaminants and exposure pathways differ during the phases of a project (e.g., construction, operations, closure). For example, it is possible that water and sediment quality in waterbodies (rivers, streams, or ponds) may be affected by runoff, seepage, discharge, or dismantling dikes or other mine infrastructure during closure in a manner they wouldn't be affected during operations. Similarly, following closure of a project, terrestrial environments that are accessible by humans and wildlife may include soil and vegetation throughout the Project site that weren't accessible during the operations phase. These areas could be influenced by Project-related emissions over the course of construction and operations, since they may be affected by dust, runoff, seepage, discharge, or spills that introduce contaminants into environmental media.

Potential Project-related sources of contaminants and exposure media (i.e., water, soil, sediment) for human and ecological receptors were considered for the following sub-areas during closure, which were identified in the ICRP (DDMI 2011):

- Open Pit, Underground and Dike Areas;
- North Country Rock Pile;
- Processed Kimberlite Containment Area;
- North Inlet Area;
- Mine Infrastructure Areas; and
- Site-wide.

In order to select relevant COPCs, future environmental media quality is evaluated by comparisons with relevant environmental quality guidelines, as well as taking into consideration baseline (naturally-occurring) environmental medial quality (Section 2.4). Potential contaminant sources and relevant environmental media for each of the sub-areas are discussed in the context of potential ecological and human health receptors.

2.3.1 Open Pit, Underground, and Dike Areas

2.3.1.1 Water

During Closure, water will inundate the three pits (A154, A418, and A21) from Lac de Gras to form pit lakes. Since water quality in the flooded pit may be affected by Project-related contaminants (e.g., from pit walls) and because people or wildlife may use the pit as a source of drinking water once filled, future inundated pit water was included as an environmental media in both the ecological and human health assessments.

2.3.1.2 Fish and Aquatic Life

In Closure, once the pits are inundated, fish may be present in habitat along the rims of the pits. Since fish may be exposed to contaminants in the pit lake water and people may fish from the pits, fish tissue was included in the assessment as an environmental media for both the ecological and human health assessments.

2.3.2 North Country Rock Pile

2.3.2.1 Soil

In Closure, the North Country Rock Pile (NCRP) will be covered with Type 1 Rock. Run off is predicted to occur from the thermally active zone. To minimize the active zone, the pile will be covered by one meter of till and three meters of Type 1 Rock (DDMI 2011). Till cover is intended to provide a thermal cover for the Waste Rock pile while Type 1 Rock (granite non- acid rock drainage [ARD] rock type) provides a physical barrier and limits the active zone. People may be exposed to Type 1 rock dermally or may incidentally ingest soil from these areas. Type 1 Rock quality was included as an environmental media in both the ecological and human health assessment.

2.3.2.2 Water

Currently there is no seepage on the west and north-west areas of the North Country Rock Pile. However, seepage may be present during Closure and may enter Lac de Gras. Although unlikely, it is possible that people or wildlife could use the seepage from the NCRP as a source of drinking water. Therefore, potential seepage from the NCRP was included as an environmental media in both the ecological and human health assessments.

2.3.3 Processed Kimberlite Containment Area

2.3.3.1 Soil

In Closure, the Processed Kimberlite Containment Area (PKCA) will be capped with Type 1 Rock (DDMI 2011). It is possible that people could be exposed to Type 1 rock via dermal contact or incidental ingestion and wildlife may incidentally ingest the soil. Therefore, similar to soil from the NCRP, Type 1 Rock within the PKCA was included as an environmental media in both the ecological and human health assessments.

2.3.3.2 Water

The top layer of soil on the PKCA is expected to freeze. As the water freezes, some water will be pushed into a pond and eventually will enter Lac de Gras. People or wildlife could use the PKCA pond water as a source of drinking water. Therefore, PKCA pond water was included as an environmental media in both the ecological and human health assessments.

2.3.4 North Inlet

2.3.4.1 Sediment

The North Inlet is currently part of the North Inlet Water Treatment Plant (NIWTP) and slurry from the NIWTP, located to the east of the North Inlet, enters the North Inlet. The North Inlet has received sludge, slurry, runoff, and other inputs throughout the mine life and North Inlet sediment toxicity has previously been identified as a potential concern (DDMI 2013a). Therefore, North Inlet sediment quality was included in the assessment as an environmental media for the ecological health assessment.

2.3.4.2 Water

Currently seepage, runoff, pit groundwater, and PKCA pond water enters North Inlet. The North Inlet is also a part of NIWTP, receiving slurry and sludge. In the future, after Closure, people or wildlife may use the North Inlet water as a source of drinking water. Therefore, North Inlet water was included as an environmental media in both the ecological and human health assessments.

2.3.4.3 Fish

It was assumed in this report that the North Inlet will be separated from Lac de Gras by barriers that prevent fish from accessing the North Inlet during Closure. Therefore, fish will not be present in North Inlet during Closure and fish tissue concentrations were not considered in the selection of COPCs for this area.

2.4 SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN

2.4.1 Types of Contaminants Considered in the Assessment

A number of classes of potential COPCs from soil, water, sediment, and fish from various Project-related sources were considered in the selection of COPCs. Ongoing monitoring programs for the Project focus on the groups of parameters that are most likely to be altered by Project activities. For the Project, the primary contaminants of potential concern (COPCs) are most likely to be metals, given that the Project is a diamond mine and metals occur naturally in the surrounding environment (e.g., soil and water). Hydrocarbons are also used at the Project site (e.g., as fuel, oil, or lubricants) so could also be introduced to the environment through accidental spills or leaks from vehicles.

Diamond mines can bring up material from below the surface that may have elevated metal concentrations compared to soil at the surface. Therefore, metals have been included in the selection of COPCs from soil.

A number of classes of water chemistry parameters from various Project-related sources were considered. Metals, ions, and nutrients may enter the receiving environment due to seepage or runoff containing blasting residues or metals from leaching of waste rock, kimberlite waste, granite waste, and schist. Therefore, nutrients, ions, pH, hardness, and total and dissolved metals have been measured as part of Aquatic Effects Monitoring Program (AEMP) and SNP and were considered in the COPC selection process. In addition, hydrocarbons have been measured in the North Inlet and were therefore also included in the COPC selection process.

In sediment and sludge samples, pH, metals, nutrients, and occasionally hydrocarbons have been measured; therefore, these data were considered in the COPC selection process.

Metals in fish tissue were included in the COPC selection process as well.

2.4.2 General Methodology for Selecting Contaminants of Potential Concern

Based on the identified exposure pathways for different receptor groups (Section 2.2), relevant environmental media from each of the Project sub-areas (Section 2.3) were examined to select appropriate COPCs for each receptor group. Selection of COPCs was conducted in two main steps. In the first screening step, the maximum or 95th percentile concentration of each parameter in an environmental media for each sub-area of the Project was compared to an appropriate environmental quality guideline. The 95th percentile concentration was used when there was adequate data available to support the calculation of this statistic (e.g., water quality data). In some cases, where only statistical summaries of environmental media concentrations were available, the 75th percentile of the data was used for the first screening step. Parameters that exceeded environmental quality guidelines were carried forward for a second screening step.

Environmental quality guidelines included those for water, sediment, soil, and fish tissue for the protection of ecological health and water, soil, and fish tissue criteria for the protection of human health. There are no guidelines specific to vegetation; however, soil quality guidelines for agricultural land use are considered to protect primary, secondary, and tertiary consumers from adverse effects due to ingestion of contaminated soil and food. Thus, vegetation was not used for screening of COPCs in this assessment.

In the second selection step, the maximum and mean concentration of the parameters with guideline exceedances were compared to maximum and mean baseline concentrations, respectively. When only statistical summaries of were available, the median and 75% percentile of the parameter were used for the second screening step to represent the probable mean and maximum concentrations, respectively. The parameters that exceeded both environmental quality guidelines and baseline concentrations were designated as final COPCs. The second screening step was done to ensure that the final COPCs were selected as a consequence of Project-related activities rather than due to natural characteristics of the local environmental media.

Although individual sub-areas of the Project were considered during the selection of COPCs, SSRBCC will ultimately be derived to be protective of health of both ecological and human receptors across the entire site.

2.4.3 Selection of COPCs for Ecological Receptors

2.4.3.1 Soil

Wildlife may ingest soil and vegetation that may grow on the NCRP and PKCA. During Closure, the NCRP and PKCA will both be covered by Type 1 Rock.

Statistical summaries of metals analysis of Type 1 Rock, including sample size, 25th percentile, median, and 75th percentile, were provided by DDMI; these summaries were used to represent the future soil quality at Closure in the NCRP.

The normal range of soil metal concentrations were determined based on data collected from 2010 and 2013 at Far-field stations (DDMI 2014), to represent natural variability of soil quality data under baseline conditions.

For COPC screening purposes, the 75th percentile concentration of Type 1 Rock soil chemistry data were compared to guidelines. The following guidelines or criteria were used in the first screening step, in order of preference (Table 2.1-2):

- Canadian Council of Ministers of the Environment (CCME) soil quality guidelines for agricultural purposes (CCME 2013a). These guidelines represent the most conservative guidelines for soil quality among the available CCME soil quality guidelines for all variables except barium. CCME soil quality guidelines are designed to protect human health, plants, and garden produce. Therefore, CCME soil quality guidelines for the protection of agricultural purposes were used as a proxy to select COPCs that have the potential to affect vegetation growing in these areas that may then be consumed by wildlife. For barium, the CCME soil quality guideline for protection of human health and environment for residential/ parkland purposes were used.
- In the absence of CCME soil quality guidelines for the protection of agriculture, United States Environmental Protection Agency (US EPA) ecological soil screening levels (ECO-SSLs) for the protection of ecological receptors were used.

Table 2.1-2. Guidelines Used in the Selection of Contaminants of Potential Concern in Soil for Ecological Receptors

Parameter	Guidelines & Objectives (mg/kg dry weight)	Parameter	Guidelines & Objectives (mg/kg dry weight)
Total Metals		**Total Metals** ***(cont'd)***	
Aluminum	Dependent on soil pH[a]	Mercury	6.6
Antimony	20	Molybdenum	5
Arsenic	12	Nickel	50
Barium	500[b]	Selenium	1
Beryllium	4	Silver	20
Boron	2	Sulphur	500
Cadmium	1.4	Thallium	1
Chromium	64	Tin	5
Cobalt	40	Uranium	23
Copper	63	Vanadium	130
Lead	70	Zinc	200

Notes:
[a] CCME soil quality guideline is not available for this parameter. Therefore, US EPA Eco-SSL lowest soil quality guidelines were used instead.
[b] CCME soil quality guidelines for barium are based on residential/parkland use.

If the 75th percentile concentration of a parameter in the Type 1 Rock exceeded the guideline, the parameter was carried forward to the second COPC selection step. In the second screening step, the 75th percentile and median concentration of the parameters with guideline exceedances was compared to the upper limit of normal range that represents baseline soil quality. If the parameter concentration exceeded the baseline soil concentration (i.e., exceeded the upper limit of normal range), the parameter was considered to be a COPC.

The list of final COPCs in soil for potential wildlife receptors is presented in Table 2.1-3. A detailed comparison of soil quality data with the objectives and guidelines and to upper limit of normal range concentrations is presented in Appendix A.

Table 2.1-3. Contaminants of Potential Concern in Soil for Wildlife Receptors by Closure Area

Lac de Gras	Pits	North Inlet	NCRP and PKCA (Type 1 Rock)	PKCA Pond
NA	NA	NA	Aluminum	NA
			Barium	
			Chromium	
			Manganese	
			Molybdenum	

Note:
NA means not applicable as there are no soil quality data associated with Lac de Gras, the pits, North Inlet, or PKCA Pond.

2.4.3.2 Water

Wildlife

Wildlife may ingest water from Lac de Gras, future pit lakes, the North Inlet, the PKCA pond, and potential seepage from the NCRP. The 95th percentile water quality from Lac de Gras Near- and Mid-field stations collected from 2007 to 2013 were used to represent closure water quality in Lac de Gras and were compared to objectives and guidelines.

The same data could also be used to represent pit lake water quality at closure since the pits will be inundated with water from Lac de Gras at Closure and are expected to have comparable water quality to the Near– and Mid-field stations. However, as a conservative measure, the predicted base case scenario for pit lake water quality associated with A154 and A148 (DDMI 2013b) was also used to represent closure water quality in the pits and compared to objectives and guidelines.

The normal ranges of water quality parameters based on data collected from 2007 to 2013 from Lac de Gras (described in the AEMP Reference Conditions Report; DDMI 2015) were used to represent baseline water quality. Normal range represents background concentrations for Lac de Gras that fall within the natural range of variability (DDMI 2015).

The SNP Station 1645-16 in the Surveillance Network Program (SNP) at Diavik was established to characterize the source water quality for the PKCA pond water. In this report, SNP Station 1645-16 refers to the water quality sampling conducted at SNP Stations 1645-16, 1645-16B, 1645-16M, and 1645-16T. DDMI provided the water quality for the SNP Station 1645-16 collected between 2007 and 2013; this data was used to represent the PKCA pond water during Closure.

PKCA pond water will eventually enter Lac de Gras; therefore, the normal ranges of water quality parameters calculated based on data collected between 2007 to 2013 from Lac de Gras (described in the AEMP Reference Conditions Report; DDMI 2015) were used to represent baseline water quality.

Water quality from the SNP Station 1645-13 is representative of the influent feed water from North Inlet entering the NIWTP. In this report, the SNP Station 1645-13 refers to the water quality collected at SNP 1645-13, 1645-13B, 1645-13M, and 1645-13T. Water quality from SNP Station 1645-13 collected between 2007 and 2013 was used to represent the North Inlet water quality during Closure.

At Closure, the North Inlet may be reconnected to Lac de Gras. Baseline water quality data for the North Inlet are assumed to be the same as for Lac de Gras as the North Inlet was originally part of Lac de Gras. Therefore, the normal ranges of water quality data from Lac de Gras from *AEMP Reference Conditions Report* (DDMI 2015) collected between 2007 to 2013 were used to represent baseline water quality of North Inlet.

For the North Inlet and the PKCA pond, 95th percentile water quality data collected from SNP Stations 1645-13 (North Inlet) and 1645-16 (PKCA pond), respectively, were compared to objectives and guidelines.

Studies on seepage quality from several test piles have been conducted at Diavik. Waste Rock piles will be covered by one meter of till and three meters of Type 1 Rock (DDMI 2011). Statistical summaries including sample size, 25th percentile, median, and 75th percentile from seepage quality from Type 1 Rock test piles provided by DDMI were used to represent the future seepage quality from the NCRP. The 75th percentile of the test piles seepage water quality data were provided by DDMI and were compared to objectives and guidelines.

Seepage may eventually enter Lac de Gras; therefore, the normal ranges of water quality parameters calculated based on data collected between 2007 to 2013 from Lac de Gras (described in the AEMP Reference Conditions Report; DDMI 2015) were used to represent baseline water quality for seepage from the NCRP.

Parameters were selected for the second screening step if the concentration exceeded CCME water quality guidelines for protection of livestock and agriculture (Table 2.1-4; CCME 2013b). These guidelines were used as a proxy to select COPCs that have the potential to affect wildlife because there are no specific CCME guidelines for the protection of wildlife.

To select the final COPCs, comparison of future concentrations with baseline concentrations were done as follows:

- for future Lac de Gras and predicted pit lake water quality, mean and 95th percentile water quality from Lac de Gras Near- and Mid-field stations were compared to Lac de Gras upper limit of normal range concentrations (DDMI 2015) for both open-water and under-ice seasons;
- for PKCA pond water and the North Inlet, mean and 95th percentile water concentrations were compared to Lac de Gras upper limit of normal range concentrations (DDMI 2015) for both open-water and under-ice seasons; and
- for NCRP seepage, the median and 75th percentile seepage concentrations from the test piles were compared to Lac de Gras upper limit of normal range concentrations (DDMI 2015).

If the concentration of a parameter from Lac de Gras, pit water, pond water within PKCA, North Inlet, or NCRP seepage comparisons exceeded both water quality guidelines and Lac de Gras upper limit of normal range concentrations, the parameter was identified as a COPC.

The list of final COPCs in water for wildlife receptors is presented in Table 2.1-5. Detailed comparison of water quality data from Lac de Gras, pit lake water, PKCA pond water, the North Inlet, and NCRP seepage to objectives and guidelines and to upper limit of normal range concentrations is presented in Appendix B.

<u>Aquatic Life</u>

Aquatic organisms may be exposed to contaminants in Lac de Gras, future pit lakes, and the North Inlet. Seepage from the NCRP and PKCA pond water would eventually enter Lac de Gras during closure. No aquatic life or fish are expected to be present in the seepage itself or in the PKCA pond water during Closure.

Table 2.1-4. **Guidelines Used in the Selection of Contaminants of Potential Concern in Water for Ecological Receptors**

	Wildlife Guidelines (mg/L)		Aquatic Life Guidelines (mg/L)		
Water Quality Variables	CCME Agricultural	CCME Livestock	Diavik Benchmarks	CCME	SSWQO
Physical / Ion					
pH (pH units)	-	-	6.5 – 9.5	-	-
Chloride	C	-	230	NA	NA
Fluoride	1	1	-	0.12	-
Potassium	-	-	-	-	70
Sulphate	-	1,000	-	-	$e^{(0.9116 \times \ln(\text{hardness}) + 1.712)}$[a]
Nutrients					
Ammonia	-	-	4.73	NA	-
Nitrate, as N	-	-	30.1	NA	NA
Nitrite, as N	-	10	0.06	NA	-
Dissolved Metals					
Aluminum	-	-	$e^{(1.6-3.327\times pH+0.402\times pH_2)}$	NA	-
Total Metals					
Aluminum	5	5	-	$e^{(1.6-3.327\times pH+0.402\times pH_2)}$	-
Antimony	-	-	-	-	-
Arsenic	0.1	0.025	0.05	NA	-
Beryllium	0.1	0.1	-	-	-
Boron	C	5	-	1.5	-
Cadmium	0.0051	0.08	0.0001	NA	-
Calcium	-	1,000	-	-	-
Chromium	0.008 Cr(IV); 0.0049 (CRIII)	0.05 Cr(IV); 0.05 (CRIII)	0.001 Cr(IV)	NA	-
Cobalt	0.05	1	-	-	-
Copper	C	L	0.002	NA	-
Iron	5	-	0.3	NA	-

(continued)

Table 2.1-4. Guidelines Used in the Selection of Contaminants of Potential Concern in Water for Ecological Receptors (continued)

	Wildlife Guidelines (mg/L)		Aquatic Life Guidelines (mg/L)		
Water Quality Variables	CCME Agricultural	CCME Livestock	Diavik Benchmarks	CCME	SSWQO
Total Metals *(cont'd)*					
Lead	0.2	0.1	0.001	NA	-
Lithium	2.5	-	-	-	-
Manganese	0.2	-	-	-	-
Mercury	-	0.003	0.000026	NA	-
Molybdenum	0.01	0.5	0.073	NA	-
Nickel	0.2	1	0.025	NA	-
Selenium	0.02	0.05	0.001	NA	-
Silver	-	-	0.0001	NA	-
Thallium	-	-	0.0008	NA	-
Uranium	0.01	0.2	-	0.015	-
Vanadium	0.1	0.1	-	-	0.03
Zinc	5	50	0.03	NA	-
Organics					
1,2-Dichlorobenzene	-	-	-	0.0007	-
Acenaphthene	-	-	-	0.0058	-
Aliphatic non-chlorinated	-	-	-	0.000012	-
Anthracene PAHs	-	-	-	0.000018	-
Ben(a)anthracene PAHs	-	-	-	0.37	-
Benzene	-	-	-	0.000015	-
Ethylbenzene	0.0024	-	-	0.09	-
Ethylene glycol	-	-	-	192	-
Fluoranthene	-	-	-	0.00004	-
Fluorene	-	-	-	0.003	-
Methyl tertiary-butyl ether (MTBE)	-	-	-	10	-

(continued)

Table 2.1-4. Guidelines Used in the Selection of Contaminants of Potential Concern in Water for Ecological Receptors (completed)

Water Quality Variables	Wildlife Guidelines (mg/L)		Aquatic Life Guidelines (mg/L)		
	CCME Agricultural	CCME Livestock	Diavik Benchmarks	CCME	SSWQO
Organics *(cont'd)*					
Naphthalene PAHs	-	-	-	0.0011	-
Phenanthrene PAHs	-	-	-	0.0004	-
Propylene glycol	-	-	-	500	-
Pyrene PAHs	-	-	-	0.000025	-
Quinoline PAHs	-	-	-	0.0034	-
Styrene	-	-	-	0.072	-
Toluene	0.024	-	-	0.002	-

Notes:
NA= not applicable. This indicates that the parameter has a guideline; however, it is not considered in the assessment. Diavik-specific Benchmarks were given precedence over CCME guidelines and SSWQOs from nearby projects. In the absence of Diavik-specific benchmarks, CCME guidelines for protection of aquatic life were given precedence over SSWQO from nearby projects.
C = dependant on the crop.
L = dependent on livestock species.
All units are in mg/L unless otherwise noted.
[a] *Relationship is limited to a hardness range of up to 160 mg/L hardness. BC MOE hardness-dependent guideline was used for hardness greater than 160 mg/L.*

Table 2.1-5. Contaminants of Potential Concern in Water for Wildlife Receptors by Closure Area

Lac de Gras	Pit Lakes	North Inlet	NCRP	PKCA Pond
NI	NI	NI	Cobalt Manganese Molybdenum Nickel Uranium	Chromium Molybdenum Nickel

Note:
NI means no COPCs for protection of aquatic life were identified in Lac de Gras, pit lakes, and North inlet.

The same sources water quality data used to select wildlife COPCs from the pits, potential seepage from NCRP, pond within PKC, and North Inlet were also used to select COPCs for aquatic life. However, NCRP and PKCA pond water entering Lac de Gras will be diluted considerably. Thus, the 75th percentile of NCRP seepage water quality concentrations and 95th percentile PKCA pond water quality concentrations were diluted by half using Lac de Gras normal upper range concentrations prior to comparisons to objectives and guidelines.

Parameters were retained for the second screening step if the relevant summary statistic (i.e., 75th percentile, 95th percentile) exceeded objectives or guidelines for the protection of aquatic life (Table 2.1-4). When more than one objective or guideline was available for comparison, the following order of preference was applied for screening:

- Diavik-specific benchmarks;
- long-term CCME water quality guidelines for the protection of aquatic life (CCME 2013b); and
- site-specific water quality objectives for nearby projects.

If a parameter was found to exceed the aquatic life guideline, comparisons to the normal baseline range of Lac de Gras were done, as described in the preceding section for wildlife. If the concentration of a parameter from Lac de Gras, the pit lakes, the North Inlet, NCRP seepage, or PKCA pond water comparisons exceeded both aquatic life guidelines and Lac de Gras upper limit of normal range concentrations (DDMI 2015), the parameter was identified as a COPC.

The list of COPCs in water for potential aquatic life receptors is presented in Table 2.1-6. Detailed comparisons of Lac de Gras, pit water, the North Inlet, NCRP seepage, and PKCA pond water quality with objectives and guidelines and to the upper limit of normal range baseline concentrations are presented in Appendix B.

Table 2.1-6. Contaminants of Potential Concern in Water for Aquatic Receptors by Closure Area

Lac de Gras	Pit Lakes	North Inlet	NCRP	PKCA Pond
NI	NI	Nitrite	Fluoride	Nitrite
		Fluoride	Potassium	Sulphate
		Chromium	Sulphate	Cadmium
		Copper	Nitrate	Chromium
		Iron	Nitrite	Copper
		Lead	Aluminum	Iron
		Mercury	Arsenic	Mercury
		Nickel	Cadmium	Molybdenum
		Selenium	Chromium	Nickel
		Silver	Copper	Potassium
		Uranium	Mercury	Selenium
		Zinc	Nickel	Silver
			Selenium	Zinc
			Silver	
			Uranium	
			Zinc	

Note: NI means no COPCs for protection of aquatic life were identified in Lac de Gras and pits.

2.4.3.3 *Fish Tissue*

Wildlife may ingest fish from Lac de Gras or the inundated pits at Closure. The North Inlet will be separated from Lac de Gras by barriers that prevent fish from entering into the North Inlet. Therefore, it was assumed that no fish will be present at North Inlet during closure.

Slimy Sculpin have limited movements and are often associated with a small home range and are considered as resident species. Therefore, the available Near-, Mid-, and Far-field station Slimy Sculpin tissue metal concentrations from 2007, 2010, and 2013 were used to represent fish tissue concentration at Closure. Slimy Sculpin fish tissue concentrations collected from the Far-field Reference stations from 2007, 2010, and 2013 were used to derive the normal range of tissue metal concentrations, following methodologies used in *AEMP Reference Conditions Report* (DDMI 2015).

Lake Trout tissue mercury concentrations were measured in 1996, 2005, 2008, and 2011 in Lac de Gras. Unlike Slimy Sculpin, Lake Trout have a large home range. Therefore, Lac de Gras Lake Trout mercury concentrations from 2005, 2008, and 2011 were assumed to represent the Closure phase mercury Lake Trout tissue concentrations. Lake Trout tissue mercury concentrations from 1996 were used to represent baseline fish tissue concentrations. The Lake Trout mercury tissue normal range concentration was derived as per methods prescribed in *AEMP Reference Conditions Report* (DDMI 2015).

Maximum Slimy Sculpin tissue metal concentrations from fish collected from Lac de Gras Near-, Mid-, and Far-field stations as well as maximum Lake Trout tissue mercury concentrations from samples collected in 2005, 2008, and 2011 were compared to fish tissue residue guidelines for wildlife consumers of fish.

Parameters were selected for the second screening step if maximum tissue residues exceeded guidelines (Table 2.1-7). The following criteria were used for screening:

- CCME methylmercury fish tissue quality guidelines for protection of wildlife consumers of aquatic biota (CCME 2003); and
- BC MOE selenium tissue residue guidelines for fish consumption by wildlife (Beatty and Russo 2014).

Table 2.1-7. Guidelines Used in the Selection of Contaminants of Potential Concern in Fish Tissue for Ecological Receptors

Parameter	CCME Tissue Quality Guidelines[a] for the Protection of Wildlife Consumers of Aquatic Biota (mg/kg wet weight)	BC MOE Tissue Residue Guidelines for Fish Consumption by Wildlife (mg/kg wet weight)
Methylmercury	0.033	0.033
Selenium	-	1[b]

[a] *Canadian Council of Minister of the Environment (CCME), accessed January 2015. http://st-ts.ccme.ca/en/index.html.*
[b] *Guideline is in dry weight. Assuming a 75% moisture content, the guideline is shown in the table in wet weight.*

If tissue concentrations were found to exceed the guidelines, the concentrations were then compared to Slimy Sculpin upper limit of normal range tissue metal concentrations and Lake Trout tissue mercury concentrations collected in 1996. If the concentrations of the parameters from fish tissue exceeded both guidelines and upper limit of normal range tissue concentrations, the parameter was identified as a COPC.

The list of final COPCs in fish tissue for wildlife receptors is presented in Table 2.1-8. Detailed comparisons of fish tissue data to guidelines and to upper limit of normal range concentrations are presented in Appendix C.

Table 2.1-8. Final COPCs in Fish for Aquatic Receptors by Closure Area

Lac de Gras	Pit Lakes	North Inlet	NCRP	PKCA Pond
Mercury	Mercury	NA	NA	NA

Note: NA means not applicable as fish are not expected to be present in North Inlet, NCRP, or PKCA Pond.

2.4.3.4 Sediment

Aquatic organisms may be exposed to contaminants in sediment in the North Inlet. The North Inlet is not expected to contain fish at closure; however, primary producers and aquatic invertebrates may be present.

Sediment quality data from North Inlet and chemistry data from NIWTP sludge samples provided by DDMI were used in this assessment to represent sediment quality in the North Inlet in Closure. A total of eight sediment quality samples with five samples collected in 2010 and three samples collected in 2011. Chemistry data from sludge samples from the NIWTP were provided by DDMI and were also used in this assessment. A total of six sludge samples with one sample collected in 2010 and five samples collected in 2011.

The normal range of sediment quality parameters based on data collected between 2007 to 2013 from Lac de Gras described in the *AEMP Reference Conditions Report* (DDMI 2015) were used to represent baseline sediment quality of North Inlet. Parameters were selected for the second screening step if maximum sediment concentrations from the North Inlet and from NIWPT sludge were greater than the CCME sediment quality guidelines for the protection of aquatic life (Table 2.1-9).

If the concentrations of a parameter exceeded the sediment quality guideline, the concentration was compared to the Lac de Gras upper limit of normal range of sediment concentrations. If the parameter concentrations exceeded both the guidelines and the upper limit of normal range of sediment concentrations the parameter was identified as a COPC. Hydrocarbons were retained as COPCs if the maximum concentration exceeded sediment quality guidelines. In addition, since the maximum arsenic and copper concentrations in the North Inlet sediment and NIWTP sludge exceeded CCME guidelines, these parameters were identified as COPCs.

The list of final COPCs in sediment for aquatic receptors is presented in Table 2.1-10. Detailed comparisons of North Inlet sediment and NIWPT sludge quality data to objectives and guidelines and to the upper limit of normal range concentrations are presented in Appendix D.

Table 2.1-9. Guidelines Used in the Selection of Contaminants of Potential Concern in Sediment for Aquatic Receptors

Parameter	CCME Freshwater Sediment Quality Guidelines for the Protection of Aquatic Life[a] (mg/kg dry weight)	
	Interim Guideline	Probable Effects Limit
Total Metals		
Arsenic	5.9	17
Cadmium	0.6	3.5
Chromium	37.3	90
Copper	35.7	197
Lead	35	91.3
Mercury	0.17	0.486
Zinc	123	315
Organics		
2-Methylnaphthalene	0.0202	0.201
Acenaphthene	0.00671	0.0889
Acenaphthylene	0.00587	0.128
Anthracene PAHs	0.0469	0.245
Ben(a)anthracene PAHs	0.0317	0.385
Benzo(a)pyrene	0.0319	0.782
Chrysene	0.0571	0.862
Dibenz(a,h)anthracene	0.00622	0.135
Fluoranthene	0.111	2.355
Fluorene	0.0212	0.144
Naphthalene PAHs	0.0346	0.391
Phenanthrene PAHs	0.0419	0.515
Pyrene PAHs	0.053	0.875

[a] *Canadian Council of Ministers of the Environment (CCME), accessed January 2015. http://st-ts.ccme.ca/en/index.html.*

Table 2.1-10. Contaminants of Potential Concern in Sediment for Ecological Receptors by Closure Area

Lac de Gras	Pit Lakes	North Inlet		NCRP	PKCA Pond
		NI-1 to NI-5	**NIWPT Sludge**		
NA	NA	Arsenic Chromium Copper Naphthalene 2-Methylnaphthalene Acenaphthylene Acenaphthene Pyrene	Arsenic Chromium	NA	NA

Note: NA means not available. Sediment quality data was either not applicable or available from these areas.

2.4.4 Summary

Following the two-step COPC selection procedures, twenty-seven COPCs were retained for ecological receptors (Table 2.1-11). Detailed results of the comparisons of summary statistics to objectives and guidelines and to the upper limit of normal range concentrations for different environmental media, as described in Section 2.4.3, are presented in Appendices A to D.

Table 2.1-11. Summary of Contaminants of Potential Concern for Ecological Receptors from Each Environmental Media

Final Contaminant of Potential Concern	Environmental Media
Metals	
Aluminum	Water, Soil
Arsenic	Water, Sediment
Barium	Soil
Cadmium	Water
Chromium	Water, Sediment, Soil
Cobalt	Water
Copper	Water, Sediment
Iron	Water
Lead	Water
Manganese	Water, Soil
Mercury	Water, Fish
Molybdenum	Soil, Water
Nickel	Water
Potassium	Water
Selenium	Water
Silver	Water
Uranium	Water
Zinc	Water
Nutrients	
Nitrate	Water
Nitrite	Water
Major Anions	
Fluoride	Water
Sulphate	Water
Polycyclic Aromatic Hydrocarbons	
Naphthalene	Sediment
2-Methylnaphthalene	Sediment
Acenaphthylene	Sediment
Acenaphthene	Sediment
Pyrene	Sediment

COPCs include eighteen metals, two nutrients, two anions, and five hydrocarbons (Table 2.1-11). Hydrocarbons were included as a result of sediment concentrations, while nutrients and anions were generally included as a result of water quality concentrations. Metals were included as a result of concentrations in a variety of environmental media. Mercury was included as a result of fish tissue and water concentrations.

2.4.5 Selection of Contaminants of Potential Concern for Human Receptors

2.4.5.1 Soil

Human receptors may accidentally ingest soil or harvest vegetation and berries that may grow on the NCRP and PKCA. During Closure, the NCRP and PKCA will be covered by Type 1 Rock. The same sources soil quality data used to select human health COPCs from the NCRP and PKCA as for ecological health. Refer to Section 2.4.3.1 of this report for further details for data used in the screening of COPCs from soil.

Statistical summaries of metals analysis of Type 1 Rock, including sample size, 25th percentile, median, and 75th percentile, were provided by DDMI. For COPC screening purposes, the 75th percentile concentration of Type 1 Rock soil chemistry data were compared to the guidelines provided in Table 2.1-2.

CCME soil quality guidelines for the protection of agricultural purposes were used to select COPCs for the protection of human health (CCME 2013a). These guidelines represent the most conservative guidelines for soil quality among the available CCME soil quality guidelines for all variables except barium. CCME soil quality guidelines are designed to protect human health, plants, and garden produce. Therefore, CCME soil quality guidelines for the protection of agricultural purposes were used as a proxy to select COPCs that have the potential to affect vegetation growing in these areas that may then be consumed by people who harvest berries or plants as country foods. For barium, the CCME soil quality guideline for protection of human health and environment for residential/ parkland purposes were used. If the 75th percentile concentration of a parameter in the Type 1 Rock exceeded the guideline, the parameter was carried forward to the second screening step.

In the second screening step, the 75th percentile and median concentration of the parameters with guideline exceedances from the Type 1 Rock were compared to the soil upper limit of normal range quality. If the primary COPC concentration exceeded the soil quality upper limit of normal range, the parameter was considered to be a final COPC. The list of COPCs in soil for potential human health receptors is presented in Table 2.1-12, and they are the same as the COPCs identified for ecological receptors (Section 2.4.3.1).

Table 2.1-12. Contaminants of Potential Concern in Soil for Human Receptors by Closure Area

Lac de Gras	Pits	North Inlet	NCRP and PKCA (Type 1 Rock)	PKCA Pond
NA	NA	NA	Aluminum Barium Chromium Manganese Molybdenum	NA

Note: NA means not applicable as there is no soil associated with Lac de Gras, pits, North Inlet, or PKCA pond.

2.4.5.2 Water

Human receptors may ingest water from Lac de Gras, future pit lakes, the North Inlet, the PKCA pond, and potential seepage from the NCRP. The same sources water quality data used to select human health COPCs from the pits, potential seepage from NCRP, the PKCA pond, and the North Inlet as for ecological health. Refer to Section 2.4.3.2 of this report for further details for data used in the screening of COPCs from water.

In the first screening step for COPCs, concentrations were compared to benchmarks and guidelines. The 95th percentile water quality from Lac de Gras Near- and Mid-field stations collected from 2007 to 2013 were used to represent closure water quality in Lac de Gras and were compared to benchmarks and guidelines.

The same data could be used to represent it water quality at Closure since the pits will be inundated with water from Lac de Gras at Closure and are expected to have comparable water quality. However, as a conservative measure, the predicted pit lake water quality for the base case scenario was also used to represent closure water quality in the pits and compared to benchmarks and guidelines.

For the North Inlet and PKCA pond, the 95th percentile water quality data collected from SNP Stations 1645-13 (North Inlet) and 1645-16 (PKCA pond), respectively, were compared to benchmarks and guidelines.

Experimental seepage water quality data from test piles at Diavik were used to represent potential water quality from NCRP seepage during Closure. The 75th percentile of the test piles seepage water quality data were provided by DDMI and compared to benchmarks and guidelines.

Parameters were carried forward to the second screening step if the concentrations exceeded the following criteria, in order of preference (Table 2.1-13):

- Diavik-specific drinking water benchmarks that are relevant to Diavik; and
- Health Canada Drinking Water Quality Guidelines (Health Canada 2012).

Table 2.1-13. Guidelines Used in the Selection of Contaminants of Potential Concern in Water for Human Receptors

Water Quality Variables	Diavik Drinking Water Benchmarks (mg/L)	Health Canada Drinking Water Guidelines (mg/L)
Physical/Ion		
pH (pH units)	6.5 – 8.5	-
Chloride	250	NA
Fluoride	-	1.5
Sulphate	500	NA
Nutrients		
Nitrate, as N	10	NA

(continued)

Table 2.1-13. Guidelines Used in the Selection of Contaminants of Potential Concern in Water for Human Receptors (completed)

Water Quality Variables	Diavik Drinking Water Benchmarks (mg/L)	Health Canada Drinking Water Guidelines (mg/L)
Total Metals		
Aluminum	-	0.1 [a]
Antimony	0.006	NA
Arsenic	0.005	NA
Barium	1	NA
Boron	5	NA
Cadmium	0.005	NA
Chromium	0.05	NA
Copper	1	NA
Iron	0.3	NA
Lead	0.01	NA
Manganese	0.05	NA
Mercury	0.001	NA
Molybdenum	0.25	-
Selenium	0.01	NA
Thallium	1.7	-
Uranium	0.02	NA
Zinc	5	NA
Organics		
Benzene	-	0.005
Benzo(a)pyrene	-	0.00001
Ethylbenzene	-	0.0024 [b]
Methyl tertiary-butyl ether (MTBE)	-	0.015 [b]
Toluene	-	0.024 [b]
Xylene	-	0.3 [b]

Notes:
NA means not applicable; due to presence of Diavik drinking water benchmark for the parameter, the health Canada drinking water guideline was not used.
[a] *Operational guidance value.*
[b] *Aesthetic objective.*

For parameters that exceeded the relevant benchmarks or guidelines, comparisons to baseline conditions were done in the second screening step as follows:

- for Lac de Gras and predicted pit water quality, water quality from Lac de Gras Near- and Mid-field stations were compared to Lac de Gras upper limit of normal range concentrations (DDMI 2015) for both open-water and under-ice seasons;

- for PKCA pond water and the North Inlet, mean and 95th percentile water concentrations of the primary COPCs selected from SNP Stations 1645-16 and 1645-13 were compared to Lac de Gras upper limit of normal range concentrations (DDMI 2015) for both open-water and under-ice seasons; and
- for NCRP seepage, the median and 75th percentile seepage concentrations from the test piles were compared to Lac de Gras upper limit of normal range concentrations (DDMI 2015).

If the concentration of a primary COPC selected from Lac de Gras, future pit lakes, pond water within the PKCA, North Inlet, or NCRP seepage comparisons exceeded both the benchmarks or guidelines and the Lac de Gras upper limit of normal range concentrations, the parameter was identified as a COPC.

The list of COPCs in water for human receptors is presented in Table 2.1-14. Detailed comparison of Lac de Gras, pit water, PKCA pond water, the North Inlet, and NCRP seepage to benchmarks or guidelines and to upper limit of normal range concentrations is presented in Appendix B.

Table 2.1-14. Contaminants of Potential Concern in Water for Human Receptors by Closure Area

Lac de Gras	Pit Lakes	North Inlet	NCRP	PKCA Pond
NI	NI	Arsenic	Sulphate	Nitrate
		Iron	Nitrite	Nitrite
		Manganese	Nitrate	Antimony
		Uranium	Nitrite	Arsenic
			Arsenic	Chromium
			Manganese	Iron
			Mercury	Manganese
			Selenium	Molybdenum
			Uranium	

Note: NI means not identified as no human health COPCs were identified in water from Lac de Gras and Pit Lakes.

2.4.5.3 *Fish Tissue*

Human receptors may eat fish from Lac de Gras or the flooded pit lakes at Closure. The North Inlet will be separated from Lac de Gras by barriers that prevent fish from entering into the North Inlet. Therefore, it was assumed that no fish will be present at North Inlet during closure.

Lake Trout tissue mercury concentrations used for the selection of COPCs for human health is consistent with Lake Trout fish tissue concentrations used for selection of COPCs for ecological health. Refer to Section 2.4.3.3 of this report for further details on data representing Closure and baseline Lake Trout mercury concentrations.

Health Canada fish tissue quality guidelines for fish consumption by humans was used as a screening tool for the evaluation of mercury. The maximum Lake Trout tissue mercury concentration from samples collected in 2005, 2008, and 2011 were compared to the fish tissue residue guideline of 0.5 mg/kg wet weight for human consumers of fish (BC MOE 2001).

If mercury exceeded the tissue residue guideline, mean and maximum mercury tissue concentrations were compared to the mean and maximum Lake Trout tissue mercury concentrations collected during baseline sampling in 1996. If fish tissue mercury concentrations exceeded both the guideline and baseline concentrations, mercury was retained as a final COPC.

The list of final COPCs in fish for potential human health receptors is presented in Table 2.1-15. Detailed comparisons of fish tissue data to tissue residue guidelines and to upper limit of normal range concentrations are presented in Appendix C.

Table 2.1-15. Contaminants of Potential Concern in Fish Tissue for Human Receptors by Closure Area

Lac de Gras	Pits	North Inlet	NCRP	PKCA Pond
Mercury	Mercury	NA	NA	NA

Note: NA means not applicable as fish are not expected to be present in these areas.

2.4.6 Summary

2.4.6.1 Contaminants of Potential Concern for Human Receptors

Following the two-step COPC selection procedures, fourteen COPCs were retained for human receptors (Table 2.1-16). Detailed results of the comparisons of summary statistics to benchmarks, objectives, and guidelines and to upper limit of normal range concentrations for different environmental media, as described in Section 2.4.3, are presented in Appendices A to C.

Table 2.1-16. Identified List of Final Contaminants of Potential Concern for Human Health

Final Contaminant of Potential Concern	Environmental Media
Total Metals	
Aluminum	Soil
Antimony	Water
Arsenic	Water
Barium	Soil
Chromium	Soil, Water
Iron	Water
Manganese	Water, Soil
Mercury	Water, Fish
Molybdenum	Soil, Water
Selenium	Water
Uranium	Water
Nutrients	
Nitrate	Water
Nitrite	Water
Physical/Ion	
Sulphate	Water

Final COPCs include eleven metals, two nutrients, and one anion. The two nutrients and anion were included as a result of concentrations in water. Metals were generally included as a result of concentrations in water, but some metals were also included because of soil concentrations (i.e., aluminum, barium, chromium, and molybdenum) or fish tissue (i.e., mercury) concentrations.

2.5 CONCEPTUAL MODEL

A conceptual model is a representation of the characteristics of the site in diagrammatic form, and is developed within a risk assessment to identify potential sources, fate, and transport of COPCs, potential exposure routes, and the possible interaction pathways between COPCs and receptors. The conceptual model is supported by the narrative provided in the preceding sections (Sections 2.5.1 and 2.5.2) and provides the framework and scope for subsequent efforts to develop SSRBCCs.

2.5.1 Ecological Conceptual Model

The conceptual model for ecological receptors during Closure, including exposure pathways and sources of COPCs is presented in Figure 2.5-1. This conceptual model will guide the remaining quantitative components of the derivation of SSRBCC for the Project.

2.5.2 Human Health Conceptual Model

The conceptual model for human receptors during Closure, including exposure pathways and sources of COPCs is presented in Figure 2.5-2. This conceptual model will guide the remaining quantitative components of the derivation of SSRBCC for the Project.

Figure 2.5-1

Ecological Receptor Conceptual Model for Derivation of Risk Based Closure Criteria for Diavik Diamond Mine

ERM

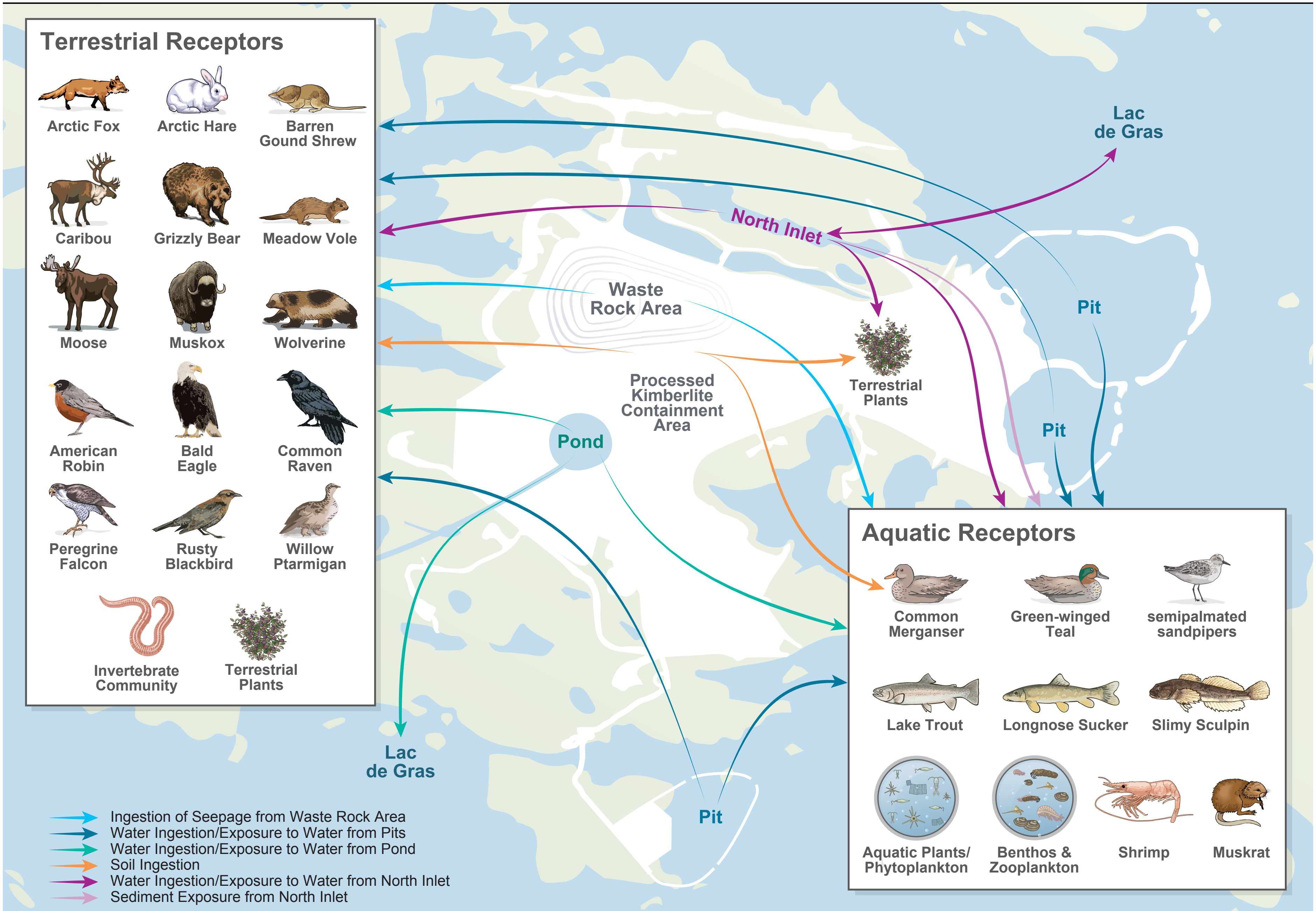
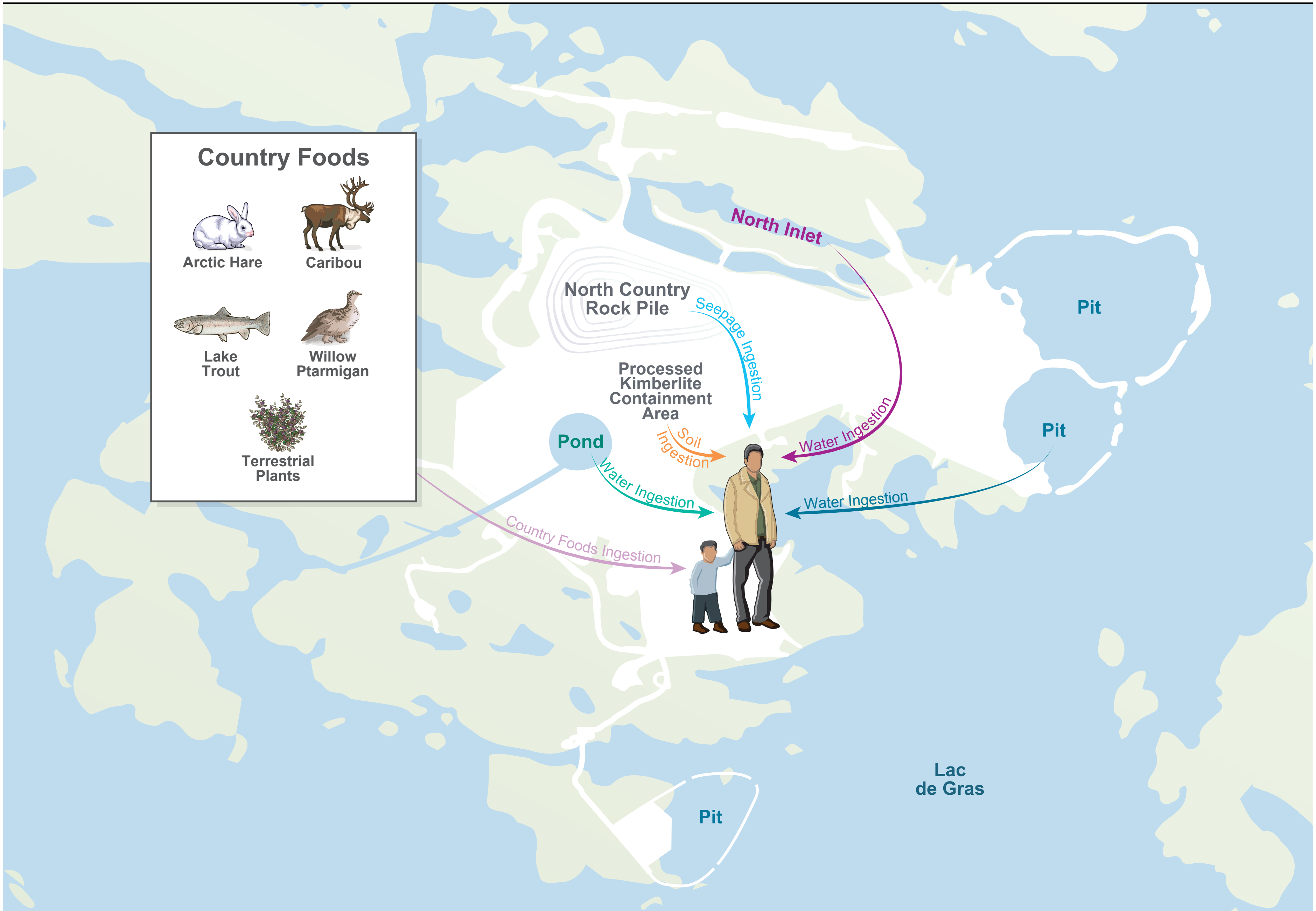


Figure 2.5-2

Human Receptor Conceptual Model for Derivation of Risk Based Closure Criteria for Diavik Diamond Mine

ERM



3. ASSUMPTIONS AND UNCERTAINTIES

All ecological and human health risk-based assessments involve assumptions and uncertainties. Key assumptions that were made and sources of uncertainty that were encountered during the development of the Problem Formulation have been identified and discussed in the following sections.

3.1 POTENTIAL RECEPTORS OF CONCERN

3.1.1 Ecological Receptors of Concern

The presence of aquatic life in Lac de Gras has been documented through the AEMP. It was assumed that aquatic life and fish species that currently inhabit Lac de Gras will also inhibit the flooded pits (i.e., pit lakes) at closure.

It was assumed that aquatic life and fish will not inhabit the PKCA pond. However, PKCA pond water will eventually enter Lac de Gras, where it will be diluted considerably. Thus, the 95th percentiles of the concentrations were diluted by half using Lac de Gras normal upper range concentrations prior to comparisons to objectives and guidelines.

Wildlife Valued Ecosystem Components (VECs) from the Diavik Diamond Project Environmental Assessment (Diavik 1998) were considered in the selection of ROCs along with additional information gathered from nearby projects to fulfill Environment Canada guidelines for the selection of ecological receptors.

3.1.2 Human Health Receptors of Concern

Receptor selection for human health was based on available traditional use and traditional knowledge reports from a nearby project and is assumed to be reflective of the potential for human use at the Project site during Closure. Although some information about the current land use was available, most of the available information was based on historical or traditional land use. As a conservative measure, it was assumed that land use during Closure will be similar to traditional land use and practices employed in the past. Although this is a conservative measure, this assumption aids in the derivation of SSRBCCs that will be protective of all potential human receptors at the Project site.

3.2 POTENTIAL EXPOSURE PATHWAYS

The identification of potential exposure pathways relies on the existence of a pathway from the point of release of a contaminant to a receptor and the ability of the receptor to take up the chemical. Although a receptor may be in contact with a contaminant, it does not guarantee that a complete exposure pathway exists. This is because the contaminant may be in a form that is not bioavailable to the receptor.

The assessment of exposure pathways did not include inhalation or dermal contact for wildlife and inhalation for human health. This is a reasonable assumption because these pathways do not typically result in significant uptake or exposure of receptors compared to other exposure pathways (i.e., these pathways contribute negligible exposures within the overall potential for exposure).

3.3 Potential Sources of Contaminants

The identification of potential sources of contaminants was based on the ICRP and the assumption that goals and objectives of the ICRP will be met at closure. If there are deviations from the ICRP at closure, the Problem Formulation component of the assessment should be revisited to ensure that the all potential sources of contaminants and receiving environments have been considered in the derivation of the SSRBCC.

3.4 Selection of Contaminants of Potential concern

Selection of COPCs for the subsequent development of SSRBCCs for use in Closure phase relied on data collected from environmental media. However, the Project is still in the Operation phase at this time and the quality of environmental media at closure is, therefore, not yet available. Consequently, it was assumed that the quality of environmental media measured during operations (e.g., chemistry of North Inlet sediments) will be representative of its quality at Closure for all environmental media in all receiving environments. However, it is likely that environmental quality will generally improve through Closure, relative to environmental quality during the operational phase of the Project. The use of environmental media quality measured in Operation phase as a surrogate for environmental media quality at Closure overestimates conditions during Closure, thereby providing a conservative measure.

The median and 75th percentile of metals data from Type 1 Rock were used to represent mean and maximum soil quality in the NCRP and PKCA. However, it is possible that the 75th percentile of the parameter was less than the guideline while the maximum concentration of the data exceeded the guideline. In such cases, parameters would have been selected as COPCs had the maximum value been used, but would not have been selected as COPCs using the 75th percentile. However, test pile soil quality data for Type I rock was collected under circumstances that would not normally be observed at site and likely represents a 'worst case scenario' for soil quality in the NCRP and PKCA during closure. It is likely that all relevant COPCs were identified.

There is currently no seepage from the west and north-west areas of the North Country Rock Pile and it is expected that there will be no seepage from the NCRP curing closure. Predicted seepage water quality data was obtained from experimental studies conducted on several test piles at Diavik. Waste Rock piles are covered by one meter of till and three meters of Type 1 Rock (DDMI 2011). Since seepage was collected at the bottom of the NCRP, the measured concentrations are highly conservative. In reality, seepage from the NCRP would be mixed with runoff and, consequently, would be much less concentrated than the water chemistry observed during the test pile studies.

Although the assumption that wildlife and people may be exposed to the 75th percentile of NCRP seepage water quality data may be a reasonable representation of maximum seepage quality from the NCRP, it is very unlikely that aquatic life and fish would be exposed to these high concentrations during Closure. Any seepage from the NCRP will be largely diluted in route to or within Lac de Gras and therefore, it was assumed that the 75^{th} percentile of the seepage water quality concentrations will be diluted by half using Lac de Gras normal upper range concentrations before any potential exposure of aquatic life and fish. As a conservative measure, median concentrations of the NCRP seepage were not diluted by Lac de Gras water to ensure all potential COPCs for aquatic life and fish were captured.

The available water quality data from the SNP stations were provided by DDMI as an Excel file ("Class A Water Licence All Data (LIST).csv file"). ERM processed the available data to identify water quality data from relevant stations and calculate summary statistics for both the PKCA pond and the North Inlet (Stations 1635-16 and 1645-13, respectively). Data manipulations included, but were not limited to, the selection of appropriate site names, removal of the blanks, removal of existing data manipulations and calculations present in the data set, averaging of duplicates, and verifying unit conversions. The data manipulations were conducted using a combination of Excel and the statistical software R. There were some uncertainties associated with the SNP data and associated units. To detect values that may have been expressed in inappropriate or inconsistent units, histograms of the final data were constructed to examine the overall data distribution of the remaining data. Rather than using maximum and mean concentrations for the screening of COPCs, 95^{th} percentile and mean concentrations were used to ensure elimination of any potential outliers from SNP Stations 1645-13 and 1645-16. Histograms depicting the data distribution of the parameters from the selected SNP stations are provided in Appendix E.

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Definitions of the acronyms and abbreviations used in this reference list can be found in the Glossary and Abbreviations section.

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Appendix A

Selection of Contaminants of Potential Concern in Soil

Table A-1. Selection of Contaminants of Potential Concern in Soil for Derivation of Site-specific Risk-based Closure Criteria for Protection of Ecological and Human Receptors

Parameter	Type 1 Rock Soil			CCME Agricultural Soil Quality Guidelines [a]	Is the Maximum Soil Concentration Greater than Guidelines?	Upper Limit of the Normal Range Concentration [b]	Is the Parameter a Contaminant of Potential Concern?
	Sample Size	Median	75th Percentile				
Aluminum	20	75,650	79,525	- [c]	Yes	11,050	Yes
Antimony	36	0.2	0.4	20	No		No
Arsenic	36	1	1	12	No		No
Barium	56	552.5	700	500 [d]	Yes	79	Yes
Beryllium	12	1	1.6	4	No		No
Boron	-	-	-	2	No		No
Cadmium	15	0.05	0.05	1.4	No		No
Chromium	20	49.5	77.5	64	Yes	61.9	Yes
Cobalt	35	4	6	40	No		No
Copper	36	2	5.5	63	No		No
Lead	35	12	25	70	No		No
Manganese	20	155	251	220 [e]	Yes	200	Yes
Mercury	1	5	5	6.6	No		No
Molybdenum	27	6	8.5	5	Yes	0.68	Yes
Nickel	35	5	7	45	No		No
Selenium	16	0.1	0.1	1	No		No
Silver	17	0.1	0.1	20	No		No
Uranium	16	5.1	5.85	23	No		No
Vanadium	20	11.5	16.3	130	No		No
Zinc	36	36	46	200	No		No

Notes: All concentrations are in mg/kg dry weight.
Hashed cells indicate no further assessment is necessary for the parameter.
Gray highlighted cells indicate that the parameter is selected as a final COPC.
[a] *Canadian Council of Ministers of the Environment (CCME) soil quality guidelines for agricultural purposes, accessed August 2015. http://st-ts.ccme.ca/en/index.html.*
[b] *Normal Range for all the soil Primary COPCs were based on 2.5th to 97.5th Percentile of the reference stations.*
[c] *Soil aluminum guideline is dependent on soil pH. Since Soil pH was not measured for Type 1 Rock, it was assumed that the soil pH of Type 1 Rock is below 5.5 and therefore, Aluminum was as a selected primary COPC.*
[d] *CCME soil quality guidelines for barium are based on residential/parkland use.*
[e] *CCME soil quality guideline is not available for this parameter. Therefore, US EPA Eco SSL lowest soil quality guidelines were used instead.*

Appendix B

Selection of Contaminants of Potential Concern in Water

Table B-1. Selection of Aquatic Life Contaminants of Potential Concern from Predicted Pit Lake Water Quality Based on the Pit Wall-washing Study for A154

Parameter	Predicted Concentrations	Guideline, Benchmark, or Objective	Is the Parameter Greater than the Guideline?
pH	6.84	6.5 to 9.0	No
Ammonia	0.046	4.73	No
Aluminum	0.0062	0.0955	No
Arsenic	0.00024	0.05	No
Cadmium	0.000003	0.0001	No
Chromium	0.000054	0.001	No
Copper	0.00049	0.002	No
Manganese	0.00028	-	No
Molybdenum	0.00050	0.073	No
Nickel	0.00077	0.025	No
Lead	0.0000053	0.001	No
Selenium	0.000025	0.001	No
Uranium	0.00014	0.015	No
Zinc	0.00062	0.03	No

Note:

All concentrations are in mg/L.

Table B-2. Selection of Aquatic Life Contaminants of Potential Concern from Predicted Pit Lake Water Quality Based on the Pit Wall-washing Study for A418

Parameter	Predicted Concentrations	Guideline, Benchmark, or Objective	Is the Parameter Greater than the Guideline?
pH	6.84	6.5 to 9.0	No
Ammonia	0.046	4.73	No
Aluminum	0.0062	0.0955	No
Arsenic	0.00024	0.05	No
Cadmium	0.0000031	0.0001	No
Chromium	0.000054	0.001	No
Copper	0.00050	0.002	No
Manganese	0.00033	-	No
Molybdenum	0.00051	0.073	No
Nickel	0.00078	0.025	No
Lead	0.0000053	0.001	No
Selenium	0.000025	0.001	No
Uranium	0.00017	0.015	No
Zinc	0.00062	0.03	No

Note:

All concentrations are in mg/L.

Table B-3. Selection of Wildlife Contaminants of Potential Concern from Predicted Pit Lake Water Quality Based on the Pit Wall-washing Study for A154

Parameter	Predicted Concentrations	Selected Guideline	Is the Parameter a Primary Contamimant of Potential Concern?
pH	6.84	-	No
Ammonia	0.046	-	No
Aluminum	0.0062	5	No
Arsenic	0.00024	0.025	No
Cadmium	0.000003	0.08	No
Chromium	0.000054	0.05	No
Copper	0.00049	-	No
Manganese	0.00028	-	No
Molybdenum	0.00050	0.5	No
Nickel	0.00077	0.2	No
Lead	0.0000053	0.1	No
Selenium	0.000025	0.02	No
Uranium	0.00014	0.2	No
Zinc	0.00062	50	No

Note:

All concentrations are in mg/L.

Table B-4. Selection of Wildlife Contaminants of Potential Concern from Predicted Pit Lake Water Quality Based on the Pit Wall-washing Study for A418

Parameter	Predicted Concentrations	Selected Guideline	Is the Parameter a Primary Contamimant of Potential Concern?
pH	6.84	-	No
Ammonia	0.046	-	No
Aluminum	0.0062	5	No
Arsenic	0.00024	0.025	No
Cadmium	0.0000031	0.08	No
Chromium	0.000054	0.05	No
Copper	0.00050	-	No
Manganese	0.00033	-	No
Molybdenum	0.00051	0.5	No
Nickel	0.00078	1	No
Lead	0.0000053	0.1	No
Selenium	0.000025	0.02	No
Uranium	0.00017	0.2	No
Zinc	0.00062	50	No

Note:

All concentrations are in mg/L.

Table B-5. Selection of Drinking Water Contaminants of Potential Concern from Predicted Pit Lake Water Quality Based on the Pit Wall-washing Study for A154

Parameter	Predicted Concentrations	Guideline, Benchmark, or Objective	Is the Parameter Greater than the Guideline?
pH	6.84	6.5 to 8.5	No
Ammonia	0.046	-	No
Aluminum	0.0062	0.1[a]	No
Arsenic	0.00024	0.005	No
Cadmium	0.000003	0.005	No
Chromium	0.000054	0.05	No
Copper	0.00049	1	No
Manganese	0.00028	0.05	No
Molybdenum	0.00050	0.05	No
Nickel	0.00077	-	No
Lead	0.0000053	0.01	No
Selenium	0.000025	0.05	No
Uranium	0.00014	0.02	No
Zinc	0.00062	5	No

Notes:

All concentrations are in mg/L.

[a] *Aesthetic objective.*

Table B-6. Selection of Drinking Water Contaminants of Potential Concern from Predicted Pit Lake Water Quality Based on the Pit Wall-washing Study for A418

Parameter	Predicted Concentrations	Guideline, Benchmark, or Objective	Is the Parameter Greater than the Guideline?
pH	6.84	6.5 to 8.5	No
Ammonia	0.046	-	No
Aluminum	0.0062	0.1[a]	No
Arsenic	0.00024	0.005	No
Cadmium	0.0000031	0.005	No
Chromium	0.000054	0.05	No
Copper	0.00050	1	No
Manganese	0.00033	0.05	No
Molybdenum	0.00051	0.05	No
Nickel	0.00078	-	No
Lead	0.0000053	0.01	No
Selenium	0.000025	0.05	No
Uranium	0.00017	0.02	No
Zinc	0.00062	5	No

Notes:

All concentrations are in mg/L.

[a] *Aesthetic objective.*

Table B-7. Selection of Aquatic Life Contaminants of Potential Concern from Lac de Gras Near- and Mid-field Stations during the Open-water Season

Parameter	Sample Size	Mean Concentrations	95th Percentile Concentrations	Guideline, Benchmark, or Objective	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range	Is the Parameter a Contaminant of Potential Concern?
Physical/Ion							
pH	476	6.85	7.08	6.5 to 9.0	No		No
Chloride	374	1.67	2.54	230	No		No
Fluoride	374	0.0245	0.0300	0.12	No		No
Potassium	374	0.712	0.888	70	No		No
Sulphate	374	2.36	3.60	128	No		No
Nutrients							
Nitrate as N	374	0.0147	0.0397	30.1	No		No
Nitrite as N	374	0.00122	0.00250	0.06	No		No
Ammonia as N	371	0.0182	0.0670	4.73	No		No
Dissolved Metals							
Aluminum	50	0.00602	0.00976	0.109	No		No
Cadmium	51	0.00000257	0.00000250	-	No		No
Calcium	323	1.25	1.56	-	No		No
Iron	111	0.00404	0.00900	-	No		No
Total Metals							
Aluminum	371	0.00595	0.0100	0.109	No		No
Antimony	374	0.0000139	0.0000200	-	No		No
Arsenic	374	0.000223	0.000267	0.05	No		No
Barium	374	0.00284	0.00390	-	No		No
Beryllium	374	0.0000615	0.000100	-	No		No
Boron	374	0.00634	0.0250	1.5	No		No
Cadmium	337	0.0000176	0.0000250	0.0001	No		No
Calcium	374	1.25	1.55	-	No		No
Chromium	332	0.0000431	0.000100	0.001	No		No
Cobalt	333	0.0000387	0.0000500	-	No		No
Copper	373	0.000441	0.000641	0.002	No		No
Hardness	374	6.57	7.99	-	No		No
Iron	272	0.00481	0.00809	0.3	No		No
Lead	374	0.0000210	0.0000600	0.001	No		No
Lithium	152	0.00149	0.00171	-	No		No
Magnesium	374	0.817	1.03	-	No		No
Manganese	332	0.00218	0.00348	-	No		No
Mercury	359	0.00000816	0.0000100	0.000026	No		No
Molybdenum	333	0.000357	0.000723	0.073	No		No
Nickel	333	0.000699	0.000924	0.025	No		No
Selenium	374	0.0000389	0.0000500	0.001	No		No
Silver	374	0.0000307	0.0000500	0.0001	No		No
Sodium	374	1.23	1.72	-	No		No
Strontium	374	0.0129	0.0182	-	No		No
Thallium	152	0.00000108	0.00000145	0.0008	No		No
Tin	152	0.0000426	0.000100	-	No		No
Titanium	152	0.000286	0.000250	-	No		No
Uranium	374	0.0000775	0.000118	0.015	No		No
Vanadium	374	0.0000516	0.000100	0.03	No		No
Zinc	374	0.000790	0.00229	0.03	No		No

Table B-8. Selection of Widlife Contaminants of Potential Concern from Lac de Gras Near- and Mid-field Stations during the Open-water Season

Parameter	Sample Size	Mean Concentrations	95th Percentile Concentrations	Guideline, Benchmark, or Objective	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range	Is the Parameter a Contaminant of Potential Concern?
Physical/Ion							
pH	476	6.85	7.08	-	No		No
Chloride	374	1.67	2.54	-	No		No
Fluoride	374	0.0245	0.0300	1	No		No
Potassium	374	0.712	0.888	-	No		No
Sulphate	374	2.36	3.60	1000	No		No
Nutrients							
Nitrate as N	374	0.0147	0.0397	-	No		No
Nitrite as N	374	0.00122	0.00250	10	No		No
Ammonia as N	371	0.0182	0.0670	-	No		No
Dissolved Metals							
Aluminum	50	0.00602	0.00976	-	No		No
Cadmium	51	0.00000257	0.00000250	-	No		No
Calcium	323	1.25	1.56	-	No		No
Iron	111	0.00404	0.00900	-	No		No
Total Metals							
Aluminum	371	0.00595	0.0100	5	No		No
Antimony	374	0.0000139	0.0000200	-	No		No
Arsenic	374	0.000223	0.000267	0.025	No		No
Barium	374	0.00284	0.00390	-	No		No
Beryllium	374	0.0000615	0.000100	0.1	No		No
Boron	374	0.00634	0.0250	5	No		No
Cadmium	337	0.0000176	0.0000250	0.0051	No		No
Calcium	374	1.25	1.55	1000	No		No
Chromium	332	0.0000431	0.000100	0.05	No		No
Cobalt	333	0.0000387	0.0000500	0.05	No		No
Copper	373	0.000441	0.000641	-	No		No
Hardness	374	6.57	7.99	-	No		No
Iron	272	0.00481	0.00809	5	No		No
Lead	374	0.0000210	0.0000600	0.1	No		No
Lithium	152	0.00149	0.00171	2.5	No		No
Magnesium	374	0.817	1.03	-	No		No
Manganese	332	0.00218	0.00348	0.2	No		No
Mercury	359	0.00000816	0.0000100	0.003	No		Yes
Molybdenum	333	0.000357	0.000723	0.5	No		No
Nickel	333	0.000699	0.000924	0.2	No		No
Selenium	374	0.0000389	0.0000500	0.02	No		No
Silver	374	0.0000307	0.0000500	-	No		No
Sodium	374	1.23	1.72	-	No		No
Strontium	374	0.0129	0.0182	-	No		No
Thallium	152	0.00000108	0.00000145	-	No		No
Tin	152	0.0000426	0.000100	-	No		No
Titanium	152	0.000286	0.000250	-	No		No
Uranium	374	0.0000775	0.000118	0.2	No		No
Vanadium	374	0.0000516	0.000100	0.1	No		No
Zinc	374	0.000790	0.00229	50	No		No

Table B-9. Selection of Drinking Water Contaminants of Potential Concern from Lac de Gras Near- and Mid-field Stations during the Open-water Season

Parameter	Sample Size	Mean Concentrations	95th Percentile Concentrations	Guideline, Benchmark, or Objective	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range	Is the Parameter a Contaminant of Potential Concern?
Physical/Ion							
pH	476	6.85	7.08	6.5 to 8.5	No		No
Chloride	374	1.67	2.54	250	No		No
Fluoride	374	0.0245	0.0300	1.5	No		No
Potassium	374	0.712	0.888	-	No		No
Sulphate	374	2.36	3.60	500	No		No
Nutrients							
Nitrate as N	374	0.0147	0.0397	10	No		No
Nitrite as N	374	0.00122	0.00250	-	No		No
Ammonia as N	371	0.0182	0.0670	-	No		No
Dissolved Metals							
Aluminum	50	0.00602	0.00976	-	No		No
Cadmium	51	0.00000257	0.00000250	-	No		No
Calcium	323	1.25	1.56	-	No		No
Iron	111	0.00404	0.00900	-	No		No
Total Metals							
Aluminum	371	0.00595	0.0100	0.1[a]	No		No
Antimony	374	0.0000139	0.0000200	0.006	No		No
Arsenic	374	0.000223	0.000267	0.005	No		No
Barium	374	0.00284	0.00390	1	No		No
Beryllium	374	0.0000615	0.000100	-	No		No
Boron	374	0.00634	0.0250	-	No		No
Cadmium	337	0.0000176	0.0000250	0.005	No		No
Calcium	374	1.25	1.55	-	No		No
Chromium	332	0.0000431	0.000100	0.05	No		No
Cobalt	333	0.0000387	0.0000500	-	No		No
Copper	373	0.000441	0.000641	1	No		No
Hardness	374	6.57	7.99	-	No		No
Iron	272	0.00481	0.00809	0.3	No		No
Lead	374	0.0000210	0.0000600	0.01	No		No
Lithium	152	0.00149	0.00171	-	No		No
Magnesium	374	0.817	1.03	-	No		No
Manganese	332	0.00218	0.00348	-	No		No
Mercury	359	0.00000816	0.0000100	0.001	No		No
Molybdenum	333	0.000357	0.000723	0.25	No		No
Nickel	333	0.000699	0.000924	-	No		No
Selenium	374	0.0000389	0.0000500	0.01	No		No
Silver	374	0.0000307	0.0000500	-	No		No
Sodium	374	1.23	1.72	200[a]	No		No
Strontium	374	0.0129	0.0182	-	No		No
Thallium	152	0.00000108	0.00000145	0.0017	No		No
Tin	152	0.0000426	0.000100	-	No		No
Titanium	152	0.000286	0.000250	-	No		No
Uranium	374	0.0000775	0.000118	0.02	No		No
Vanadium	374	0.0000516	0.000100	-	No		No
Zinc	374	0.000790	0.00229	5	No		No

Table B-10. Selection of Aquatic Life Contaminants of Potential Concern from Lac de Gras Near- and Mid-field Stations during the Ice-cover Season

Parameter	Sample Size	Mean Concentrations	95th Percentile Concentrations	Guideline, Benchmark, or Objective	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range	Is the Parameter a Contaminant of Potential Concern?
Physical/Ion							
pH	1183	6.83	7.07	6.5 to 9.0	No		No
Chloride	968	1.95	4.15	230	No		No
Fluoride	968	0.0251	0.0300	0.12	No		No
Potassium	975	0.753	1.09	70	No		No
Sulphate	969	2.49	4.05	128	No		No
Nutrients							
Nitrate as N	968	0.0444	0.126	30.1	No		No
Nitrite as N	968	0.00143	0.00250	0.06	No		No
Ammonia as N	966	0.0194	0.0579	4.73	No		No
Dissolved Metals							
Aluminum	51	0.00415	0.00834	0.102	No		No
Cadmium	51	0.00000259	0.00000250	-	No		No
Calcium	815	1.35	2.01	-	No		No
Iron	255	0.00728	0.0130	-	No		No
Total Metals							
Aluminum	974	0.00631	0.0133	0.102	No		No
Antimony	975	0.0000156	0.0000300	-	No		No
Arsenic	975	0.000231	0.000288	0.05	No		No
Barium	975	0.00342	0.00529	-	No		No
Beryllium	975	0.0000752	0.000100	-	No		No
Boron	975	0.00566	0.0250	1.5	No		No
Cadmium	975	0.0000197	0.0000250	0.0001	No		No
Calcium	975	1.36	2.11	-	No		No
Chromium	975	0.0000471	0.000120	0.001	No		No
Cobalt	975	0.0000409	0.0000500	-	No		No
Copper	975	0.000453	0.000738	0.002	No		No
Hardness	968	7.04	10.4	-	No		No
Iron	771	0.00512	0.0119	0.3	No		No
Lead	974	0.0000344	0.0000900	0.001	No		No
Lithium	255	0.00162	0.00230	-	No		No
Magnesium	975	0.862	1.28	-	No		No
Manganese	975	0.00253	0.00613	-	No		No
Mercury	923	0.0000103	0.0000100	0.000026	No		No
Molybdenum	975	0.000416	0.00113	0.073	No		No
Nickel	975	0.000769	0.00106	0.025	No		No
Selenium	975	0.0000454	0.0000500	0.001	No		No
Silver	975	0.0000377	0.0000500	0.0001	No		No
Sodium	975	1.36	2.61	-	No		No
Strontium	975	0.0145	0.0270	-	No		No
Thallium	255	0.00000116	0.00000200	0.0008	No		No
Tin	255	0.0000217	0.0000820	-	No		No
Titanium	255	0.000265	0.000250	-	No		No
Uranium	975	0.0000932	0.000180	0.015	No		No
Vanadium	975	0.0000438	0.000100	0.03	No		No
Zinc	975	0.000858	0.00238	0.03	No		No

Table B-11. Selection of Widlife Contaminants of Potential Concern from Lac de Gras Near- and Mid-field Stations during the Ice-cover Season

Parameter	Sample Size	Mean Concentrations	95th Percentile Concentrations	Guideline, Benchmark, or Objective	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range	Is the Parameter a Contaminant of Potential Concern?
Physical/Ion							
pH	1183	6.83	7.07	-	No		No
Chloride	968	1.95	4.15	-	No		No
Fluoride	968	0.0251	0.0300	1	No		No
Potassium	975	0.753	1.09	-	No		No
Sulphate	969	2.49	4.05	1000	No		No
Nutrients							
Nitrate as N	968	0.0444	0.126	-	No		No
Nitrite as N	968	0.00143	0.00250	10	No		No
Ammonia as N	966	0.0194	0.0579	-	No		No
Dissolved Metals							
Aluminum	51	0.00415	0.00834	-	No		No
Cadmium	51	0.00000259	0.00000250	-	No		No
Calcium	815	1.35	2.01	-	No		No
Iron	255	0.00728	0.0130	-	No		No
Total Metals							
Aluminum	974	0.00631	0.0133	5	No		No
Antimony	975	0.0000156	0.0000300	-	No		No
Arsenic	975	0.000231	0.000288	0.025	No		No
Barium	975	0.00342	0.00529	-	No		No
Beryllium	975	0.0000752	0.000100	0.1	No		No
Boron	975	0.00566	0.0250	5	No		No
Cadmium	975	0.0000197	0.0000250	0.0051	No		No
Calcium	975	1.36	2.11	1000	No		No
Chromium	975	0.0000471	0.000120	0.05	No		No
Cobalt	975	0.0000409	0.0000500	0.05	No		No
Copper	975	0.000453	0.000738	-	No		No
Hardness	968	7.04	10.4	-	No		No
Iron	771	0.00512	0.0119	5	No		No
Lead	974	0.0000344	0.0000900	0.1	No		No
Lithium	255	0.00162	0.00230	2.5	No		No
Magnesium	975	0.862	1.28	-	No		No
Manganese	975	0.00253	0.00613	0.2	No		No
Mercury	923	0.0000103	0.0000100	0.003	No		No
Molybdenum	975	0.000416	0.00113	0.5	No		No
Nickel	975	0.000769	0.00106	0.2	No		No
Selenium	975	0.0000454	0.0000500	0.02	No		No
Silver	975	0.0000377	0.0000500	-	No		No
Sodium	975	1.36	2.61	-	No		No
Strontium	975	0.0145	0.0270	-	No		No
Thallium	255	0.00000116	0.00000200	-	No		No
Tin	255	0.0000217	0.0000820	-	No		No
Titanium	255	0.000265	0.000250	-	No		No
Uranium	975	0.0000932	0.000180	0.2	No		No
Vanadium	975	0.0000438	0.000100	0.1	No		No
Zinc	975	0.000858	0.00238	50	No		No

Table B-12. Selection of Drinking Water Contaminants of Potential Concern from Lac de Gras Near- and Mid-field Stations during the Ice-cover Season

Parameter	Sample Size	Mean Concentrations	95th Percentile Concentrations	Guideline, Benchmark, or Objective	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range	Is the Parameter a Contaminant of Potential Concern?
Physical/Ion							
pH	1183	6.83	7.07	6.5 to 8.5	No		No
Chloride	968	1.95	4.15	250	No		No
Fluoride	968	0.0251	0.0300	1.5	No		No
Potassium	975	0.753	1.09	-	No		No
Sulphate	969	2.49	4.05	500	No		No
Nutrients							
Nitrate as N	968	0.0444	0.126	10	No		No
Nitrite as N	968	0.00143	0.00250	-	No		No
Ammonia as N	966	0.0194	0.0579	-	No		No
Dissolved Metals							
Aluminum	51	0.00415	0.00834	-	No		No
Cadmium	51	0.00000259	0.00000250	-	No		No
Calcium	815	1.35	2.01	-	No		No
Iron	255	0.00728	0.0130	-	No		No
Total Metals							
Aluminum	974	0.00631	0.0133	0.1[a]	No		No
Antimony	975	0.0000156	0.0000300	0.006	No		No
Arsenic	975	0.000231	0.000288	0.005	No		No
Barium	975	0.00342	0.00529	1	No		No
Beryllium	975	0.0000752	0.000100	-	No		No
Boron	975	0.00566	0.0250	-	No		No
Cadmium	975	0.0000197	0.0000250	0.005	No		No
Calcium	975	1.36	2.11	-	No		No
Chromium	975	0.0000471	0.000120	0.05	No		No
Cobalt	975	0.0000409	0.0000500	-	No		No
Copper	975	0.000453	0.000738	1	No		No
Hardness	968	7.04	10.4	-	No		No
Iron	771	0.00512	0.0119	0.3	No		No
Lead	974	0.0000344	0.0000900	0.01	No		No
Lithium	255	0.00162	0.00230	-	No		No
Magnesium	975	0.862	1.28	-	No		No
Manganese	975	0.00253	0.00613	-	No		No
Mercury	923	0.0000103	0.0000100	0.001	No		Yes
Molybdenum	975	0.000416	0.00113	0.25	No		No
Nickel	975	0.000769	0.00106	-	No		No
Selenium	975	0.0000454	0.0000500	0.01	No		No
Silver	975	0.0000377	0.0000500	-	No		No
Sodium	975	1.36	2.61	200[a]	No		No
Strontium	975	0.0145	0.0270	-	No		No
Thallium	255	0.00000116	0.00000200	0.0017	No		No
Tin	255	0.0000217	0.0000820	-	No		No
Titanium	255	0.000265	0.000250	-	No		No
Uranium	975	0.0000932	0.000180	0.02	No		No
Vanadium	975	0.0000438	0.000100	-	No		No
Zinc	975	0.000858	0.00238	5	No		No

Table B-13. Selection of Aquatic Life Contaminants of Potential Concern from Potential Waste Rock Pile Seepage Based on Test Piles Seepage Data

Parameter	Sample Size	Median	75th Percentile	Guideline, Benchmark, or Objective	Is the 75th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range	Is the Parameter a Contaminant of Potential Concern?
Physical/Ions							
pH	886	6.96	7.38	6.5 to 9.0	No		No
Bromide	873	0.888	4.01	-	No		No
Chloride	874	24.0	78.2	120	No		No
Fluoride	180	0.500	0.500	0.12	Yes	0.0300	Yes
Potassium	915	45.2	81.1	70	Yes	0.670	Yes
Sulphate	873	324	705	NA	Yes	2.50	Yes
Nutrients							
Nitrite	874	0.579	2.24	0.06	Yes	0.00200	Yes
Nitrate	874	334	896	3	Yes	0.0152	Yes
Ammonia	736	0.395	3.40	4.73	No		No
Total Metals							
Aluminum	873	0.0509	0.180	0.125	Yes	0.00620	Yes
Antimony	872	0.000926	0.00216	0.02	No		No
Arsenic	873	0.00252	0.00555	0.005	Yes	0.00220	Yes
Boron	460	0.0956	0.163	1.5	No		No
Barium	871	0.0388	0.0579	1	No		No
Beryllium	458	0.0000795	0.000934	-	No		No
Cadmium	872	0.00106	0.00359	0.00037	Yes	0.00000500	Yes
Calcium	915	106	255	-	No		No
Chromium	872	0.000348	0.00122	0.001	Yes	0.0000600	Yes
Cobalt	873	0.0203	0.0791	-	No		No
Copper	872	0.0480	0.191	0.002	Yes	0.000800	Yes
Iron	873	0.0482	0.135	0.3	No		No
Lead	871	0.00115	0.00279	0.007	No		No
Lithium	188	0.211	0.470	-	No		No
Magnesium	915	65.8	170	-	No		No
Manganese	873	1.07	3.51	-	No		No
Mercury	81	0.00136	0.00230	0.000026	Yes	0.0000100	Yes
Molybdenum	872	0.00910	0.0447	0.073	No		No
Nickel	873	0.127	0.501	0.15	Yes	0.00112	Yes
Selenium	843	0.00772	0.0138	0.001	Yes	0.0000400	Yes
Silicon	549	7.25	10.4	-	No		No
Silver	802	0.000920	0.00446	0.00025	Yes	0.00000500	Yes
Sodium	914	53.8	116	-	No		No
Strontium	761	1.03	2.51	-	No		No
Tin	872	0.00207	0.00475	-	No		No
Titanium	872	0.000680	0.00192	-	No		No
Thallium	873	0.000291	0.000735	0.0008	No		No
Uranium	873	0.0870	0.237	0.015	Yes	0.0000300	Yes
Vanadium	871	0.000440	0.00128	0.03	No		No
Zinc	873	0.0370	0.150	0.03	Yes	0.00204	Yes

Notes:

Gray shading indicates exceedance of aquatic life water quality guideline.

Hashed cells indicate no further assessment ins necessary for the parameter.

Orange shading indicates parameter is a considered a final contamimants of potential concern.

All concentrations are in mg/L.

Table B-14. Selection of Wildlife Contaminants of Potential Concern from Potential Waste Rock Pile Seepage Based on Test Piles Seepage Data

Parameter	Sample Size	Median	75th Percentile	Guideline, Benchmark, or Objective	Is the 75th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range	Is the Parameter a Contaminant of Potential Concern?
Physical/Ions							
pH	886	6.96	7.38	-	No		No
Bromide	873	0.888	4.01	-	No		No
Chloride	874	24.0	78.2	-	No		No
Fluoride	180	0.500	0.500	1	No		No
Potassium	915	45.2	81.1	-	No		No
Sulphate	873	324	705	1000	No		No
Nutrients							
Nitrite	874	0.579	2.24	10	Yes		No
Nitrate	874	334	896	-	No		No
Ammonia	736	0.395	3.40	-	No		No
Total Metals							
Aluminum	873	0.0509	0.180	5	No		No
Antimony	872	0.000926	0.00216	-	No		No
Arsenic	873	0.00252	0.00555	0.025	No		No
Boron	460	0.0956	0.163	5	No		No
Barium	871	0.0388	0.0579	-	No		No
Beryllium	458	0.0000795	0.000934	0.1	No		No
Cadmium	872	0.00106	0.00359	0.0051	No		No
Calcium	915	106	255	1000	No		No
Chromium	872	0.000348	0.00122	0.0049	No		No
Cobalt	873	0.0203	0.0791	0.05	Yes	0.0000400	Yes
Copper	872	0.0480	0.191	0.3	No		No
Iron	873	0.0482	0.135	5	No		No
Lead	871	0.00115	0.00279	0.1	No		No
Lithium	188	0.211	0.470	2.5	No		No
Magnesium	915	65.8	170	-	No		No
Manganese	873	1.07	3.51	0.2	Yes	0.00467	Yes
Mercury	81	0.00136	0.00230	0.003	No		No
Molybdenum	872	0.00910	0.0447	0.01	Yes	0.000130	Yes
Nickel	873	0.127	0.501	0.2	Yes	0.00112	Yes
Selenium	843	0.00772	0.0138	0.02	No		No
Silicon	549	7.25	10.4	-	No		No
Silver	802	0.000920	0.00446	-	No		No
Sodium	914	53.8	116	-	No		No
Strontium	761	1.03	2.51	-	No		No
Tin	872	0.00207	0.00475	-	No		No
Titanium	872	0.000680	0.00192	-	No		No
Thallium	873	0.000291	0.000735	-	No		No
Uranium	873	0.0870	0.237	0.01	Yes	0.0000300	Yes
Vanadium	871	0.000440	0.00128	0.1	No		No
Zinc	873	0.0370	0.150	50	No		No

Notes:

Gray shading indicates exceedance of widlife water quality guideline.

Hashed cells indicate no further assessment ins necessary for the parameter.

Orange shading indicates parameter is a considered a final contamimants of potential concern.

All concentrations are in mg/L.

Table B-15. Selection of Drinking Water Contaminants of Potential Concern from Potential Waste Rock Pile Seepage Based on Test Piles Seepage Data

Parameter	Sample Size	Median	75th Percentile	Guideline, Benchmark, or Objective	Is the 75th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range	Is the Parameter a Contaminant of Potential Concern?
Physical/Ions							
pH	886	6.96	7.38	6.5-8.5	No		No
Bromide	873	0.888	4.01	-	No		No
Chloride	874	24.0	78.2	250	No		No
Fluoride	180	0.500	0.500	1.5	No		No
Potassium	915	45.2	81.1	-	No		No
Sulphate	873	324	705	500	Yes	2.50	Yes
Nutrients							
Nitrite	874	0.579	2.24	1	Yes	0.00200	Yes
Nitrate	874	334	896	10	Yes	0.0152	Yes
Ammonia	736	0.395	3.40	-	No		No
Total Metals							
Aluminum	873	0.0509	0.180	0.1[a]	Yes	0.00620	No
Antimony	872	0.000926	0.00216	0.006	No		No
Arsenic	873	0.00252	0.00555	0.005	Yes	0.00220	Yes
Boron	460	0.0956	0.163	5	No		No
Barium	871	0.0388	0.0579	1	No		No
Beryllium	458	0.0000795	0.00093425	-	No		No
Cadmium	872	0.00106	0.00359	0.005	No		No
Calcium	915	106	255	-	No		No
Chromium	872	0.000348	0.00122	0.05	No		No
Cobalt	873	0.0203	0.0791	-	No		No
Copper	872	0.0480	0.191	1	No		No
Iron	873	0.0482	0.135	0.3	No		No
Lead	871	0.00115	0.0027895	0.01	No		No
Lithium	188	0.211	0.470	-	No		No
Magnesium	915	65.8	170	-	No		No
Manganese	873	1.07	3.51	0.05	Yes	0.00467	Yes
Mercury	81	0.00136	0.00230	0.001	Yes	0.0000100	Yes
Molybdenum	872	0.00910	0.0447	0.25	No		No
Nickel	873	0.127	0.501	-	No		No
Selenium	843	0.00772	0.0138	0.01	Yes	0.0000400	Yes
Silicon	549	7.25	10.4	-	No		No
Silver	802	0.000920	0.00446	-	No		No
Sodium	914	53.8	116	-	No		No
Strontium	761	1.03	2.51	-	No		No
Tin	872	0.00207	0.00475	-	No		No
Titanium	872	0.000680	0.00192	-	No		No
Thallium	873	0.000291	0.000735	0.0017	No		No
Uranium	873	0.0870	0.237	0.02	Yes	0.0000300	Yes
Vanadium	871	0.000440	0.00128		No		No
Zinc	873	0.0370	0.150	5	No		No

Notes:

Gray shading indicates exceedance of drinking water quality guideline.

Hashed cells indicate no further assessment ins necessary for the parameter.

Orange shading indicates parameter is a considered a final contamimants of potential concern.

All concentrations are in mg/L.

[a] *Aesthetic objective.*

Table B-16. Selection of Aquatic Life Contaminants of Potential Concern from North Inlet SNP 1645-13 Station during the Ice-cover Season

Parameters	Guideline, Benchmark, or Objective	Sample Size	Mean Water Quality at SNP 1645-13 Station	95th percentile (undiluted) Water Quality at SNP 1645-13 Station	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range (Ice-cover)	Is the Parameter a Contaminant of Potential Concern?
Physical Parameters							
pH (pH units)	6.5 to 9.0	617	8.35	9.62	No		No
Nutrients							
Nitrate (as N)	30.1	392	3.77	8.50	No		No
Nitrite (as N)	0.06	394	0.103	0.298	Yes	0.00200	Yes
Ammonia	4.73	398	0.904	3.26	No		No
Major Anions							
Chloride	230	25	71.1	83.0	No		No
Fluoride	0.12	391	0.116	0.140	Yes	0.0300	Yes
Sulphate	76.6	191	19.7	64.7	No		No
Total Metals							
Aluminum	3.85	394	0.468	0.931	No		No
Antimony	0.02	369	0.000535	0.000960	No		No
Arsenic	0.05	198	0.00391	0.00826	No		No
Barium	-	394	0.132	0.366	No		No
Beryllium	-	394	0.000251	0.000500	No		No
Boron	1.5	394	0.0291	0.0400	No		No
Cadmium	0.00010	381	0.0000564	0.000100	No		No
Chromium	0.001	394	0.00237	0.00777	Yes	0.0000600	Yes
Cobalt	-	371	0.000697	0.00154	No		No
Copper	0.0020	394	0.00272	0.0118	Yes	0.000800	Yes
Iron	0.300	394	0.438	0.898	Yes	0.00500	Yes
Lead	0.00100	394	0.000500	0.00154	Yes	0.00000700	Yes
Lithium	-	198	0.0148	0.0168	No		No
Manganese	-	394	0.0881	0.313	No		No
Mercury	0.000026	383	0.0000461	0.000100	Yes	0.0000100	Yes
Molybdenum	0.073	394	0.0287	0.0574	No		No
Nickel	0.025	394	0.0121	0.0251	Yes	0.00110	Yes
Potassium (as KCl)	70	394	11.9	22.0	No		No
Selenium	0.001	394	0.000991	0.00447	Yes	0.0000400	Yes
Silver	0.000100	394	0.000104	0.000200	Yes	0.00000500	Yes
Strontium	-	394	0.496	0.642	No		No
Thallium	0.000800	394	0.0000499	0.000200	No		No
Uranium	0.015	369	0.0105	0.0266	Yes	0.0000300	Yes
Vanadium	0.03	394	0.00190	0.00411	No		No
Zinc	0.03	394	0.00530	0.0180	No		No
Dissolved Metals							
Aluminum	3.85	257	0.141	0.254	No		No
Calcium	-	-	-	-	No		No
Cadmium	0.000234	-	-	-	No		No
Iron	-	257	0.0569	0.137	No		No
Organics							
1,2-Dichlorobenzene	0.00070	-	-	-	No		No
Acenaphthene	0.0058	-	-	-	No		No
Acenaphtylene	-	-	-	-	No		No
Aliphatic nonchlorinated	-	-	-	-	No		No
Anthracene PAHs	0.0000120	-	-	-	No		No
Ben(a)anthracene PAHs	0.0000180	-	-	-	No		No
Benzene	0.37	34	0.000200	0.000200	No		No
Benzo(a)pyrene	0.0000150	-	-	-	No		No
Benzo(b)fluoranthene	-	-	-	-	No		No
Benzo(k)fluoranthene	-	-	-	-	No		No
Chrysene	-	-	-	-	No		No
Dibenz(a,h)anthracene	-	-	-	-	No		No
Diethylene glycol	-	-	-	-	No		No
Ethylbenzene	0.09	34	0.00020	0.00020	No		No
Ethylene glycol	192	-	-	-	No		No
Fluoranthene	0.000040	-	-	-	No		No
Fluorene	0.003	-	-	-	No		No
Indeno(1,2,3-c,d)pyrene PAHs	-	-	-	-	No		No
Methyl tertiary-butyl ether (MTBE)	10	-	-	-	No		No
Naphthalene PAHs	0.0011	-	-	-	No		No
Phenanthrene PAHs	4.00E-04	-	-	-	No		No
Propylene glycol	500	-	-	-	No		No
Pyrene PAHs	0.0000250	-	-	-	No		No
Quinoline PAHs	0.0034	-	-	-	No		No
Styrene	0.072	-	-	-	No		No
Toluene	0.002	34	0.000200	0.000200	No		No
Xylene	-	34	0.000200	0.000200	No		No

Notes:

Gray shading indicates exceedance of aquatic life water quality guideline.

Hashed cells indicate no further assessment ins necessary for the parameter.

Orange shading indicates parameter is a considered a final contamimants of potential concern.

All concentrations are in mg/L.

Table B-17. Selection of Aquatic Life Contaminants of Potential Concern from Potential Seepage from Processed Kimberlite Containment Area, Represented by SNP 1645-16 Station, during the Ice-cover Season

Parameters	Guideline, Benchmark, or Objective	Sample Size	95th percentile (diluted) Water Quality at SNP 1645-16 Station	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range (Ice-cover)	Is the Parameter a Contaminant of Potential Concern?
Physical Parameters						
pH (pH units)	6.5 to 9.0	235	8.80	No		No
Nutrients						
Nitrate (as N)	30.1	137	20.2	No		No
Nitrite (as N)	0.06	137	1.79	Yes	0.00200	Yes
Ammonia	4.73	136	2.37	No		No
Major Anions						
Chloride	230	6	34.1	No		No
Fluoride	0.12	136	0.105	No		No
Sulphate	101	52	165	Yes	2.50	Yes
Total Metals						
Aluminum	27.9	135	1.28	No		No
Antimony	0.02	129	0.00431	No		No
Arsenic	0.05	84	0.00264	No		No
Barium	-	135	0.371	No		No
Beryllium	-	135	0.000300	No		No
Boron	1.5	135	0.0341	No		No
Cadmium	0.00010	129	0.000403	Yes	0.00000500	Yes
Chromium	0.001	135	0.0408	Yes	0.0000600	Yes
Cobalt	-	135	0.00576	No		No
Copper	0.0020	135	0.00570	Yes	0.000800	Yes
Iron	0.30000	135	3.40	Yes	0.00500	Yes
Lead	0.0010	135	0.000863	No		No
Lithium	-	51	0.00940	No		No
Manganese	-	135	0.0815	No		No
Mercury	0.000026	127	0.0000550	Yes	0.0000100	Yes
Molybdenum	0.073	135	0.263	Yes	0.0000900	Yes
Nickel	0.025	135	0.104	Yes	0.00110	Yes
Potassium (as KCl)	70	135	86.9	Yes	0.670	Yes
Selenium	0.001	135	0.00188	Yes	0.0000400	Yes
Silver	0.000100	135	0.000103	Yes	0.00000500	Yes
Strontium	-	135	0.720	No		No
Thallium	0.000800	135	0.000151	No		No
Uranium	0.015	129	0.00684	No		No
Vanadium	0.03	135	0.00890	No		No
Zinc	0.03	135	0.0186	No		No
Dissolved Metals						
Aluminum	27.9	135	0.0905	No		No
Calcium	-	-	-	No		No
Cadmium	0.000295	-	-	No		No
Iron	-	134	0.394	No		No
Organics						
1,2-Dichlorobenzene	0.00070	-	-	No		No
Acenaphthene	0.0058	-	-	No		No
Acenaphtylene	-	-	-	No		No
Aliphatic nonchlorinated	-	-	-	No		No
Anthracene PAHs	0.0000120	-	-	No		No
Ben(a)anthracene PAHs	0.0000180	-	-	No		No
Benzene	0.37	-	-	No		No
Benzo(a)pyrene	0.0000150	-	-	No		No
Benzo(b)fluoranthene	-	-	-	No		No
Benzo(k)fluoranthene	-	-	-	No		No
Chrysene	-	-	-	No		No
Dibenz(a,h)anthracene	-	-	-	No		No
Diethylene glycol	-	-	-	No		No
Ethylbenzene	0.09	-	-	No		No
Ethylene glycol	192	-	-	No		No
Fluoranthene	0.000040	-	-	No		No
Fluorene	0.003	-	-	No		No
Indeno(1,2,3-c,d)pyrene PAHs	-	-	-	No		No
Methyl tertiary-butyl ether (MTBE)	10	-	-	No		No
Naphthalene PAHs	0.0011	-	-	No		No
Phenanthrene PAHs	4.00E-04	-	-	No		No
Propylene glycol	500	-	-	No		No
Pyrene PAHs	0.0000250	-	-	No		No
Quinoline PAHs	0.0034	-	-	No		No
Styrene	0.072	-	-	No		No
Toluene	0.002	-	-	No		No
Xylene	-	-	-	No		No

Notes:

Gray shading indicates exceedance of aquatic life water quality guideline.

Hashed cells indicate no further assessment ins necessary for the parameter.

Orange shading indicates parameter is a considered a final contamimants of potential concern.

All concentrations are in mg/L.

Mean Water Quality at SNP 1645-16 Station during ice-cover season is provided in Tables B-21 and B-25.

Table B-18. Selection of Aquatic Life Contaminants of Potential Concern from North Inlet SNP 1645-13 Station during the Open-water Season

Parameters	Guideline, Benchmark, or Objective	Sample Size	Mean Water Quality at SNP 1645-13 Station	95th percentile (undiluted) Water Quality at SNP 1645-13 Station	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range (Open-water)	Is the Parameter a Contaminant of Potential Concern?
Physical Parameters							
pH (pH units)	6.5 to 9.0	52	8.38	9.65	No		No
Nutrients							
Nitrate (as N)	30.1	33	3.77	8.27	No		No
Nitrite (as N)	0.06	33	0.123	0.348	Yes	0.00200	Yes
Ammonia	4.73	33	0.252	0.928	No		No
Major Anions							
Chloride	230	3	75.7	76.6	No		No
Fluoride	0.12	32	0.110	0.137	Yes	0.0300	Yes
Sulphate	81.4	20	29.7	72.9	No		No
Total Metals							
Aluminum	5.80	39	0.381	0.548	No		No
Antimony	0.02	36	0.000808	0.00250	No		No
Arsenic	0.05	24	0.00285	0.00525	No		No
Barium	-	39	0.106	0.310	No		No
Beryllium	-	39	0.000310	0.000500	No		No
Boron	1.5	39	0.0257	0.0500	No		No
Cadmium	0.00010	38	0.0000614	0.000100	No		No
Chromium	0.001	39	0.00136	0.00596	Yes	0.0000600	Yes
Cobalt	-	36	0.000524	0.000925	No		No
Copper	0.0020	39	0.00208	0.00470	Yes	0.000600	Yes
Iron	0.30000	39	0.222	0.269	No		No
Lead	0.00100	39	0.000244	0.000410	No		No
Lithium	-	15	0.0185	0.0313	No		No
Manganese	-	39	0.0414	0.114	No		No
Mercury	0.000026	30	0.0000484	0.000100	Yes	0.0000100	Yes
Molybdenum	0.073	39	0.0358	0.0663	No		No
Nickel	0.025	39	0.00831	0.0157	No		No
Potassium (as KCl)	70	39	13.5	23.6	No		No
Selenium	0.001	39	0.000854	0.00328	Yes	0.0000400	Yes
Silver	0.000100	39	0.000125	0.000200	Yes	0.00000500	Yes
Strontium	-	39	0.437	0.628	No		No
Thallium	0.000800	39	0.0000372	0.0000500	No		No
Uranium	0.015	36	0.0124	0.0239	Yes	0.0000290	Yes
Vanadium	0.03	39	0.00528	0.00311	No		No
Zinc	0.03	39	0.0123	0.0992	Yes	0.00204	Yes
Dissolved Metals	-						
Aluminum	5.80	23	0.201	0.349	No		No
Calcium	-	NA	NA	NA	No		No
Cadmium	0.000246	NA	NA	NA	No		No
Iron	-	23	0.00894	0.0259	No		No
Organics							
1,2-Dichlorobenzene	0.00070	-	NA	NA	No		No
Acenaphthene	0.0058	-	NA	NA	No		No
Acenaphtylene	-	-	-	-	No		No
Aliphatic nonchlorinated	-	-	-	-	No		No
Anthracene PAHs	1.20E-05	-	NA	NA	No		No
Ben(a)anthracene PAHs	1.80E-05	-	NA	NA	No		No
Benzene	0.37	-	NA	NA	No		No
Benzo(a)pyrene	1.50E-05	-	NA	NA	No		No
Benzo(b)fluoranthene	-	-	-	-	No		No
Benzo(k)fluoranthene	-	-	NA	NA	No		No
Chrysene	-	-	-	-	No		No
Dibenz(a,h)anthracene	-	-	-	-	No		No
Diethylene glycol	-	-	-	-	No		No
Ethylbenzene	0.09	-	NA	NA	No		No
Ethylene glycol	192	-	-	-	No		No
Fluoranthene	4.00E-05	-	NA	NA	No		No
Fluorene	0.003	-	NA	NA	No		No
Indeno(1,2,3-c,d)pyrene PAHs	-	-	-	-	No		No
Methyl tertiary-butyl ether (MTBE)	10	-	-	-	No		No
Naphthalene PAHs	0.0011	-	NA	NA	No		No
Phenanthrene PAHs	4.00E-04	-	NA	NA	No		No
Propylene glycol	500	-	NA	NA	No		No
Pyrene PAHs	2.50E-05	-	NA	NA	No		No
Quinoline PAHs	0.0034	-	NA	NA	No		No
Styrene	0.072	-	NA	NA	No		No
Toluene	0.002	-	NA	NA	No		No
Xylene	-	-	NA	NA	No		No

Notes:

Gray shading indicates exceedance of aquatic life guideline.

Hashed cells indicate no further assessment ins necessary for the parameter.

Orange shading indicates parameter is a considered a final contamimants of potential concern.

All concentrations are in mg/L.

Table B-19. Selection of Aquatic Life Contaminants of Potential Concern from Potential Seepage from Processed Kimberlite Containment Area, Represented by SNP 1645-16 Station, during the Open-water Season

Parameters	Guideline, Benchmark, or Objective	Sample Size	95th percentile (diluted) Water Quality at SNP 1645-16 Station	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range (Open-water)	Is the Parameter a Contaminant of Potential Concern?
Physical Parameters						
pH (pH units)	6.5 to 9.0	22	8.10	No		No
Nutrients						
Nitrate (as N)	30.1	12	4.14	No		No
Nitrite (as N)	0.06	12	0.175	Yes	0.00200	Yes
Ammonia	4.73	12	0.466	No		No
Major Anions						
Chloride	230	1	38.8	No		No
Fluoride	0.12	12	0.0836	No		No
Sulphate	NA	9	37.5	Yes	2.10	Yes
Total Metals						
Aluminum	24.8	12	0.277	No		No
Antimony	0.02	11	0.00126	No		No
Arsenic	0.05	9	0.00272	No		No
Barium	-	12	0.156	No		No
Beryllium	-	12	0.000300	No		No
Boron	1.5	12	0.0275	No		No
Cadmium	0.00010	11	0.0000500	Yes	0	Yes
Chromium	0.001	12	0.00301	Yes	0.0000600	Yes
Cobalt	-	12	0.000483	No		No
Copper	0.0020	12	0.00265	Yes	0.000600	Yes
Iron	0.30000	12	0.139	Yes	0.00760	Yes
Lead	0.0010	12	0.000208	No		No
Lithium	-	3	0.0163	No		No
Manganese	-	12	0.0591	No		No
Mercury	0.000026	11	0.0000550	Yes	0.0000100	Yes
Molybdenum	0.073	12	0.0332	Yes	0.000130	Yes
Nickel	0.025	12	0.00841	Yes	0.00112	Yes
Potassium (as KCl)	70	12	12.1	No		No
Selenium	0.001	12	0.00166	Yes	0.0000400	Yes
Silver	0.000100	12	0.000103	Yes	0.00000500	Yes
Strontium	-	12	0.318	No		No
Thallium	0.000800	12	0.0000260	No		No
Uranium	0.015	11	0.0120	No		No
Vanadium	0.03	12	0.00161	No		No
Zinc	0.03	12	0.0506	Yes	0.00204	Yes
Dissolved Metals						
Aluminum	24.8	12	0.349	No		No
Calcium	-	NA	NA	No		No
Cadmium	0.000352	NA	NA	No		No
Iron	-	12	0.0259	No		No
Organics						
1,2-Dichlorobenzene	0.00070	-	NA	No		No
Acenaphthene	0.0058	-	NA	No		No
Acenaphtylene	-	-	-	No		No
Aliphatic nonchlorinated	-	-	-	No		No
Anthracene PAHs	1.20E-05	-	NA	No		No
Ben(a)anthracene PAHs	1.80E-05	-	NA	No		No
Benzene	0.37	-	NA	No		No
Benzo(a)pyrene	1.50E-05	-	NA	No		No
Benzo(b)fluoranthene	-	-	-	No		No
Benzo(k)fluoranthene	-	-	NA	No		No
Chrysene	-	-	-	No		No
Dibenz(a,h)anthracene	-	-	-	No		No
Diethylene glycol	-	-	-	No		No
Ethylbenzene	0.09	-	NA	No		No
Ethylene glycol	192	-	-	No		No
Fluoranthene	4.00E-05	-	NA	No		No
Fluorene	0.003	-	NA	No		No
Indeno(1,2,3-c,d)pyrene PAHs	-	-	-	No		No
Methyl tertiary-butyl ether (MTBE)	10	-	-	No		No
Naphthalene PAHs	0.0011	-	NA	No		No
Phenanthrene PAHs	4.00E-04	-	NA	No		No
Propylene glycol	500	-	NA	No		No
Pyrene PAHs	2.50E-05	-	NA	No		No
Quinoline PAHs	0.0034	-	NA	No		No
Styrene	0.072	-	NA	No		No
Toluene	0.002	-	NA	No		No
Xylene	-	-	NA	No		No

Notes:

Gray shading indicates exceedance of aquatic life guideline.

Hashed cells indicate no further assessment ins necessary for the parameter.

Orange shading indicates parameter is a considered a final contamimants of potential concern.

All concentrations are in mg/L.

Mean Water Quality at SNP 1645-16 Station during open-water season is provided in Tables B-23 and B-27.

Table B-20. Selection of Wildlife Contaminants of Potential Concern from North Inlet SNP 1645-13 Station during the Ice-cover Season

Parameters	Guideline, Benchmark, or Objective	Sample Size	Mean Water Quality at SNP 1645-13 Station	95th percentile (undiluted) Water Quality at SNP 1645-13 Station	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range (Ice-cover)	Is the Parameter a Contaminant of Potential Concern?
Physical Parameters							
pH (pH units)	-	617	8.35	9.62	No		No
Nutrients							
Nitrate (as N)	-	392	3.77	8.50	No		No
Nitrite (as N)	10	394	0.103	0.298	No		No
Ammonia	-	398	0.904	3.26	No		No
Major Anions							
Bromide	-	-	-	-	No		No
Chloride	-	25	71.12	83.0	No		No
Fluoride	1	391	0.116	0.140	No		No
Sulphate	1,000	191	19.7	64.7	No		No
Total Metals							
Aluminum	5	394	0.468	0.931	No		No
Antimony	-	369	0.000535	0.000960	No		No
Arsenic	0.025	198	0.00391	0.00826	No		No
Barium	-	394	0.132	0.366	No		No
Beryllium	0.1	394	0.000251	0.000500	No		No
Boron	5	394	0.0291	0.0400	No		No
Cadmium	0.08	381	0.0000564	0.000100	No		No
Chromium	0.05	394	0.00237	0.00777	No		No
Cobalt	0.05	371	0.000697	0.00154	No		No
Copper	-	394	0.00272	0.0118	No		No
Iron	-	394	0.438	0.898	No		No
Lead	0.1	394	0.000500	0.00154	No		No
Lithium	-	198	0.0148	0.0168	No		No
Manganese	-	394	0.0881	0.313	No		No
Mercury	0.003	383	0.0000461	0.000100	No		No
Molybdenum	0.5	394	0.0287	0.0574	No		No
Nickel	0.2	394	0.0121	0.0251	No		No
Potassium (as KCl)	-	394	11.9	22.0	No		No
Selenium	0.02	394	0.000991	0.00447	No		No
Silver	-	394	0.000104	0.000200	No		No
Strontium	-	394	0.496	0.642	No		No
Thallium	-	394	0.0000499	0.000200	No		No
Uranium	0.2	369	0.0105	0.0266	No		No
Vanadium	0.1	394	0.00190	0.00411	No		No
Zinc	50	394	0.00530	0.0180	No		No
Dissolved Metals							
Aluminum	-	257	0.141	0.254	No		No
Calcium	-	-	-	-	No		No
Cadmium	-	-	-	-	No		No
Iron	-	257	0.0569	0.137	No		No
Organics							
1,2-Dichlorobenzene	-	-	-	-	No		No
Acenaphthene	-	-	-	-	No		No
Acenaphtylene	-	-	-	-	No		No
Aliphatic nonchlorinated	-	-	-	-	No		No
Anthracene PAHs	-	-	-	-	No		No
Ben(a)anthracene PAHs	-	-	-	-	No		No
Benzene	-	34	0.000200	0.000200	No		No
Benzo(a)pyrene	-	-	-	-	No		No
Benzo(b)fluoranthene	-	-	-	-	No		No
Benzo(k)fluoranthene	-	-	-	-	No		No
Chrysene	-	-	-	-	No		No
Dibenz(a,h)anthracene	-	-	-	-	No		No
Diethylene glycol	-	-	-	-	No		No
Ethylbenzene	0.0024	34	0.000200	0.000200	No		No
Ethylene glycol	-	-	-	-	No		No
Fluoranthene	-	-	-	-	No		No
Fluorene	-	-	-	-	No		No
Indeno(1,2,3-c,d)pyrene PAHs	-	-	-	-	No		No
Methyl tertiary-butyl ether (MTBE)	-	-	-	-	No		No
Naphthalene PAHs	-	-	-	-	No		No
Phenanthrene PAHs	-	-	-	-	No		No
Propylene glycol	-	-	-	-	No		No
Pyrene PAHs	-	-	-	-	No		No
Quinoline PAHs	-	-	-	-	No		No
Styrene	-	-	-	-	No		No
Toluene	0.024	34	0.000200	0.000200	No		No
Xylene	-	34	0.000200	0.000200	No		No

Notes:

Hashed cells indicate no further assessment ins necessary for the parameter.

Orange shading indicates parameter is a considered a final contamimants of potential concern.

All concentrations are in mg/L.

Table B-21. Selection of Wildlife Contaminants of Potential Concern from Potential Seepage from Processed Kimberlite Containment Area, Represented by SNP 1645-16 Station, during the Ice-cover Season

Parameters	Guideline, Benchmark, or Objective	Sample Size	Mean Water Quality at SNP 1645-16 Station	95th percentile (undiluted) Water Quality at SNP 1645-16 Station	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range (Ice-cover)	Is the Parameter a Contaminant of Potential Concern?
Physical Parameters							
pH (pH units)	-	235	8.77	9.75	No		No
Nutrients							
Nitrate (as N)	-	137	12.3	40.5	No		No
Nitrite (as N)	10	137	1.14	3.59	No		No
Ammonia	-	136	1.79	4.72	No		No
Major Anions							
Bromide	-	-	-	-	No		No
Chloride	-	6	49.4	67.2	No		No
Fluoride	1	136	0.109	0.18	No		No
Sulphate	1,000	52	146	327.50	No		No
Total Metals							
Aluminum	5	135	0.674	2.55	No		No
Antimony	-	129	0.00449	0.00860	No		No
Arsenic	0.025	84	0.00302	0.00506	No		No
Barium	-	135	0.274	0.740	No		No
Beryllium	0.1	135	0.000324	0.000500	No		No
Boron	5	135	0.0329	0.0632	No		No
Cadmium	0.08	129	0.000289	0.000800	No		No
Chromium	0.05	135	0.0166	0.0816	Yes	0.0000600	Yes
Cobalt	0.05	135	0.00272	0.0115	No		No
Copper	-	135	0.00301	0.0106	No		No
Iron	-	135	1.71	6.80	No		No
Lead	0.1	135	0.000506	0.00172	No		No
Lithium	-	51	0.00887	0.0173	No		No
Manganese	-	135	0.0471	0.161	No		No
Mercury	0.003	127	0.0000627	0.000100	No		No
Molybdenum	0.5	135	0.276	0.526	Yes	0.0000900	Yes
Nickel	0.2	135	0.0565	0.206	No	0.00110	Yes
Potassium (as KCl)	-	135	72.7	173	No		No
Selenium	0.02	135	0.00133	0.00372	No		No
Silver	-	135	0.000130	0.000200	No		No
Strontium	-	135	0.703	1.43	No		No
Thallium	-	135	0.0000627	0.000300	No		No
Uranium	0.2	129	0.00344	0.0136	No		No
Vanadium	0.1	135	0.00427	0.0177	No		No
Zinc	50	135	0.0110	0.0356	No		No
Dissolved Metals							
Aluminum	-	135	0.149	0.0905	No		No
Calcium	-	-	-	-	No		No
Cadmium	-	-	-	-	No		No
Iron	-	134	0.0636	0.394	No		No
Organics							
1,2-Dichlorobenzene	-	-	-	-	No		No
Ace-phthene	-	-	-	-	No		No
Ace-phtylene	-	-	-	-	No		No
Aliphatic nonchlori-ted	-	-	-	-	No		No
Anthracene PAHs	-	-	-	-	No		No
Ben(a)anthracene PAHs	-	-	-	-	No		No
Benzene	-	-	-	-	No		No
Benzo(a)pyrene	-	-	-	-	No		No
Benzo(b)fluoranthene	-	-	-	-	No		No
Benzo(k)fluoranthene	-	-	-	-	No		No
Chrysene	-	-	-	-	No		No
Dibenz(a,h)anthracene	-	-	-	-	No		No
Diethylene glycol	-	-	-	-	No		No
Ethylbenzene	0.0024	-	-	-	No		No
Ethylene glycol	-	-	-	-	No		No
Fluoranthene	-	-	-	-	No		No
Fluorene	-	-	-	-	No		No
Indeno(1,2,3-c,d)pyrene PAHs	-	-	-	-	No		No
Methyl tertiary-butyl ether (MTBE)	-	-	-	-	No		No
-phthalene PAHs	-	-	-	-	No		No
Phe-nthrene PAHs	-	-	-	-	No		No
Propylene glycol	-	-	-	-	No		No
Pyrene PAHs	-	-	-	-	No		No
Quinoline PAHs	-	-	-	-	No		No
Styrene	-	-	-	-	No		No
Toluene	0.024	-	-	-	No		No
Xylene	-	-	-	-	No		No

Notes:

Gray shading indicates exceedance of wildlife guideline.

Hashed cells indicate no further assessment ins necessary for the parameter.

Orange shading indicates parameter is a considered a final contamimants of potential concern.

All concentrations are in mg/L.

Table B-22. Selection of Wildlife Contaminants of Potential Concern from North Inlet SNP 1645-13 Station during the Open-water Season

Parameters	Guideline, Benchmark, or Objective	Sample Size	Mean Water Quality at SNP 1645-13 Station	95th percentile (undiluted) Water Quality at SNP 1645-13 Station	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range (Open-water)	Is the Parameter a Contaminant of Potential Concern?
Physical Parameters							
pH (pH units)	-	52	8.38	9.65	No		No
Nutrients							
Nitrate (as N)	-	33	3.77	8.27	No		No
Nitrite (as N)	10	33	0.123	0.348	No		No
Ammonia	-	33	0.252	0.928	No		No
Major Anions							
Bromide	-	-	-	-	-	-	-
Chloride	-	3	75.7	76.6	No		No
Fluoride	1	32	0.110	0.137	No		No
Sulphate	1,000	20	29.7	72.9	No		No
Total Metals							
Aluminum	5	39	0.381	0.548	No		No
Antimony	-	36	0.000808	0.00250	No		No
Arsenic	0.025	24	0.00285	0.00525	No		No
Barium	-	39	0.106	0.310	No		No
Beryllium	0.1	39	0.000310	0.000500	No		No
Boron	5	39	0.0257	0.0500	No		No
Cadmium	0.08	38	0.0000614	0.000100	No		No
Calcium	1000	NA	NA	NA	No		No
Chromium	0.05	39	0.00136	0.00596	No		No
Cobalt	0.05	36	0.000524	0.000925	No		No
Copper	-	39	0.00208	0.00470	No		No
Iron	-	39	0.222	0.269	No		No
Lead	0.1	39	0.000244	0.000410	No		No
Lithium	-	15	0.0185	0.0313	No		No
Manganese	-	39	0.0414	0.114	No		No
Mercury	0.003	30	0.0000484	0.000100	No		No
Molybdenum	0.5	39	0.0358	0.0663	No		No
Nickel	0.2	39	0.00831	0.0157	No		No
Potassium (as KCl)	-	39	13.5	23.6	No		No
Selenium	0.02	39	0.000854	0.00328	No		No
Silver	-	39	0.000125	0.000200	No		No
Strontium	-	39	0.437	0.628	No		No
Thallium	-	39	0.0000372	0.0000500	No		No
Uranium	0.2	36	0.0124	0.0239	No		No
Vanadium	0.1	39	0.00528	0.00311	No		No
Zinc	50	39	0.0123	0.0992	No		No
Dissolved Metals							
Aluminum	-	23	0.201	0.349	No		No
Calcium	-	-	-	-	No		No
Cadmium	-	-	-	-	No		No
Iron	-	23	0.00894	0.0259	No		No
Organics							
1,2-Dichlorobenzene	-	-	-	-	No		No
Acenaphthene	-	-	-	-	No		No
Acenaphtylene	-	-	-	-	No		No
Aliphatic nonchlorinated	-	-	-	-	No		No
Anthracene PAHs	-	-	-	-	No		No
Ben(a)anthracene PAHs	-	-	-	-	No		No
Benzene	-	-	-	-	No		No
Benzo(a)pyrene	-	-	-	-	No		No
Benzo(b)fluoranthene	-	-	-	-	No		No
Benzo(k)fluoranthene	-	-	-	-	No		No
Chrysene	-	-	-	-	No		No
Dibenz(a,h)anthracene	-	-	-	-	No		No
Diethylene glycol	-	-	-	-	No		No
Ethylbenzene	0.0024	-	-	-	No		No
Ethylene glycol	-	-	-	-	No		No
Fluoranthene	-	-	-	-	No		No
Fluorene	-	-	-	-	No		No
Indeno(1,2,3-c,d)pyrene PAHs	-	-	-	-	No		No
Methyl tertiary-butyl ether (MTBE)	-	-	-	-	No		No
Naphthalene PAHs	-	-	-	-	No		No
Phenanthrene PAHs	-	-	-	-	No		No
Propylene glycol	-	-	-	-	No		No
Pyrene PAHs	-	-	-	-	No		No
Quinoline PAHs	-	-	-	-	No		No
Styrene	-	-	-	-	No		No
Toluene	0.024	-	-	-	No		No
Xylene	-	-	-	-	No		No

Notes:

Hashed cells indicate no further assessment ins necessary for the parameter.

Orange shading indicates parameter is a considered a final contamimants of potential concern.

All concentrations are in mg/L.

Table B-23. Selection of Wildlife Contaminants of Potential Concern from Potential Seepage from Processed Kimberlite Containment Area, Represented by SNP 1645-16 Station, during the Open-water Season

Parameters	Guideline, Benchmark, or Objective	Sample Size	Mean Water Quality at SNP 1645-16 Station	95th percentile (undiluted) Water Quality at SNP 1645-16 Station	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range (Open-water)	Is the Parameter a Contaminant of Potential Concern?
Physical Parameters							
pH (pH units)	-	22	8.74	9.59	No		No
Nutrients							
Nitrate (as N)	-	12	11.3	32.2	No		No
Nitrite (as N)	10	12	0.870	2.24	No		No
Ammonia	-	12	0.713	2.19	No		No
Major Anions							
Bromide	-	-	-	-	-	-	-
Chloride	-	1	38.1	38.1	No		No
Fluoride	1	12	0.0974	0.154	No		No
Sulphate	1,000	9	191	391	No		No
Total Metals							
Aluminum	5	12	1.28	4.80	No		No
Antimony	-	11	0.00437	0.00808	No		No
Arsenic	0.025	9	0.00427	0.00777	No		No
Barium	-	12	0.270	0.523	No		No
Beryllium	0.1	12	0.000378	0.000500	No		No
Boron	5	12	0.0341	0.0541	No		No
Cadmium	0.08	11	0.000369	0.000710	No		No
Calcium	1000	NA	NA	NA	No		No
Chromium	0.05	12	0.0231	0.0961	Yes	0.0000600	Yes
Cobalt	0.05	12	0.00395	0.0159	No		No
Copper	-	12	0.00460	0.0136	No		No
Iron	-	12	2.89	12.2	No		No
Lead	0.1	12	0.000977	0.00330	No		No
Lithium	-	3	0.00542	0.00672	No		No
Manganese	-	12	0.0662	0.224	No		No
Mercury	0.003	11	0.0000565	0.000100	No		No
Molybdenum	0.5	12	0.275	0.411	No		No
Nickel	0.2	12	0.0761	0.271	No	0.00112	Yes
Potassium (as KCl)	-	12	77.3	161	No		No
Selenium	0.02	12	0.00151	0.00393	No		No
Silver	-	12	0.000151	0.000200	No		No
Strontium	-	12	0.720	1.24	No		No
Thallium	-	12	0.0000632	0.000156	No		No
Uranium	0.2	11	0.00373	0.00870	No		No
Vanadium	0.1	12	0.00720	0.0317	No		No
Zinc	50	12	0.0107	0.0297	No		No
Dissolved Metals							
Aluminum	-	12	0.0143	0.0615	No		No
Calcium	-	-	-	-	No		No
Cadmium	-	-	-	-	No		No
Iron	-	12	0.0868	0.451	No		No
Organics							
1,2-Dichlorobenzene	-	-	-	-	No		No
Acenaphthene	-	-	-	-	No		No
Acenaphtylene	-	-	-	-	No		No
Aliphatic nonchlorinated	-	-	-	-	No		No
Anthracene PAHs	-	-	-	-	No		No
Ben(a)anthracene PAHs	-	-	-	-	No		No
Benzene	-	-	-	-	No		No
Benzo(a)pyrene	-	-	-	-	No		No
Benzo(b)fluoranthene	-	-	-	-	No		No
Benzo(k)fluoranthene	-	-	-	-	No		No
Chrysene	-	-	-	-	No		No
Dibenz(a,h)anthracene	-	-	-	-	No		No
Diethylene glycol	-	-	-	-	No		No
Ethylbenzene	0.0024	-	-	-	No		No
Ethylene glycol	-	-	-	-	No		No
Fluoranthene	-	-	-	-	No		No
Fluorene	-	-	-	-	No		No
Indeno(1,2,3-c,d)pyrene PAHs	-	-	-	-	No		No
Methyl tertiary-butyl ether (MTBE)	-	-	-	-	No		No
Naphthalene PAHs	-	-	-	-	No		No
Phenanthrene PAHs	-	-	-	-	No		No
Propylene glycol	-	-	-	-	No		No
Pyrene PAHs	-	-	-	-	No		No
Quinoline PAHs	-	-	-	-	No		No
Styrene	-	-	-	-	No		No
Toluene	0.024	-	-	-	No		No
Xylene	-	-	-	-	No		No

Notes:

Gray shading indicates exceedance of wildlife guideline.

Hashed cells indicate no further assessment ins necessary for the parameter.

Orange shading indicates parameter is a considered a final contamimants of potential concern.

All concentrations are in mg/L.

Table B-24. Selection of Drinking Water Contaminants of Potential Concern from North Inlet SNP 1645-13 Station during the Ice-cover Season

Parameters	Guideline, Benchmark, or Objective	Sample Size	Mean Water Quality at SNP 1645-13 Station	95th percentile (undiluted) Water Quality at SNP 1645-13 Station	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range (Ice-cover)	Is the Parameter a Contaminant of Potential Concern?
Physical Parameters							
pH (pH units)	6.5 to 8.5	617	8.35	9.62	No		No
Nutrients							
Nitrate (as N)	10	392	3.77	8.50	No		No
Nitrite (as N)	1	394	0.103	0.298	No		No
Ammonia	-	398	0.904	3.26	No		No
Major Anions							
Bromide	-	-	-	-	No		
Chloride	250	25	71.1	83.0	No		No
Fluoride	1.5	391	0.116	0.140	No		No
Sulphate	500	191	19.7	64.7	No		No
Total Metals							
Aluminum	0.1[a]	394	0.468	0.931	Yes	0.00390	No
Antimony	0.006	369	0.000535	0.000960	No		No
Arsenic	0.005	198	0.00391	0.00826	Yes	0.000220	Yes
Barium	1	394	0.132	0.366	No		No
Beryllium	-	394	0.000251	0.000500	No		No
Boron	5.0	394	0.0291	0.0400	No		No
Cadmium	0.005	381	0.0000564	0.000100	No		No
Chromium	0.05	394	0.00237	0.00777	No		No
Cobalt	-	371	0.000697	0.00154	No		No
Copper	1	394	0.00272	0.0118	No		No
Iron	0.3	394	0.438	0.898	Yes	0.00500	Yes
Lead	0.01	394	0.000500	0.00154	No		No
Lithium	-	198	0.0148	0.0168	No		No
Manganese	0.05	394	0.0881	0.313	Yes	0.00195	Yes
Mercury	0.001	383	0.0000461	0.000100	No		No
Molybdenum	0.25	394	0.0287	0.0574	Yes		No
Nickel	-	394	0.0121	0.0251	No		No
Potassium (as KCl)	-	394	11.9	22.0	No		No
Selenium	0.01	394	0.000991	0.00447	No		No
Silver	-	394	0.000104	0.000200	No		No
Sodium	200	NA	NA	NA	No		No
Strontium	-	394	0.496	0.642	No		No
Thallium	0.0017	394	0.0000499	0.000200	No		No
Uranium	0.02	369	0.0105	0.0266	Yes	0.0000300	Yes
Vanadium	-	394	0.00190	0.00411	No		No
Zinc	5	394	0.00530	0.0180	No		No
Dissolved Metals							
Aluminum	-	257	0.141	0.254	No		No
Calcium	-	NA	NA	NA	No		No
Cadmium	-	NA	NA	NA	No		No
Iron	-	257	0.0569	0.137	No		No
Organics							
1,2-Dichlorobenzene	-	-	NA	NA	No		No
Acenaphthene	-	-	NA	NA	No		No
Acenaphtylene	-	-	-	-	No		No
Aliphatic nonchlorinated	-	-	-	-	No		No
Anthracene PAHs	-	-	NA	NA	No		No
Ben(a)anthracene PAHs	-	-	NA	NA	No		No
Benzene	0.005	34	0.000200	0.000200	No		No
Benzo(a)pyrene	1.00E-05	-	NA	NA	No		No
Benzo(b)fluoranthene	-	-	-	-	No		No
Benzo(k)fluoranthene	1.70	-	NA	NA	No		No
Chrysene	-	-	-	-	No		No
Dibenz(a,h)anthracene	-	-	-	-	No		No
Diethylene glycol	-	-	-	-	No		No
Ethylbenzene	0.0024	34	0.000200	0.000200	No		No
Ethylene glycol	-	-	-	-	No		No
Fluoranthene	-	-	NA	NA	No		No
Fluorene	-	-	NA	NA	No		No
Indeno(1,2,3-c,d)pyrene PAHs	-	-	-	-	No		No
Methyl tertiary-butyl ether (MTBE)	0.015	-	-	-	No		No
Naphthalene PAHs	-	-	NA	NA	No		No
Phenanthrene PAHs	-	-	NA	NA	No		No
Propylene glycol	-	-	NA	NA	No		No
Pyrene PAHs	-	-	NA	NA	No		No
Quinoline PAHs	-	-	NA	NA	No		No
Styrene	-	-	NA	NA	No		No
Toluene	0.024	34	0.000200	0.000200	No		No
Xylene	0.3	34	0.000200	0.000200	No		No

Notes:

Gray shading indicates exceedance of drinking water guideline.

Hashed cells indicate no further assessment ins necessary for the parameter.

Orange shading indicates parameter is a considered a final contamimants of potential concern.

All concentrations are in mg/L.

[a] *Aesthetic objective.*

Table B-25. Selection of Drinking Water Contaminants of Potential Concern from Potential Seepage from Processed Kimberlite Containment Area, Represented by SNP 1645-16 Station, during the Ice-cover Season

Parameters	Guideline, Benchmark, or Objective	Sample Size	Mean Water Quality at SNP 1645-16 Station	95th percentile (undiluted) Water Quality at SNP 1645-16 Station	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range (Ice-cover)	Is the Parameter a Contaminant of Potential Concern?
Physical Parameters							
pH (pH units)	6.5 to 8.5	235	8.77	9.75	No		No
Nutrients							
Nitrate (as N)	10	137	12.3	40.5	Yes	0.0152	Yes
Nitrite (as N)	1	137	1.14	3.59	Yes	0.00200	Yes
Ammonia	-	136	1.79	4.72	No		No
Major Anions							
Bromide	-	-	-	-	No		No
Chloride	250	6	49.4	67.2	No		No
Fluoride	1.5	136	0.109	0.180	No		No
Sulphate	500	52	146	328	No		No
Total Metals							
Aluminum	0.1[a]	135	0.674	2.55	Yes	0.00390	No
Antimony	0.006	129	0.00449	0.00860	Yes	0.0000200	Yes
Arsenic	0.005	84	0.00302	0.00506	Yes	0.000220	Yes
Barium	1	135	0.274	0.740	No		No
Beryllium	-	135	0.000324	0.000500	No		No
Boron	5.0	135	0.0329	0.0632	No		No
Cadmium	0.005	129	0.000289	0.000800	No		No
Chromium	0.05	135	0.0166	0.0816	Yes	0.0000600	Yes
Cobalt	-	135	0.00272	0.0115	No		No
Copper	1	135	0.00301	0.0106	No		No
Iron	0.3	135	1.71	6.80	Yes	0.00500	Yes
Lead	0.01	135	0.000506	0.00172	No		No
Lithium	-	51	0.00887	0.0173	No		No
Manganese	0.05	135	0.0471	0.161	Yes	0.00195	Yes
Mercury	0.001	127	0.0000627	0.000100	No		No
Molybdenum	0.25	135	0.276	0.526	Yes	0.0000900	Yes
Nickel	-	135	0.0565	0.206	No		No
Potassium (as KCl)	-	135	72.7	173	No		No
Selenium	0.01	135	0.00133	0.00372	No		No
Silver	-	135	0.000130	0.000200	No		No
Sodium	200	NA	NA	NA	No		No
Strontium	-	135	0.703	1.43	No		No
Thallium	0.0017	135	0.0000627	0.000300	No		No
Uranium	0.02	129	0.00344	0.0136	No		No
Vanadium	-	135	0.00427	0.0177	No		No
Zinc	5	135	0.0110	0.0356	No		No
Dissolved Metals							
Aluminum	-	135	0.149	0.0905	No		No
Calcium	-	NA	NA	NA	No		No
Cadmium	-	NA	NA	NA	No		No
Iron	-	134	0.0636	0.394	No		No
Organics							
1,2-Dichlorobenzene	-	-	NA	NA	No		No
Acenaphthene	-	-	NA	NA	No		No
Acenaphtylene	-	-	-	-	No		No
Aliphatic nonchlorinated	-	-	-	-	No		No
Anthracene PAHs	-	-	NA	NA	No		No
Ben(a)anthracene PAHs	-	-	NA	NA	No		No
Benzene	0.005	-	NA	NA	No		No
Benzo(a)pyrene	1.00E-05	-	NA	NA	No		No
Benzo(b)fluoranthene	-	-	-	-	No		No
Benzo(k)fluoranthene	1.70	-	NA	NA	No		No
Chrysene	-	-	-	-	No		No
Dibenz(a,h)anthracene	-	-	-	-	No		No
Diethylene glycol	-	-	-	-	No		No
Ethylbenzene	0.0024	-	NA	NA	No		No
Ethylene glycol	-	-	-	-	No		No
Fluoranthene	-	-	NA	NA	No		No
Fluorene	-	-	NA	NA	No		No
Indeno(1,2,3-c,d)pyrene PAHs	-	-	-	-	No		No
Methyl tertiary-butyl ether (MTBE)	0.015	-	-	-	No		No
Naphthalene PAHs	-	-	NA	NA	No		No
Phenanthrene PAHs	-	-	NA	NA	No		No
Propylene glycol	-	-	NA	NA	No		No
Pyrene PAHs	-	-	NA	NA	No		No
Quinoline PAHs	-	-	NA	NA	No		No
Styrene	-	-	NA	NA	No		No
Toluene	0.024	-	NA	NA	No		No
Xylene	0.3	-	NA	NA	No		No

Notes:

Gray shading indicates exceedance of drinking water guideline.

Hashed cells indicate no further assessment ins necessary for the parameter.

Orange shading indicates parameter is a considered a final contamimants of potential concern.

All concentrations are in mg/L.

[a] *Aesthetic objective.*

Table B-26. Selection of Drinking Water Contaminants of Potential Concern from North Inlet SNP 1645-13 Station during the Open-water Season

Parameters	Guideline, Benchmark, or Objective	Sample Size	Mean Water Quality at SNP 1645-13 Station	95th percentile (undiluted) Water Quality at SNP 1645-13 Station	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range (Open-water)	Is the Parameter a Contaminant of Potential Concern?
Physical Parameters							
pH (pH units)	6.5 to 8.5	52	8.38	9.65	No		No
Nutrients							
Nitrate (as N)	10	33	3.77	8.27	No		No
Nitrite (as N)	1	33	0.123	0.348	No		No
Ammonia	-	33	0.252	0.928	No		No
Major Anions							
Bromide		-	-	-	No		No
Chloride	250	3	75.7	76.6	No		No
Fluoride	1.5	32	0.110	0.137	No		No
Sulphate	500	20	29.7	72.9	No		No
Total Metals							
Aluminum	0.1[a]	39	0.381	0.548	Yes	0.00620	No
Antimony	0.006	36	0.000808	0.00250	No		No
Arsenic	0.005	24	0.00285	0.00525	Yes	0.000190	Yes
Barium	1	39	0.106	0.310	No		No
Beryllium	-	39	0.000310	0.000500	No		No
Boron	5.0	39	0.0257	0.0500	No		No
Cadmium	0.005	38	0.0000614	0.000100	No		No
Chromium	0.05	39	0.00136	0.00596	No		No
Cobalt	-	36	0.000524	0.000925	No		No
Copper	1	39	0.00208	0.00470	No		No
Iron	0.3	39	0.222	0.269	No		No
Lead	0.01	39	0.000244	0.000410	No		No
Lithium	-	15	0.0185	0.0313	No		No
Manganese	0.05	39	0.0414	0.114	Yes	0.00467	Yes
Mercury	0.001	30	0.0000484	0.000100	No		No
Molybdenum	0.25	39	0.0358	0.0663	Yes		No
Nickel	-	39	0.00831	0.0157	No		No
Potassium (as KCl)	-	39	13.5	23.6	No		No
Selenium	0.01	39	0.000854	0.00328	No		No
Silver	-	39	0.000125	0.000200	No		No
Sodium	200	NA	NA	NA	No		No
Strontium	-	39	0.437	0.628	No		No
Thallium	0.0017	39	0.0000372	0.0000500	No		No
Uranium	0.02	36	0.0124	0.0239	Yes	0.0000290	Yes
Vanadium	-	39	0.00528	0.00311	No		No
Zinc	5	39	0.0123	0.0992	No		No
Dissolved Metals							
Aluminum	-	23	0.201	0.349	No		No
Calcium	-	NA	NA	NA	No		No
Cadmium	-	NA	NA	NA	No		No
Iron	-	23	0.00894	0.0259	No		No
Organics							
1,2-Dichlorobenzene	-	-	NA	NA	No		No
Acenaphthene	-	-	NA	NA	No		No
Acenaphtylene	-	-	-	-	No		No
Aliphatic nonchlorinated	-	-	-	-	No		No
Anthracene PAHs	-	-	NA	NA	No		No
Ben(a)anthracene PAHs	-	-	NA	NA	No		No
Benzene	0.005	-	NA	NA	No		No
Benzo(a)pyrene	1.00E-05	-	NA	NA	No		No
Benzo(b)fluoranthene	-	-	-	-	No		No
Benzo(k)fluoranthene	1.70	-	NA	NA	No		No
Chrysene	-	-	-	-	No		No
Dibenz(a,h)anthracene	-	-	-	-	No		No
Diethylene glycol	-	-	-	-	No		No
Ethylbenzene	0.0024	-	NA	NA	No		No
Ethylene glycol	-	-	-	-	No		No
Fluoranthene	-	-	NA	NA	No		No
Fluorene	-	-	NA	NA	No		No
Indeno(1,2,3-c,d)pyrene PAHs	-	-	-	-	No		No
Methyl tertiary-butyl ether (MTBE)	0.015	-	-	-	No		No
Naphthalene PAHs	-	-	NA	NA	No		No
Phenanthrene PAHs	-	-	NA	NA	No		No
Propylene glycol	-	-	NA	NA	No		No
Pyrene PAHs	-	-	NA	NA	No		No
Quinoline PAHs	-	-	NA	NA	No		No
Styrene	-	-	NA	NA	No		No
Toluene	0.024	-	NA	NA	No		No
Xylene	0.3	-	NA	NA	No		No

Notes:

Gray shading indicates exceedance of drinking water guideline.

Hashed cells indicate no further assessment ins necessary for the parameter.

Orange shading indicates parameter is a considered a final contamimants of potential concern.

All concentrations are in mg/L.

[a] *Aesthetic objective.*

Table B-27. Selection of Drinking Water Contaminants of Potential Concern from Potential Seepage from Processed Kimberlite Containment Area, Represented by SNP 1645-16 Station, during the Open-water Season

Parameters	Guideline, Benchmark, or Objective	Sample Size	Mean Water Quality at SNP 1645-16 Station	95th percentile (undiluted) Water Quality at SNP 1645-16 Station	Is the 95th Percentile Concentration Greater than the Guideline?	Upper Limit of Normal Range (Open-water)	Is the Parameter a Contaminant of Potential Concern?
Physical Parameters							
pH (pH units)	6.5 to 8.5	22	8.74	9.59	No		No
Nutrients							
Nitrate (as N)	10	12	11.3	32.2	Yes	0.00200	Yes
Nitrite (as N)	1	12	0.870	2.24	Yes	0.00200	Yes
Ammonia	-	12	0.713	2.19	No		No
Major Anions							
Bromide	-	-	-	-	No		No
Chloride	250	1	38.1	38.1	No		No
Fluoride	1.5	12	0.0974	0.154	No		No
Sulphate	500	9	191	391	No		No
Total Metals							
Aluminum	0.1[a]	12	1.28	4.80	Yes	0.00620	No
Antimony	0.006	11	0.00437	0.00808	Yes	0.0000200	Yes
Arsenic	0.005	9	0.00427	0.00777	Yes	0.000190	Yes
Barium	1	12	0.270	0.523	No		No
Beryllium	-	12	0.000378	0.000500	No		No
Boron	5.0	12	0.0341	0.0541	No		No
Cadmium	0.005	11	0.000369	0.000710	No		No
Chromium	0.05	12	0.0231	0.0961	Yes	0.0000600	Yes
Cobalt	-	12	0.00395	0.0159	No		No
Copper	1	12	0.00460	0.0136	No		No
Iron	0.3	12	2.89	12.2	Yes	0.00760	Yes
Lead	0.01	12	0.000977	0.00330	No		No
Lithium	-	3	0.00542	0.00672	No		No
Manganese	0.05	12	0.0662	0.224	Yes	0.00467	Yes
Mercury	0.001	11	0.0000565	0.000100	No		No
Molybdenum	0.25	12	0.275	0.411	Yes	0.000130	Yes
Nickel	-	12	0.0761	0.271	No		No
Potassium (as KCl)	-	12	77.3	161	No		No
Selenium	0.01	12	0.00151	0.00393	No		No
Silver	-	12	0.000151	0.000200	No		No
Sodium	200	NA	NA	NA	No		No
Strontium	-	12	0.720	1.24	No		No
Thallium	0.0017	12	0.0000632	0.000156	No		No
Uranium	0.02	11	0.00373	0.00870	No		No
Vanadium	-	12	0.00720	0.0317	No		No
Zinc	5	12	0.0107	0.0297	No		No
Dissolved Metals							
Aluminum	-	12	0.0143	0.0615	No		No
Calcium	-	NA	NA	NA	No		No
Cadmium	-	NA	NA	NA	No		No
Iron	-	12	0.0868	0.451	No		No
Organics							
1,2-Dichlorobenzene	-	-	NA	NA	No		No
Acenaphthene	-	-	NA	NA	No		No
Acenaphtylene	-	-	-	-	No		No
Aliphatic nonchlorinated	-	-	-	-	No		No
Anthracene PAHs	-	-	NA	NA	No		No
Ben(a)anthracene PAHs	-	-	NA	NA	No		No
Benzene	0.005	-	NA	NA	No		No
Benzo(a)pyrene	1.00E-05	-	NA	NA	No		No
Benzo(b)fluoranthene	-	-	-	-	No		No
Benzo(k)fluoranthene	1.70	-	NA	NA	No		No
Chrysene	-	-	-	-	No		No
Dibenz(a,h)anthracene	-	-	-	-	No		No
Diethylene glycol	-	-	-	-	No		No
Ethylbenzene	0.0024	-	NA	NA	No		No
Ethylene glycol	-	-	-	-	No		No
Fluoranthene	-	-	NA	NA	No		No
Fluorene	-	-	NA	NA	No		No
Indeno(1,2,3-c,d)pyrene PAHs	-	-	-	-	No		No
Methyl tertiary-butyl ether (MTBE)	0.015	-	-	-	No		No
Naphthalene PAHs	-	-	NA	NA	No		No
Phenanthrene PAHs	-	-	NA	NA	No		No
Propylene glycol	-	-	NA	NA	No		No
Pyrene PAHs	-	-	NA	NA	No		No
Quinoline PAHs	-	-	NA	NA	No		No
Styrene	-	-	NA	NA	No		No
Toluene	0.024	-	NA	NA	No		No
Xylene	0.3	-	NA	NA	No		No

Notes:

Gray shading indicates exceedance of drinking water guideline.

Hashed cells indicate no further assessment ins necessary for the parameter.

Orange shading indicates parameter is a considered a final contamimants of potential concern.

All concentrations are in mg/L.

[a] *Aesthetic objective.*

Appendix C

Selection of Contaminants of Potential Concern in Fish

Table C-1. Selection of Contaminants of Potential Concern in Fish Tissue Residue from Slimy Sculpin Collected in 2007 for Protection of Wildlife Receptors

Parameter	Mean	Maximum	Tissue Residue Guideline for Protection of Wildlife Consumers	Is the Maximum Fish Tissue Concentrations Greater than the Tissue Residue Guidelines?	Upper Limit of Normal Range (2007)	Is the Parameter a Contaminant of Potential Concern?
Mercury	0.143	0.440	0.033	Yes	0.085	Yes
Selenium	0.517	0.710	1	No		No

Notes:
Sample size for mercury and selenium fish tissue was n = 15.
Hashed cells indicate no further assessment is necessary for the parameter.
Gray shading indicates selection of COPCs due to exceedance of criteria.

Table C-2. Selection of Contaminants of Potential Concern in Fish Tissue Residue from Slimy Sculpin Collected in 2010 and 2013 for Protection of Wildlife Receptors

Parameter	Mean	Maximum	Tissue Residue Guideline for Protection of Wildlife Consumers	Is the Maximum Fish Tissue Concentrations Greater than the Tissue Residue Guidelines?	Upper Limit of Normal Range (2010-2013)	Is the Parameter a Contaminant of Potential Concern?
Mercury	0.016	0.032	0.033	No		No
Selenium	0.261	0.361	1	No		No

Notes:
Sample size for mercury fish tissue was n = 39 and for selenium fish tissue was n = 40.
Hashed cells indicate no further assessment is necessary for the parameter.

Table C-3. Selection of Contaminants of Potential Concern in Fish Tissue Residue from Lake Trout Collected between 2005 and 2011 for Protection of Wildlife Receptors

Parameter	Mean	Maximum	Tissue Residue Guideline for Protection of Wildlife Consumers	Is the Maximum Fish Tissue Concentrations Greater than the Tissue Residue Guidelines?	Upper Limit of Normal Range (1996)	Is the Parameter a Final Contaminant of Potential Concern?
Mercury	0.239	1.99	0.033	Yes	0.371	Yes

Notes:
Sample size for mercury fish tissue was n = 116.
Gray shading indicates selection of COPCs due to exceedance of criteria.

Table C-4. Selection of Contaminants of Potential Concern in Fish Tissue Residue from Lake Trout Collected between 2005 and 2011 for Protection of Human Receptors

Parameter	Mean	Maximum	Tissue Residue Guideline for Protection Human Health	Is the Maximum Fish Tissue Concentrations Greater than the Tissue Residue Guidelines?	Upper Limit of Normal Range (1996)	Is the Parameter a Final Contaminant of Potential Concern?
Mercury	0.239	1.99	0.5	Yes	0.371	Yes

Notes:
Sample size for mercury fish tissue was n = 116.
Gray shading indicates selection of COPCs due to exceedance of criteria.

Appendix D

Selection of Contaminants of Potential Concern in Sediment

Table D-1. Selection of Contaminants of Potential Concern in Sediment from North Inlet for Derivation of Site-specific Risk-based Closure Criteria for Protection of Ecological Receptors

	North Inlet Sediment Quality		CCME Sediment Quality Guideline [1]		Is the Maximum North Inlet Sediment Concentration Greater than ISQG or PEL?	Upper Limit of North Inlet Reference Sediment Quality Normal Range	Is the Parameter a Final Contaminant of Potential Concern?
Parameter	**Mean**	**Max**	**ISQG**	**PEL**			
Total Metals[3]							
Arsenic	12.2	28.7	5.9	17	Yes	UA	Yes
Cadmium	0.227	0.455	0.6	3.5	No		No
Chromium	110	171	37.3	90	Yes	67	Yes
Copper	35.9	53.1	35.7	90	Yes	UA	Yes
Lead	26.5	32.6	35	91.3	No		No
Mercury	0.0250	0.0250	0.17	0.486	No		No
Zinc	103	116	123	315	No		No
Polyaromatic Hydrocarbons[3]							
Naphthalene	0.028	0.043	0.0346	0.391	No	UA	Yes
2-Methylnaphthalene	0.022	0.027	0.0202	0.201	Yes	UA	Yes
Acenaphthylene	0.0039	0.0064	0.00587	0.128	No	UA	Yes
Acenaphthene	0.011	0.02	0.00671	0.0889	Yes	UA	Yes
Fluorene	0.0077	0.011	0.0212	0.144	No		No
Phenanthrene	0.020	0.027	0.0419	0.515	No		No
Anthracene	0.0029	0.0043	0.0469	0.245	No		No
Fluoranthene	0.017	0.023	0.111	2.355	No		No
Pyrene	0.054	0.064	0.053	0.875	Yes	UA	Yes
Benz(a)anthracene	0.0023	0.0025	0.0317	0.385	No		No
Chrysene	0.010	0.011	0.0571	0.862	No		No
Benzo(a)pyrene	0.0043	0.008	0.0319	0.782	No		No
Dibenz(a,h)anthracene	0.000833	0.00125	0.00622	0.135	No		No
Total PAH [4]	0.18	0.19	10	20	No		No

Notes:
All concentrations are in mg/kg dry weight.
UA = Unavailable; the parameter was not measured.
[1] *CCME Canadian sediment quality guideline for protection of aquatic life.*
[2] *Mean and maximum concentrations for the North Inlet metal concentrations are based on a total of eight samples (five samples collected in 2010 and three samples collected in 2011).*
[3] *Mean and maximum concentrations of polycyclic aromatic hydrocarbons are based on three samples collected in 2011.*
[4] *Guidelines for total PAHs are from BC CSR Schedule 9 Generic Numerical Sediment Criteria (sensitive and typical).*

Table D-2. Selection of Contaminants of Potential Concern in Sediment from North Inlet Water Treatment Plant Sludge for Derivation of Site-specific Risk-based Closure Criteria for Protection of Ecological Receptors

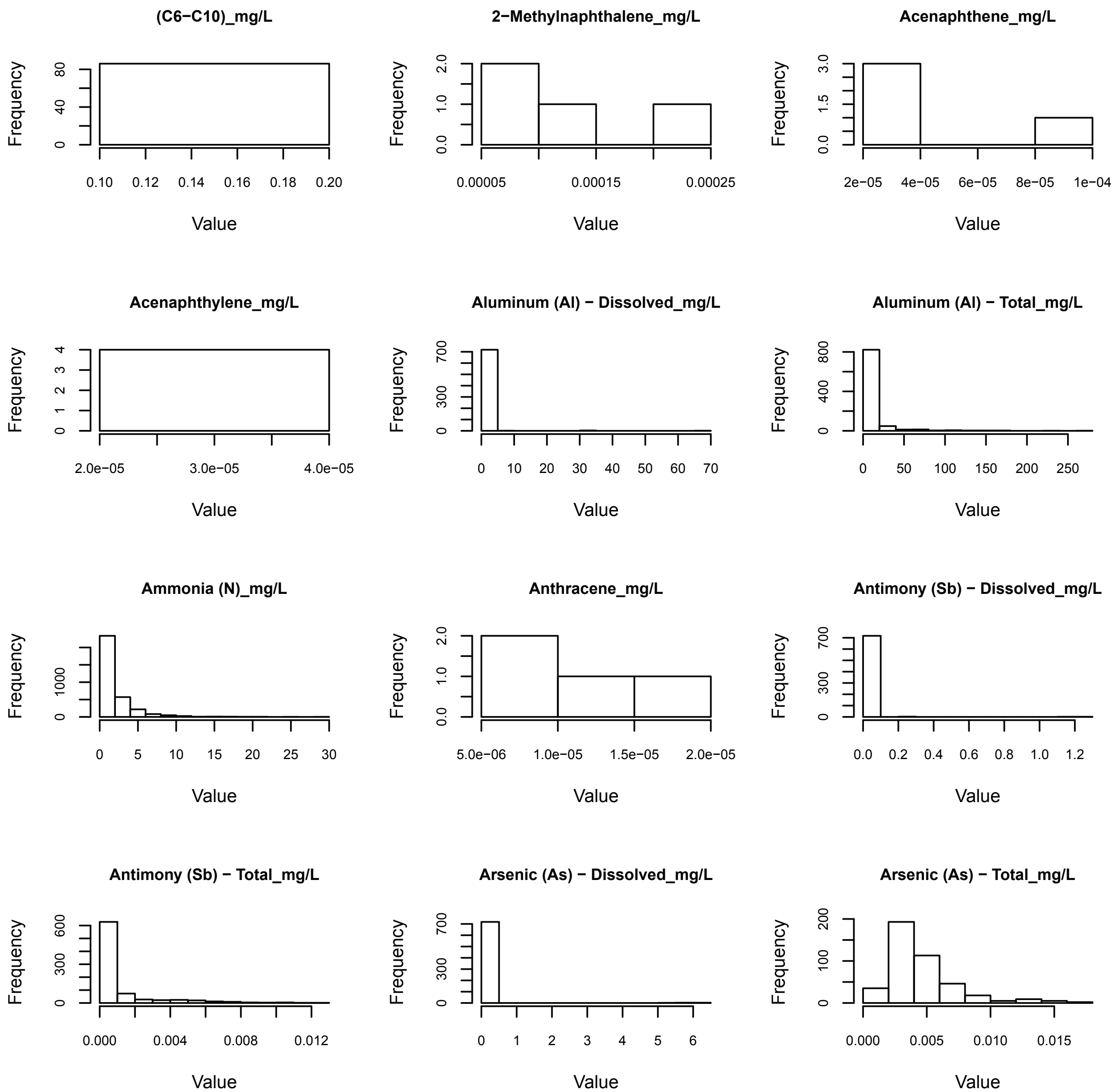
	NIWTP Sediment Quality		CCME Sediment Quality Guideline [2]				
Parameter[1]	**Mean**	**Max**	**ISQG**	**PEL**	**Is the Maximum NIWTP Sludge Concentration Greater than ISQG or PEL?**	**North Inlet Upper Limit of Reference Sediment Quality Normal Range**	**Is the Parameter a Final Contaminant of Potential Concern?**
Arsenic	148	192	5.9	17	Yes	UA	Yes
Cadmium	0.0955	0.148	0.6	3.5	No		No
Chromium	36.7	64.7	37.3	90	No	67	Yes
Copper	19.7	26.2	35.7	90	No		No
Lead	13.2	25.5	35	91.3	No		No
Mercury	0.0250	0.0250	0.17	0.486	No		No
Zinc	51.2	82.9	123	315	No		No

Notes:
All concentrations are in mg/kg dry weight.
NIWPT = North Inlet Water Treatment Plant
UA = Unavailable; the parameter was not measured.
[1] Mean and maximum concentrations for the NIWPT sludge metal concentrations are based on a total of six samples (one sample collected in 2010 and five samples collected in 2011).
[2] CCME Canadian sediment quality guideline for protection of aquatic life.

Appendix E.1

Data Distribution within the Ice-cover Season

APPENDIX E.1
Data Distribution within the Ice-cover Season



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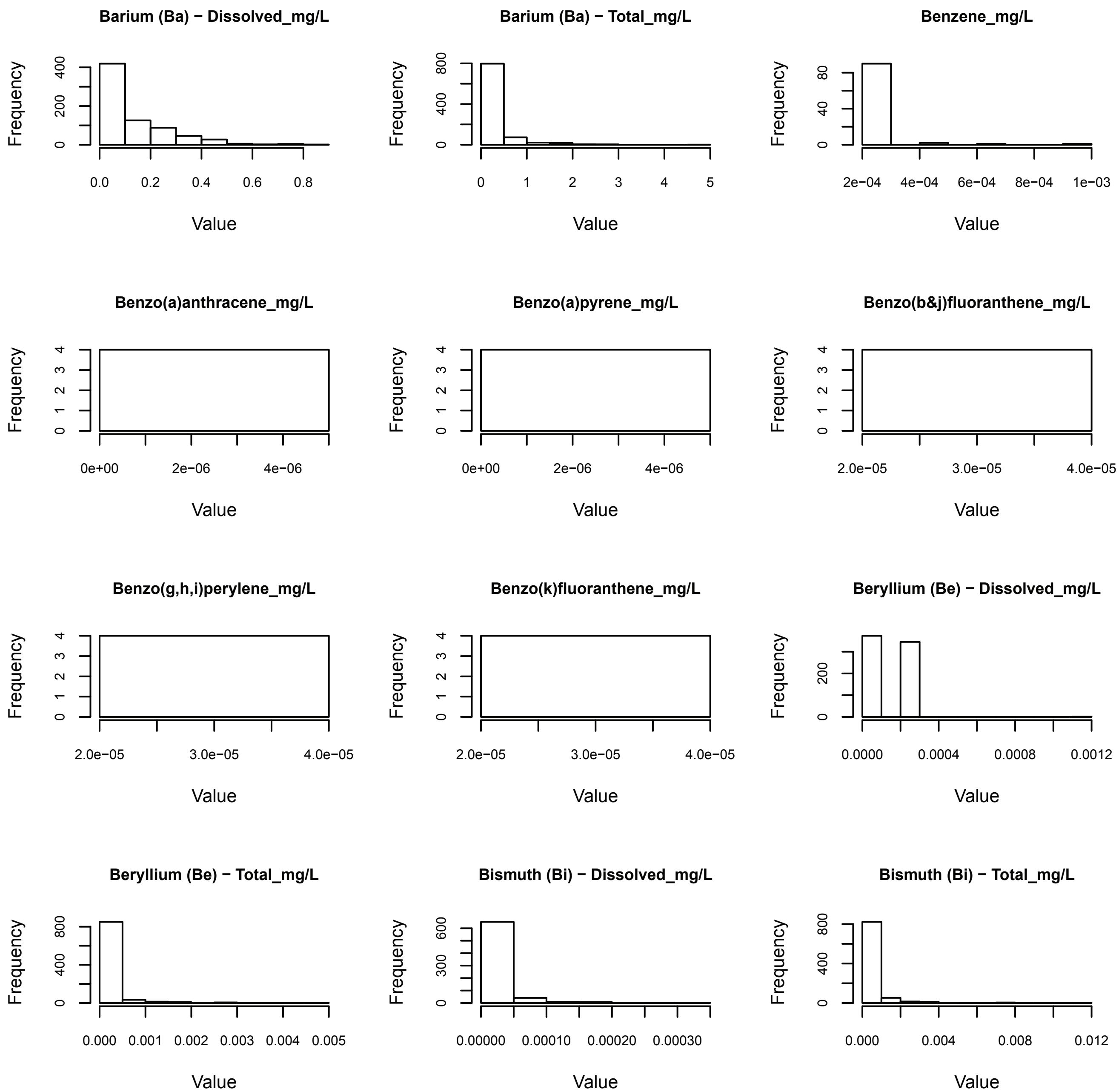
Data Distribution within the Ice-cover Season



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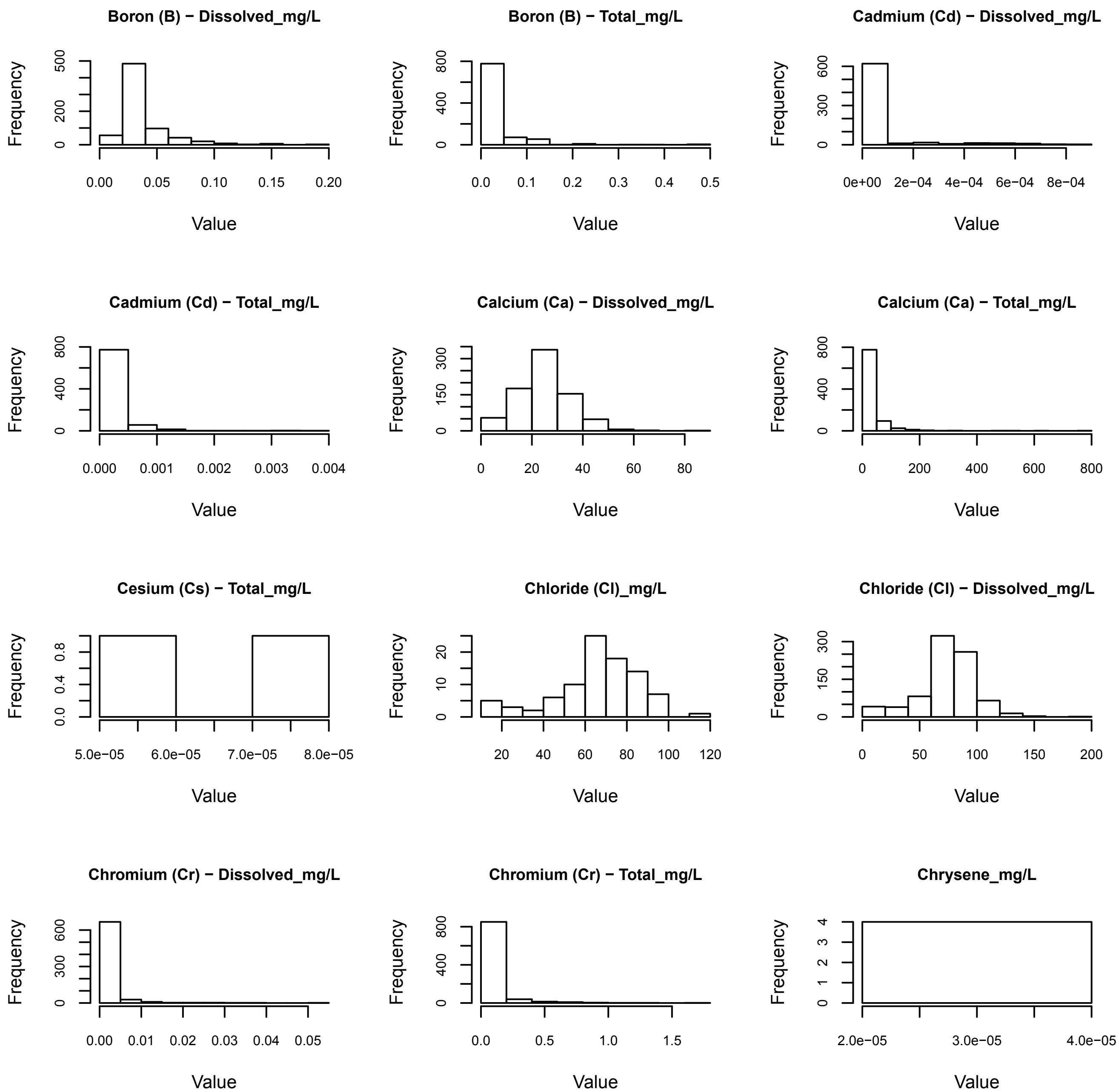

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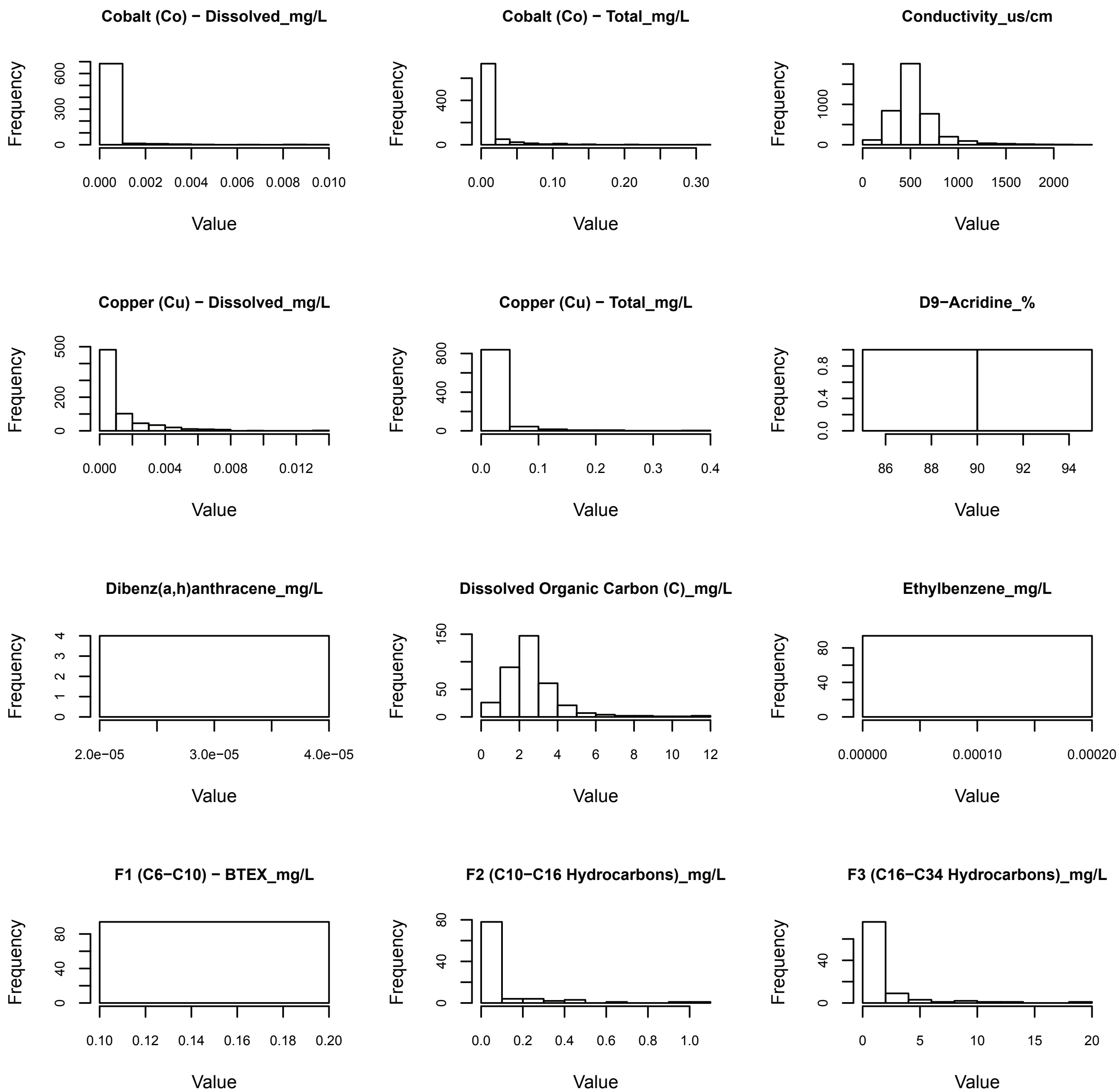

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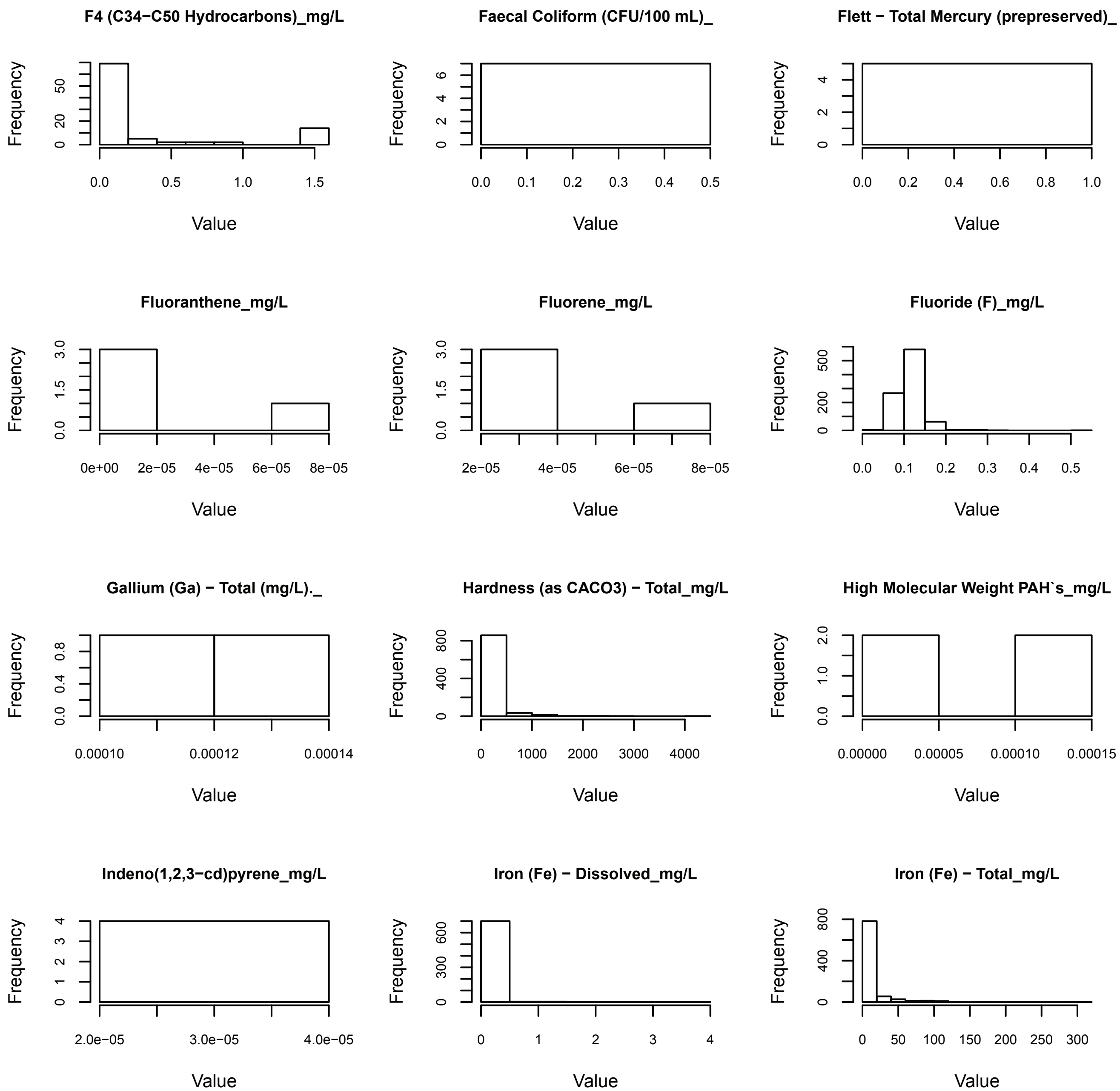

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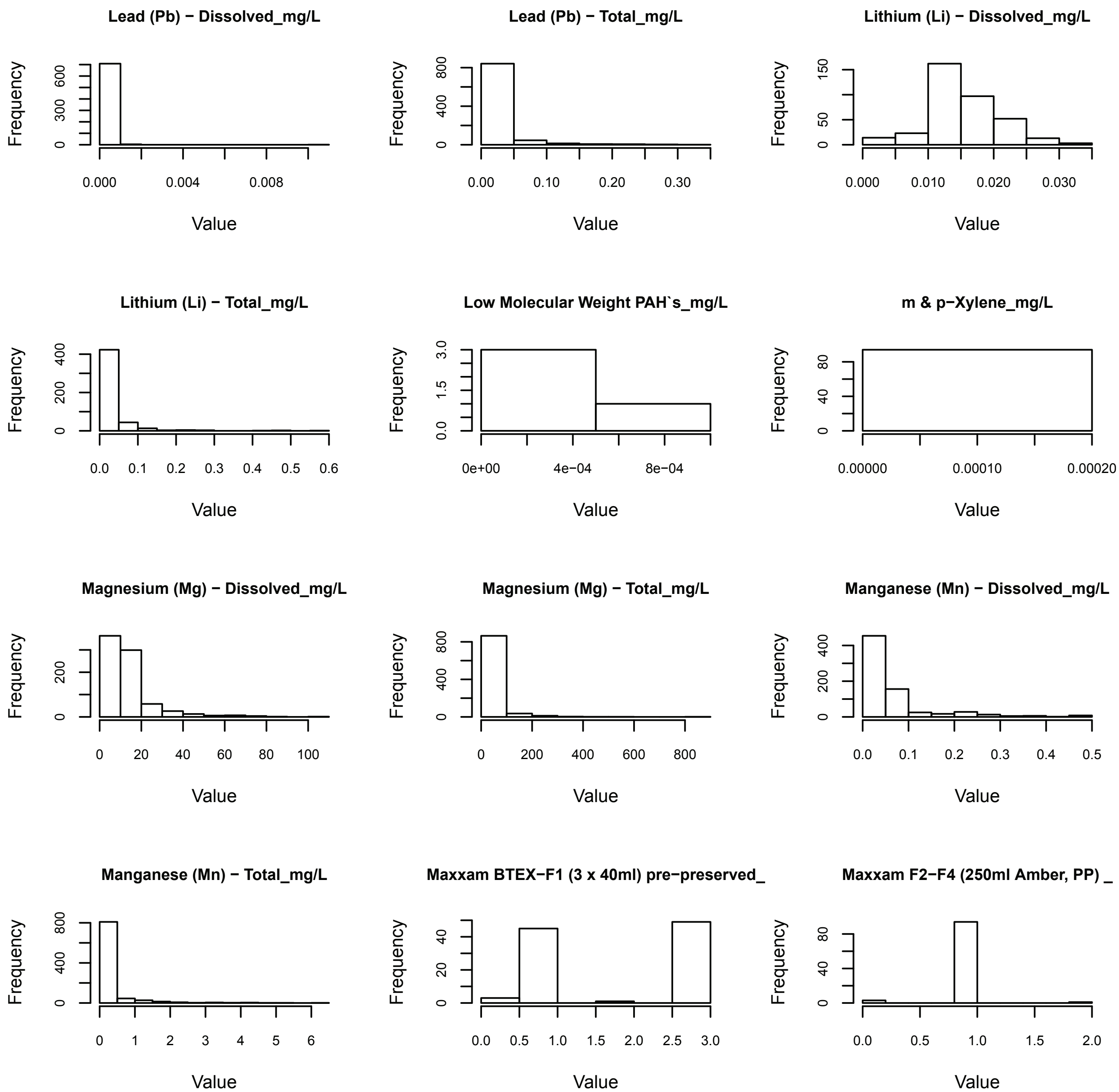

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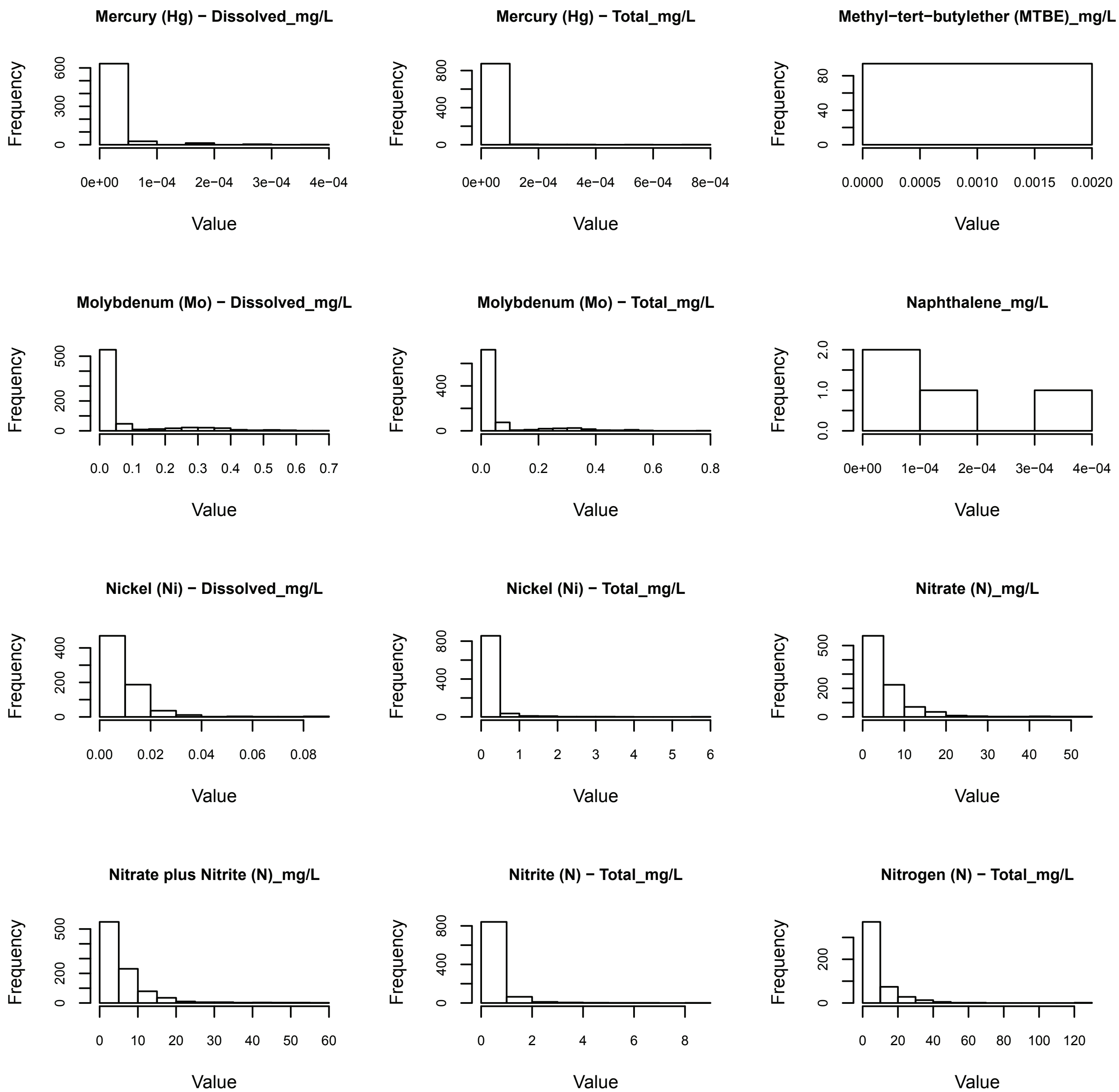

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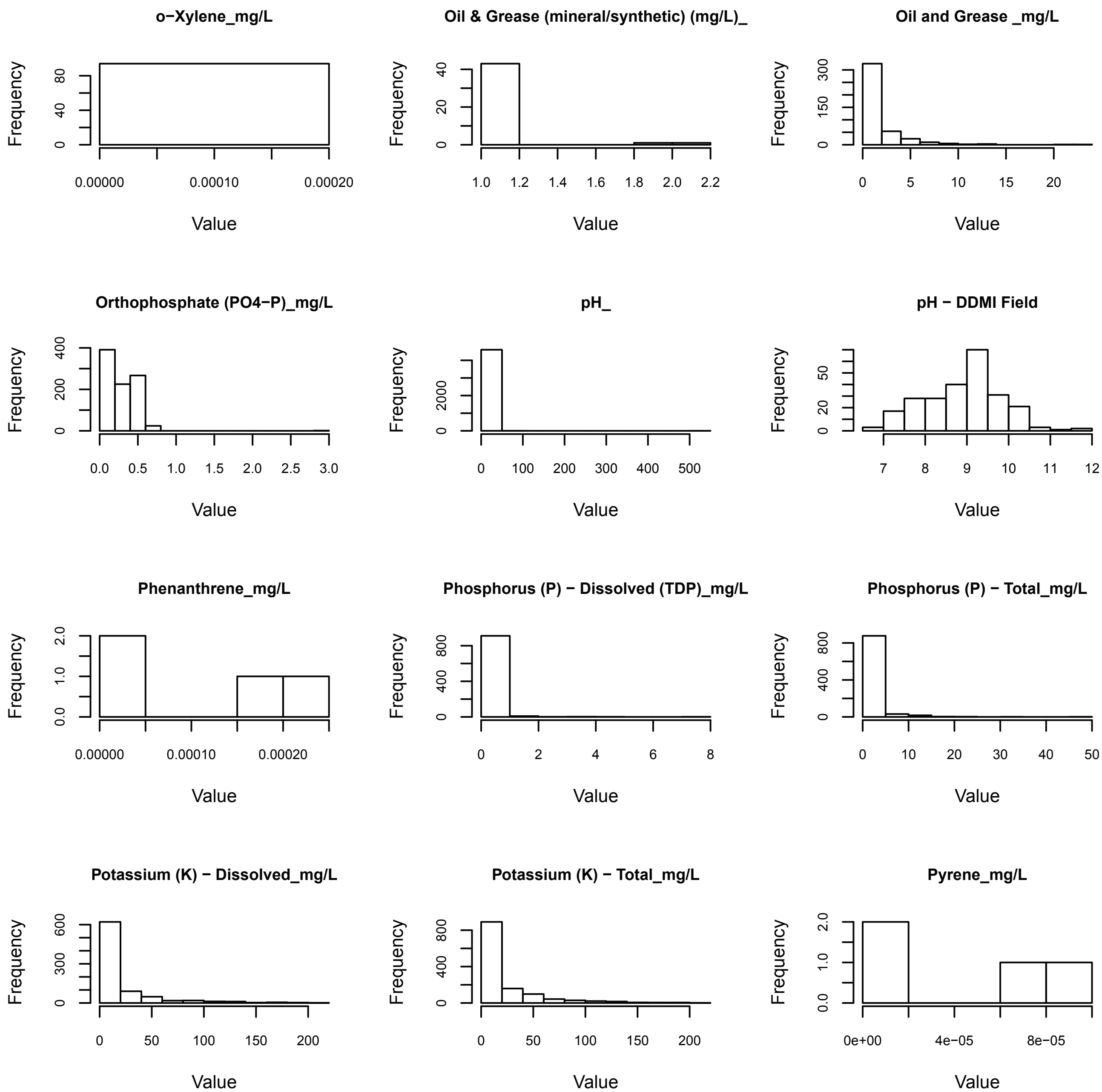

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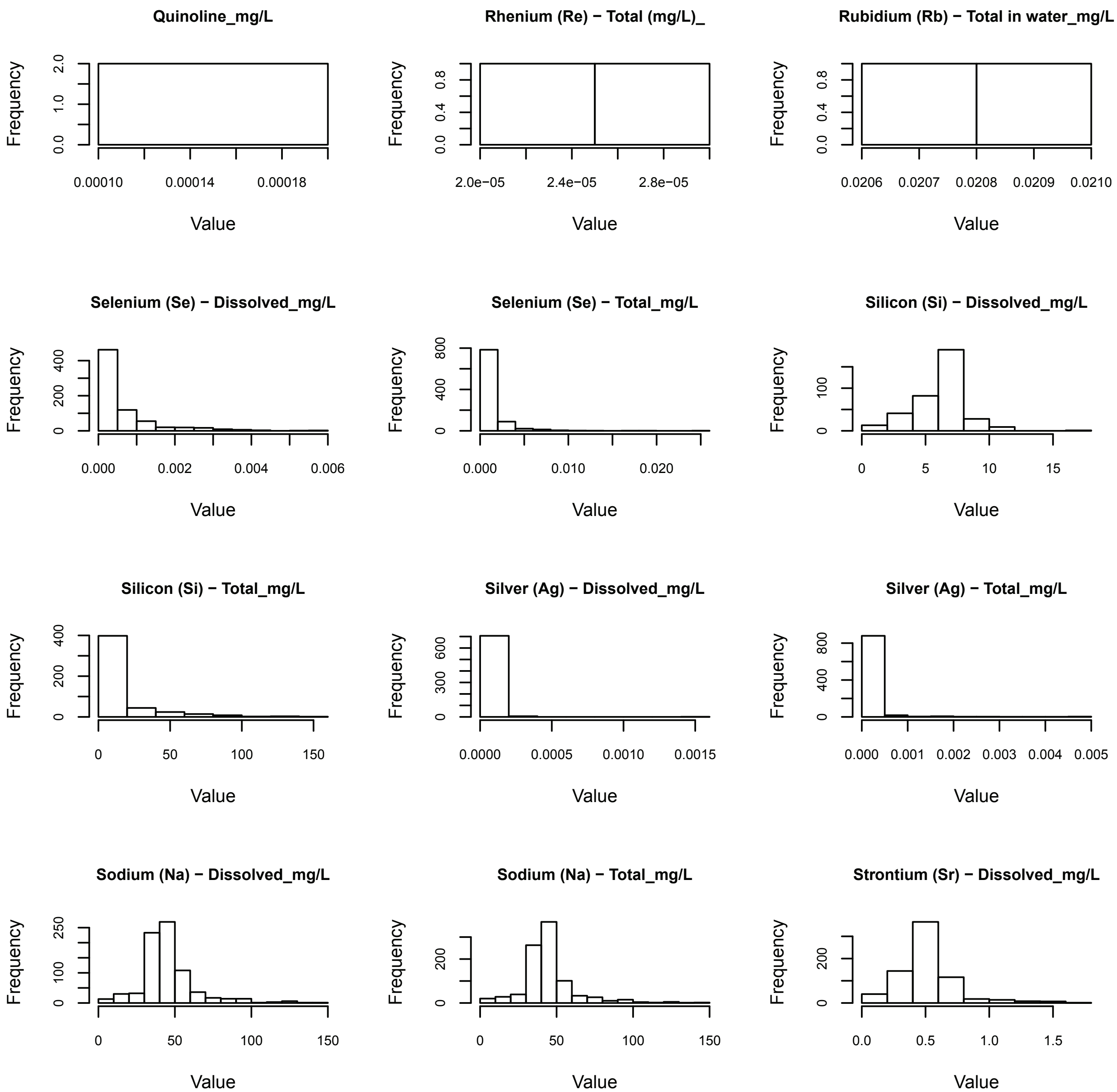

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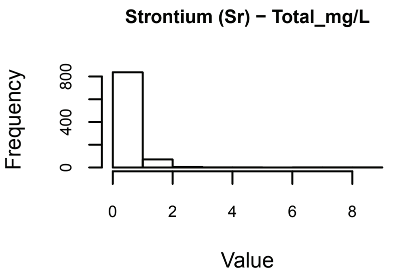

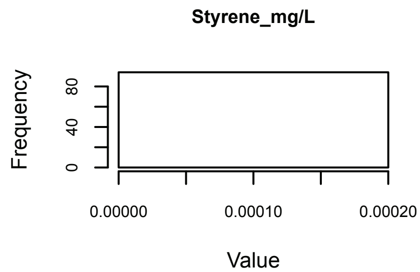

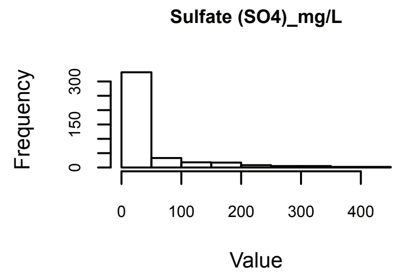

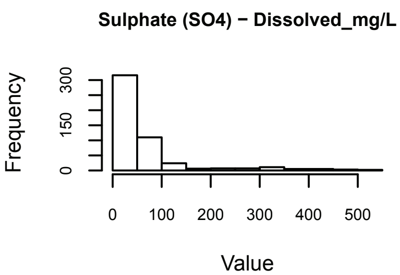

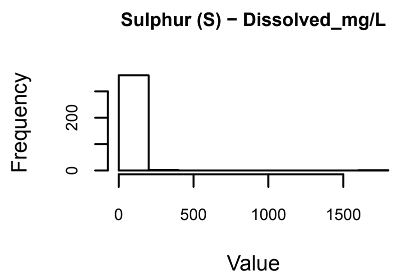

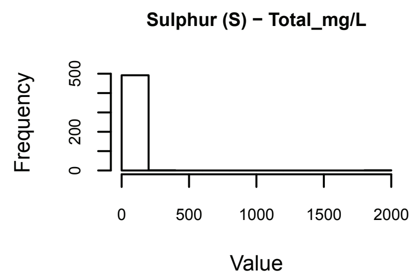

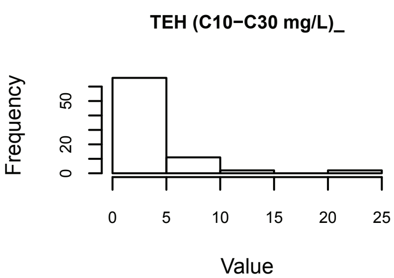

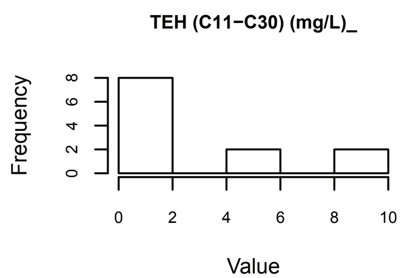

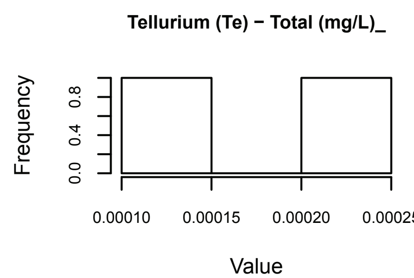

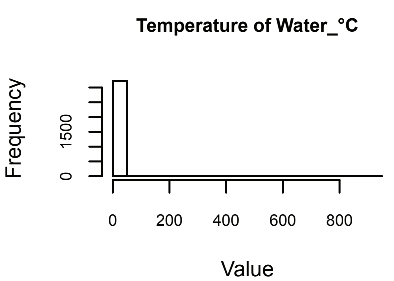

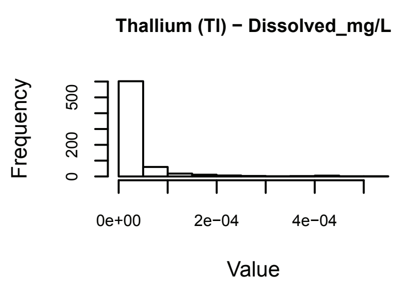

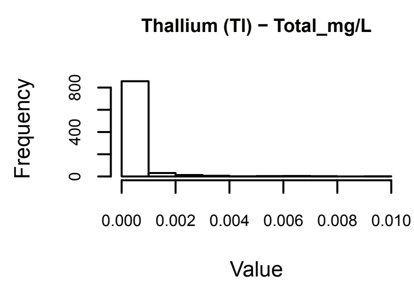

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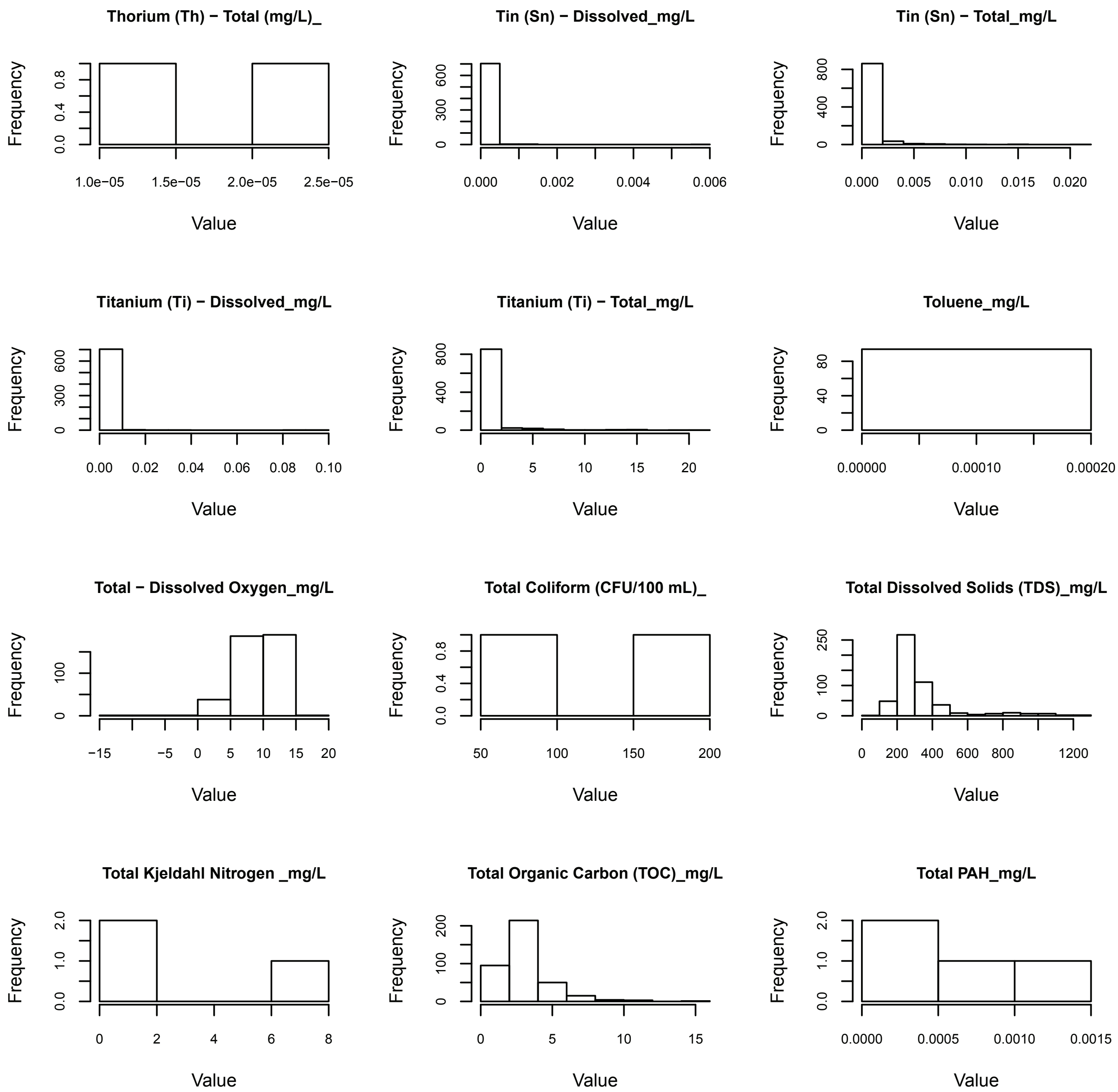
Data Distribution within the Ice-cover Season



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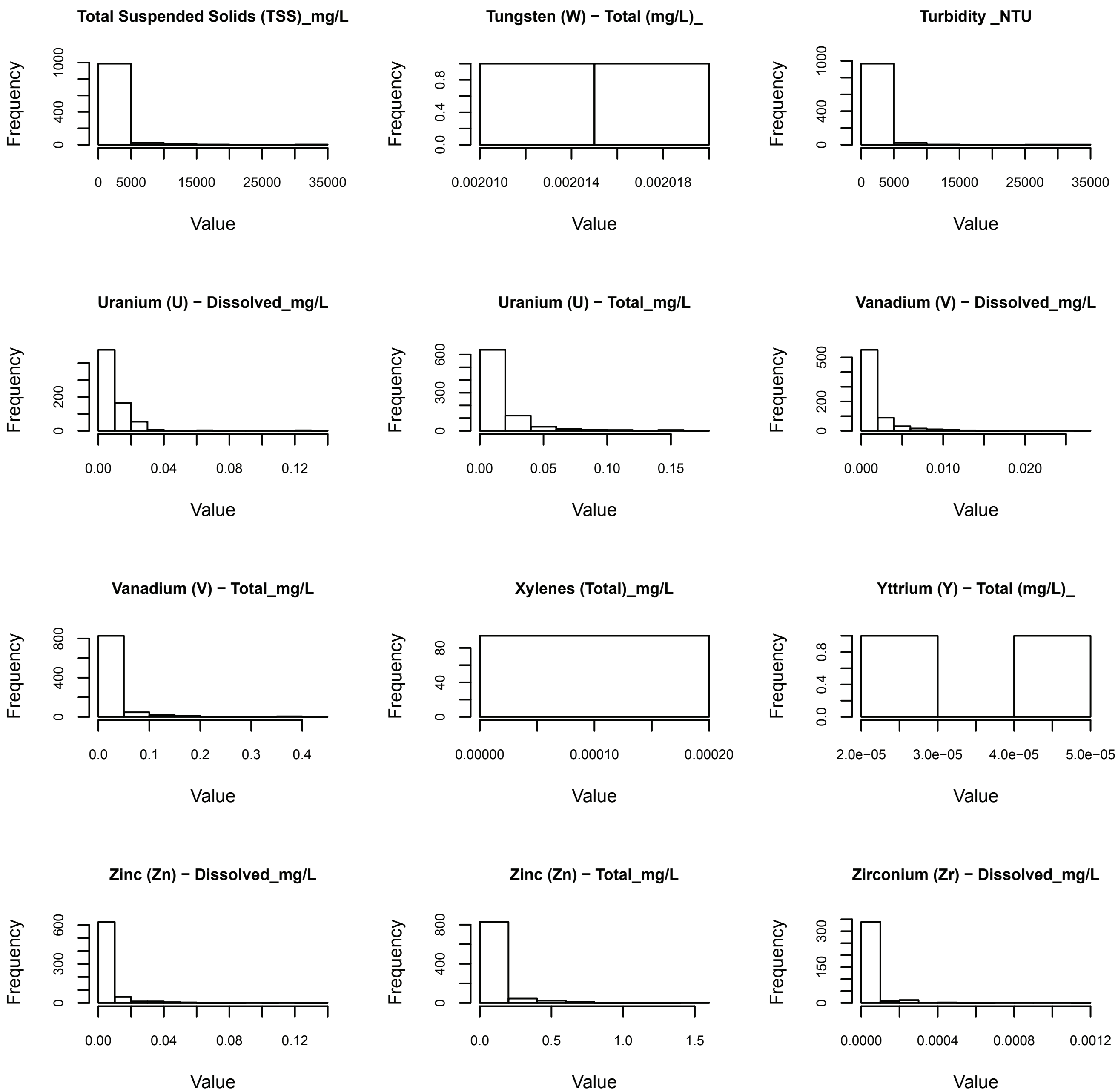
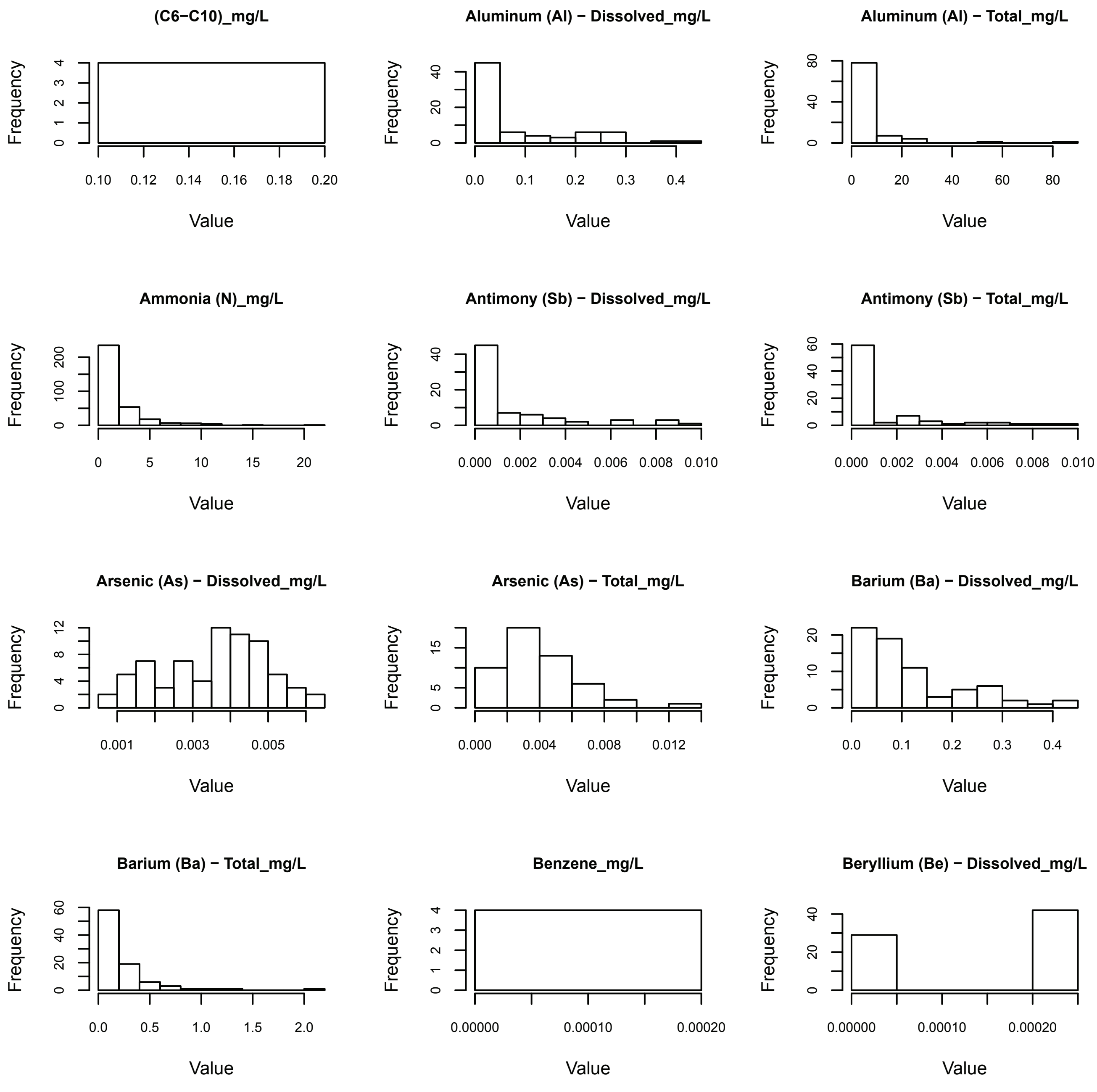


Appendix E.2

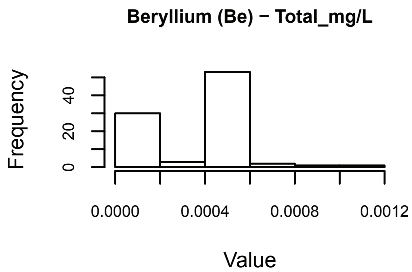
Data Distribution within the Open-water Season

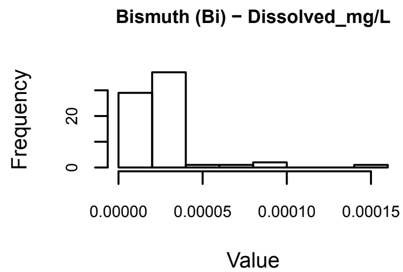
APPENDIX E.2
Data Distribution within the Open-water Season

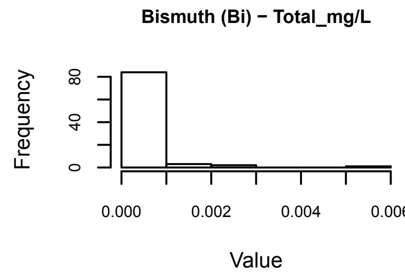


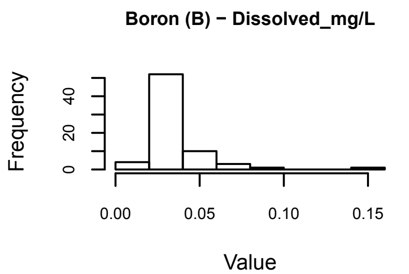
APPENDIX E.2

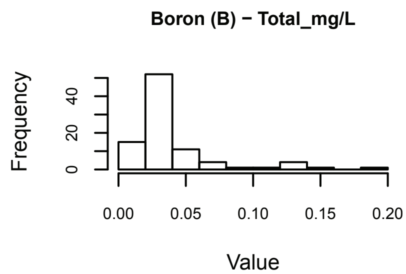
Data Distribution within the Open-water Season

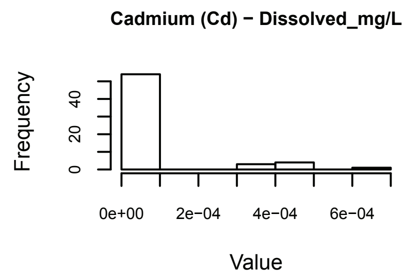


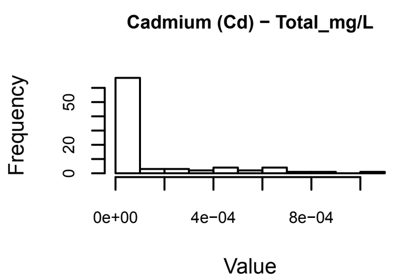


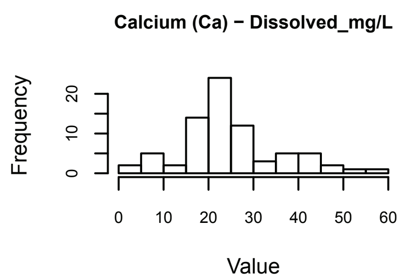


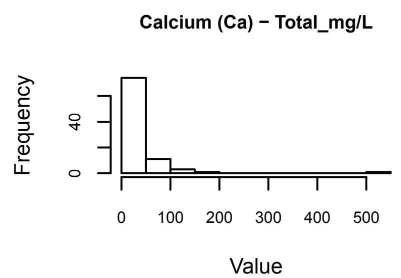


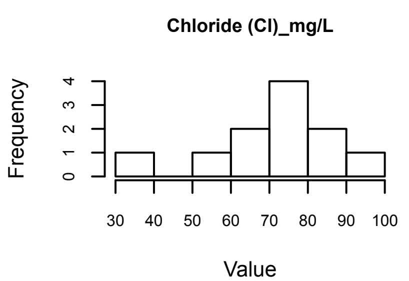


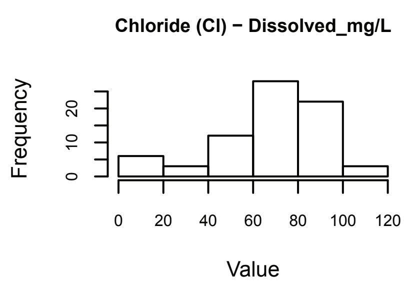


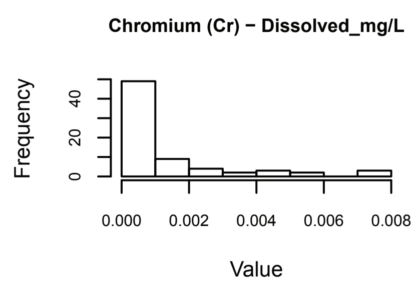




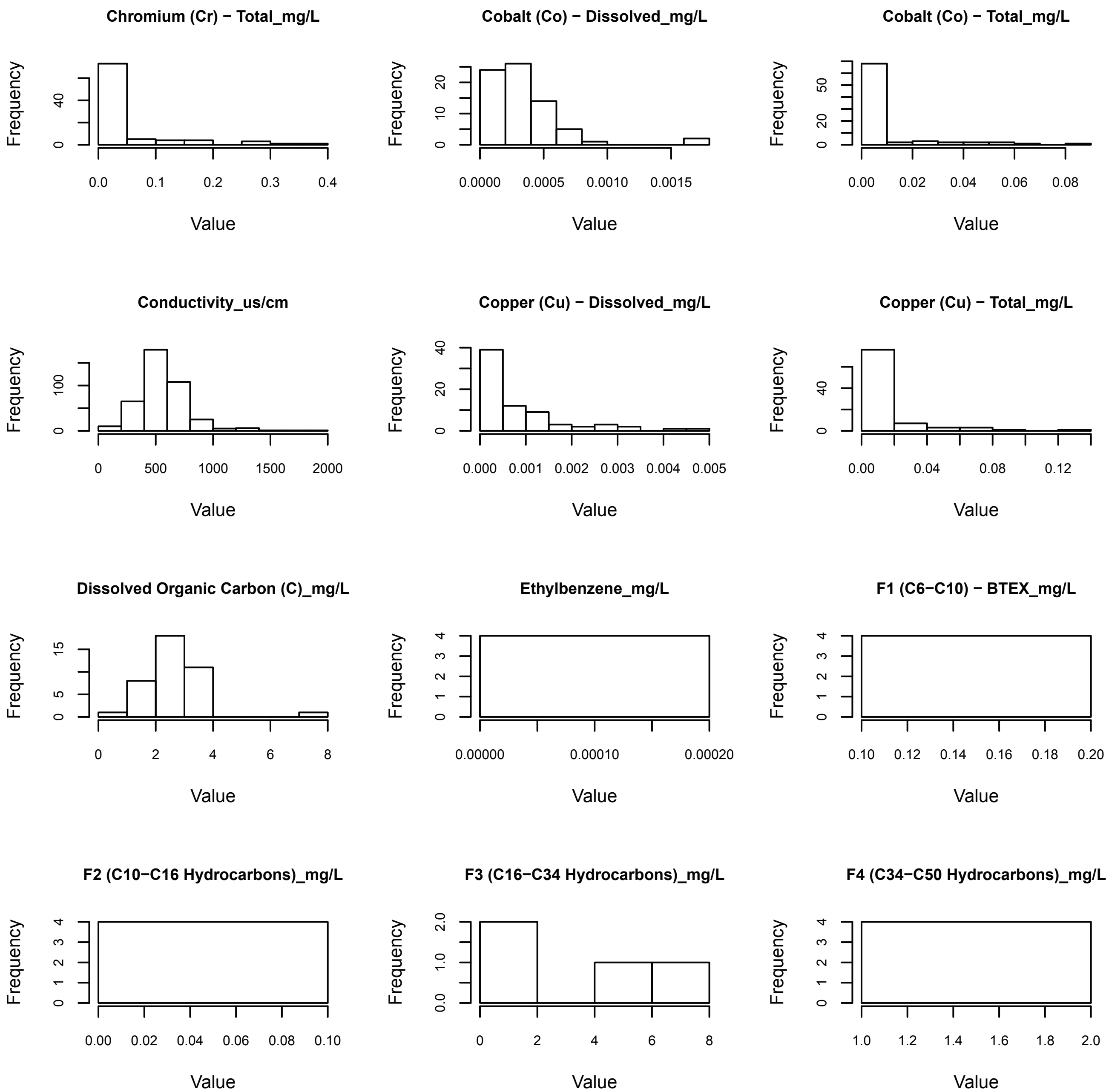








APPENDIX E.2
Data Distribution within the Open-water Season



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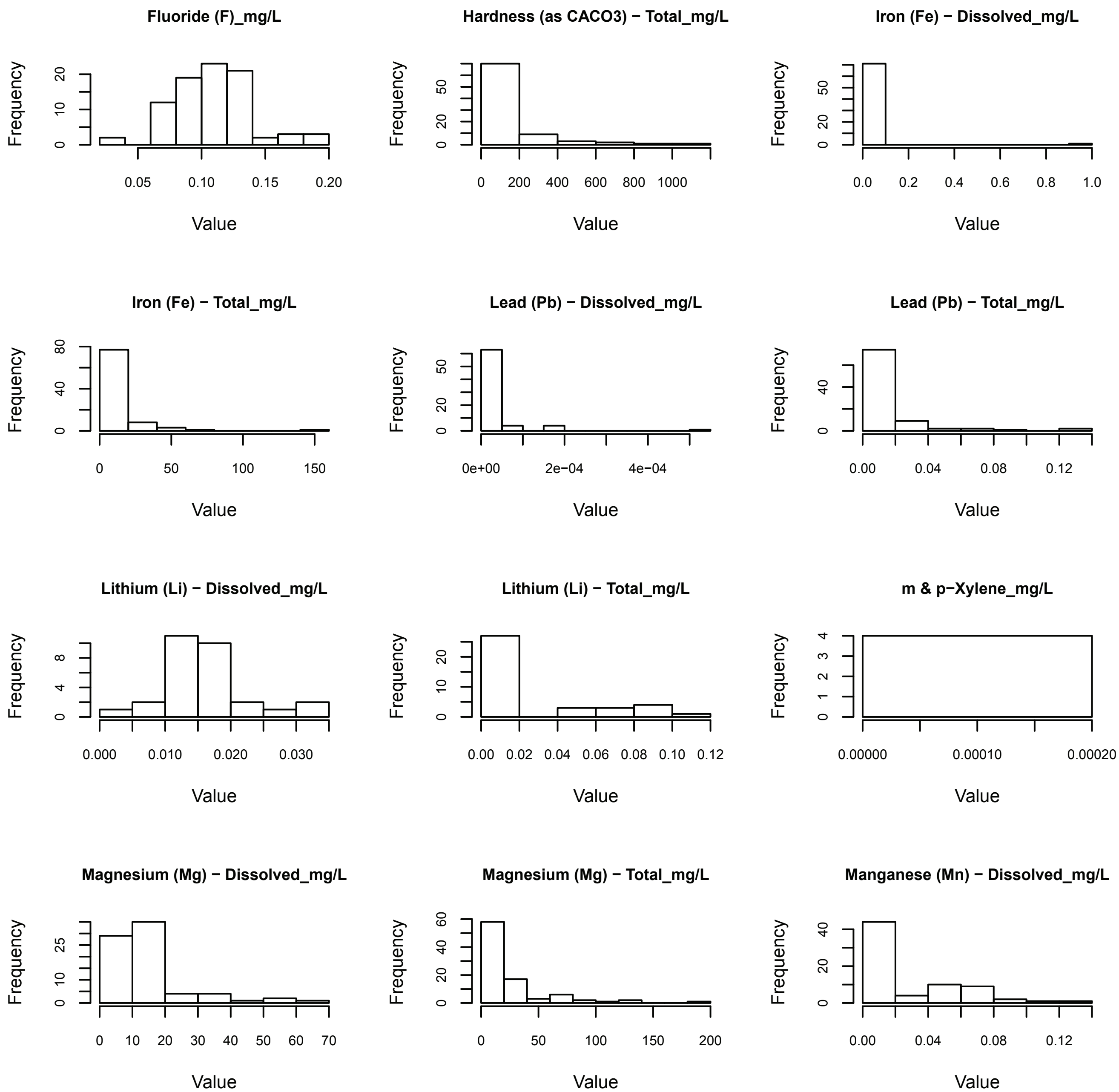
Data Distribution within the Open-water Season



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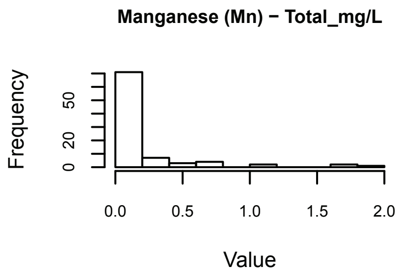
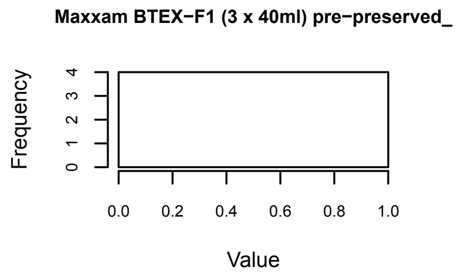
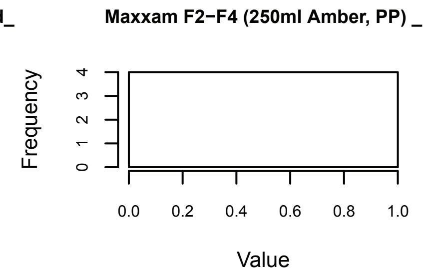
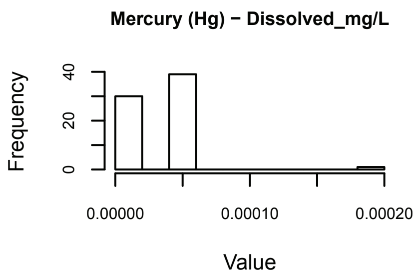
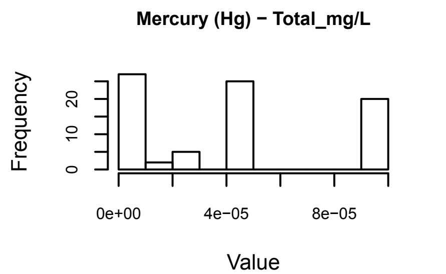
Data Distribution within the Open-water Season

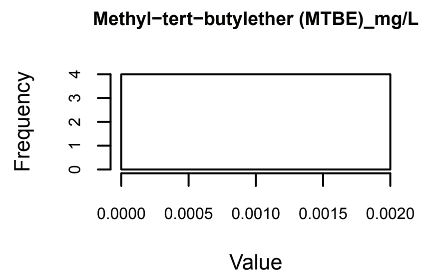


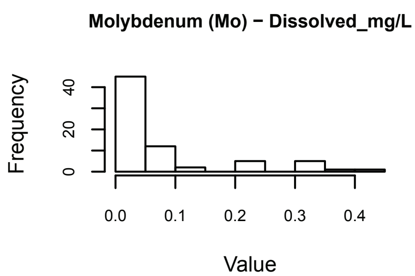


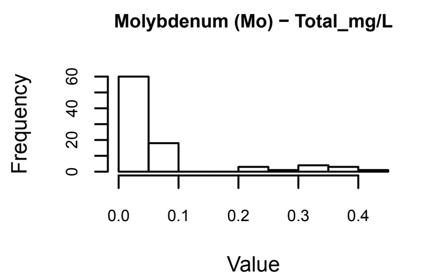


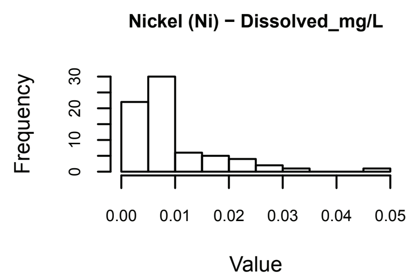


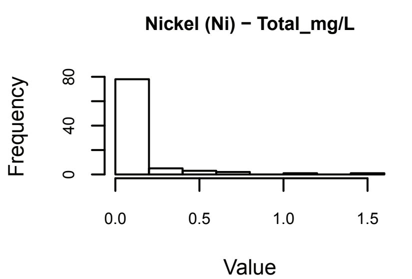


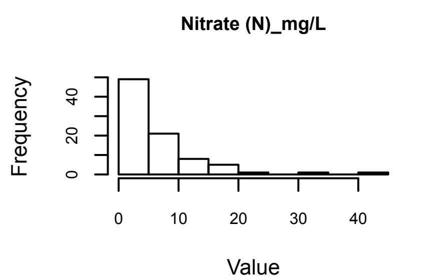


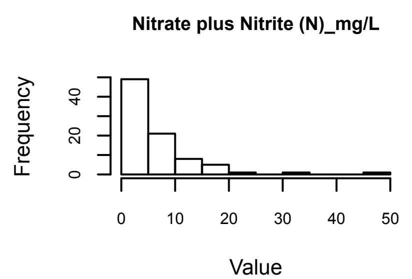




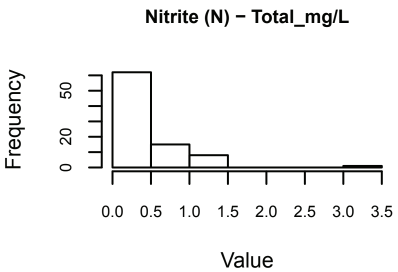


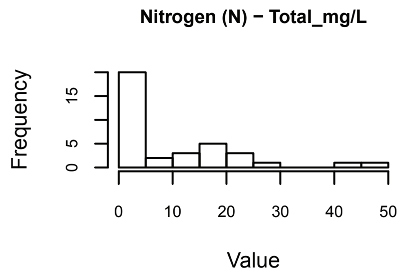


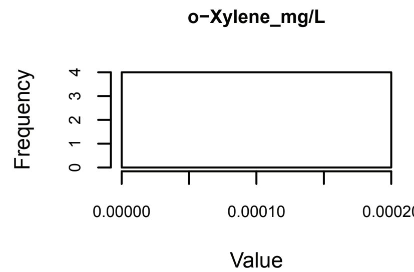


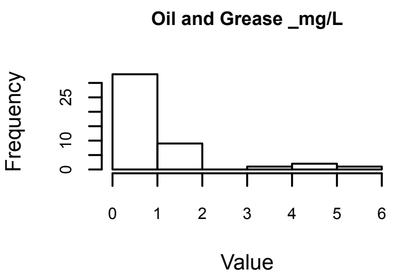


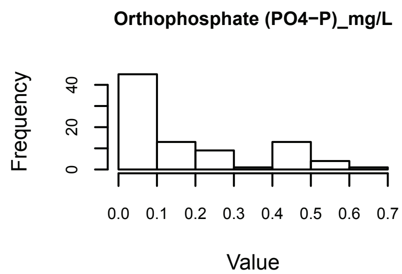
APPENDIX E.2
Data Distribution within the Open-water Season

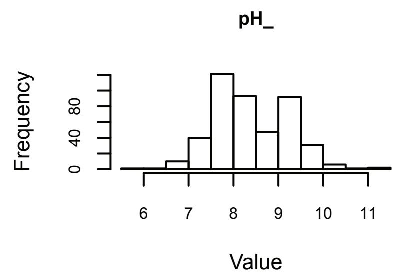


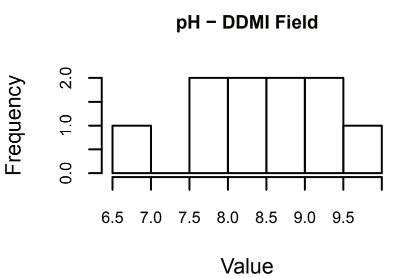


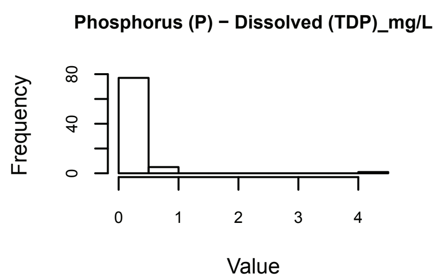


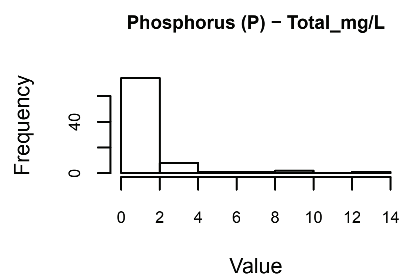


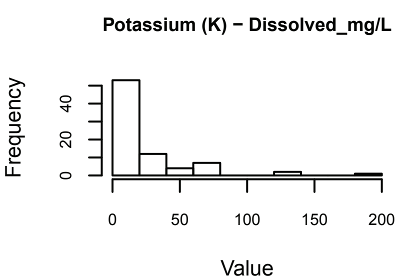


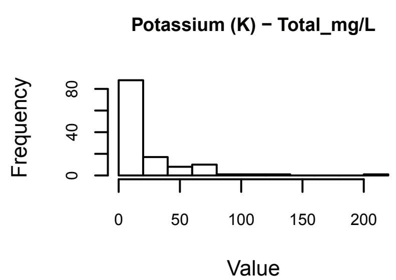


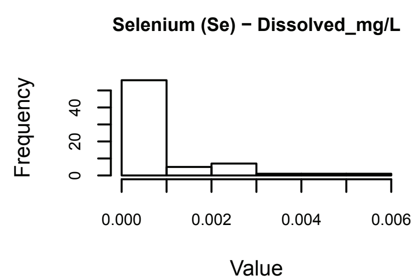












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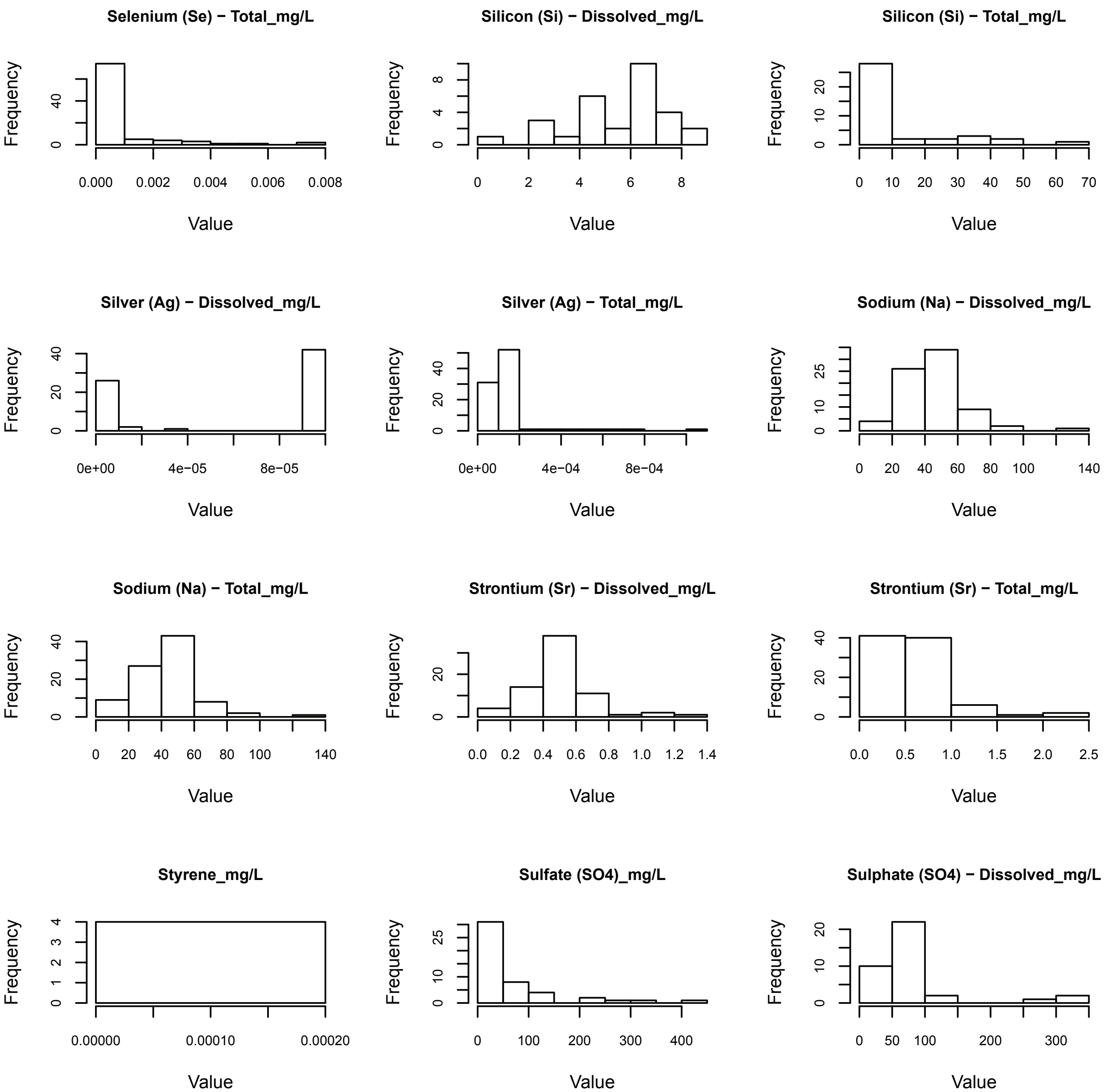

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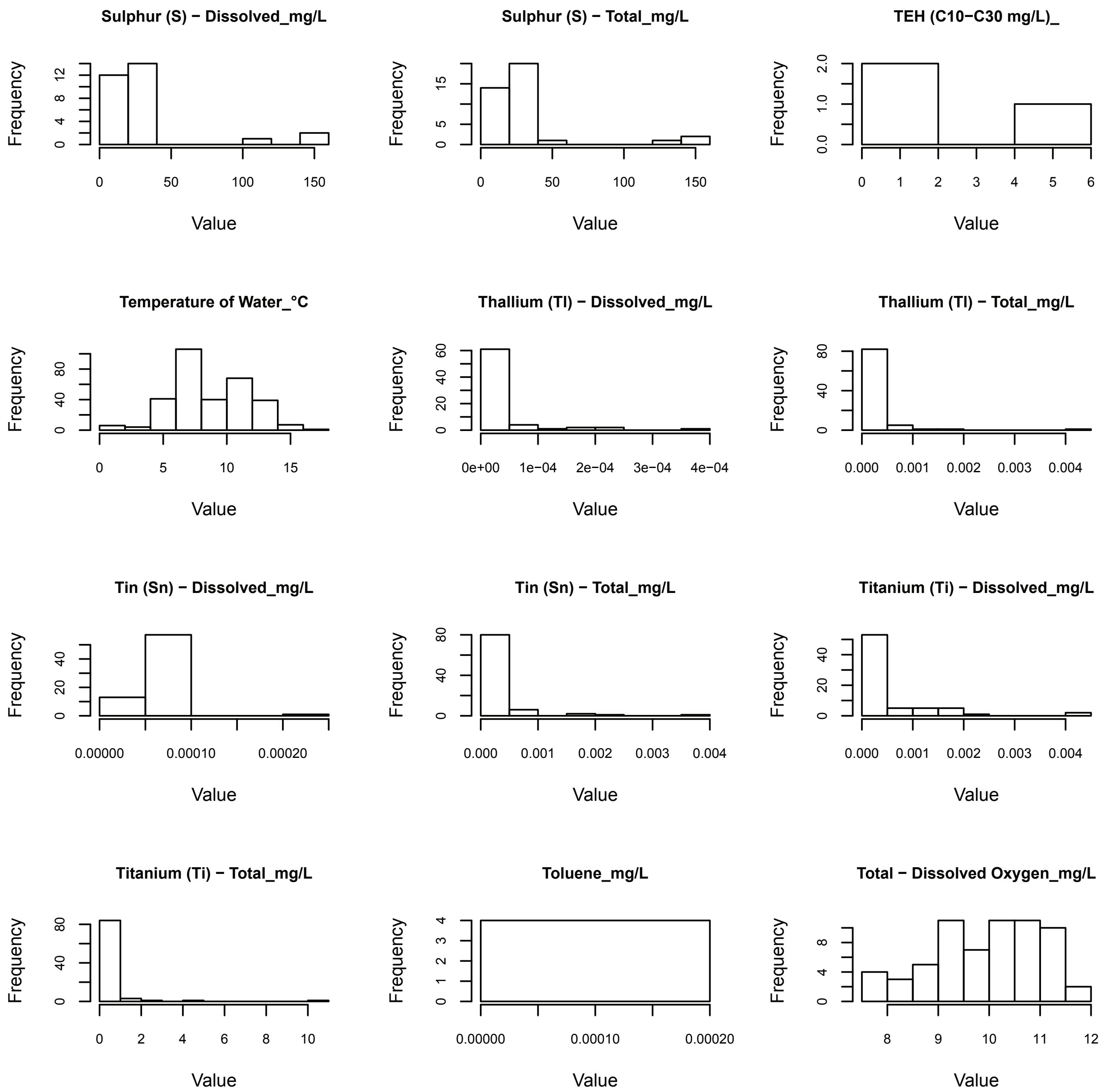

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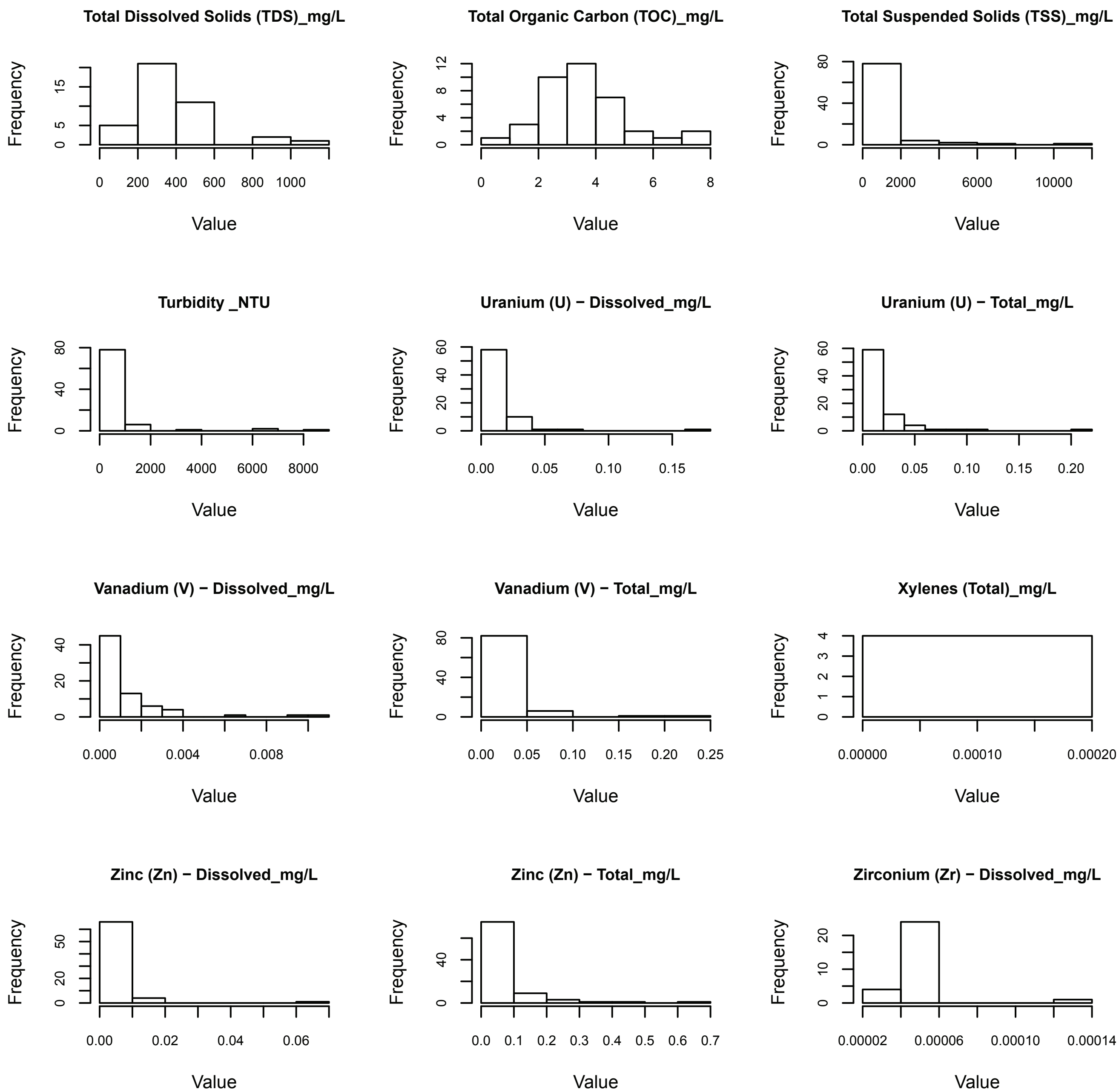

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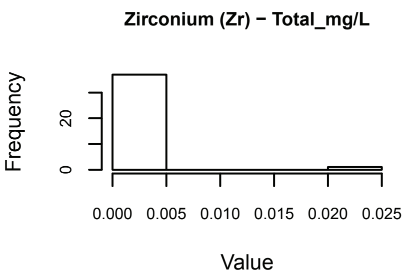

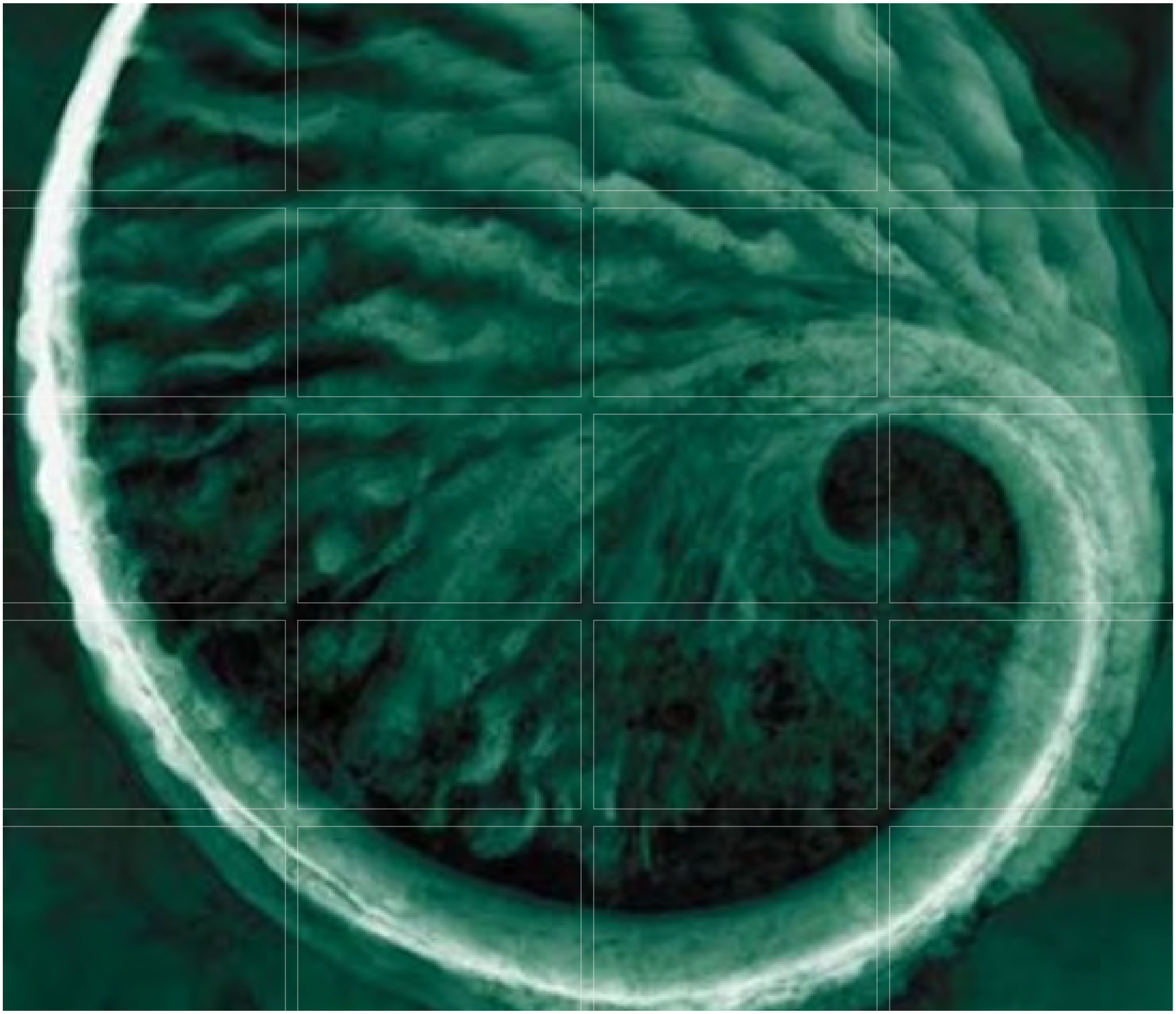

Prepared for:

Rio Tinto
Dominion Diamond Corporation
Diavik Diamond Mine

DIAVIK DIAMOND MINE

Site-specific Risk-based Closure Criteria Phase II Report

March 2016

ERM

The world's leading sustainability consultancy

Diavik Diamond Mines (2012) Inc.

DIAVIK DIAMOND MINE

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Site-specific Risk-based Closure Criteria Phase II Report

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

AF_G	Absorption factor for the gut
AF_S	Absorption factor for the skin
ATSDR	Agency for Toxic Substances and Disease Registry
BAF	Bioaccumulation factor
BCF	Bioconcentration factor
BC MOE	British Columbia Ministry of Environment
BF	Bioavailability
BSAF	Biota-sediment accumulation factor
BSC	Background soil concentration
BTF	Biotransfer factor
BW	Body weight
CCME	Canadian Council of Ministers of the Environment
COPC	Contaminants of potential concern
DDMI	Diavik Diamond Mines (2012) Inc.
DL_H	Dermal loading of soil to hands
DL_O	Dermal loading of soil to skin other than hands
DTED	Daily effects threshold dose
dw	Dry weight
DWQG	Drinking water quality guideline
EC_X	Effects concentration ‘X’
Eco SSL	Ecological Soil Screening Level
ED_X	Effects dose ‘X’
EDI	Estimated daily intake

EF	Exposure frequency
ERM	Environmental Resource Management Consultants Canada Ltd.
ET	Exposure time
FAO	Food and Agriculture Organization of the United Nations
IR_B	Bird ingestion rate
IR_F	Food ingestion rate
IR_{Fi}	Fish ingestion rate
IR_L	Land animal ingestion rate
IR_P	Plant ingestion rate
IR_S	Soil/sediment ingestion rate
IR_W	Water ingestion rate
IRIS	Integrated Risk Information System
ISQG	Interim sediment quality guidelines
JECFA	Joint Expert Committee on Food Additives and Contaminants
LC_X	Lethal concentration 'X'
LD_X	Lethal dose 'X'
LOAEL	Lowest observed adverse effects level
LOEC	Lowest observed effect concentration
MATC	Maximum acceptable toxicant concentration
MRL	Minimal risk level
NOAEL	No observed adverse effects level
NOEC	No observed effect concentration
NT	Northwest Territories
ORNL	Oak Ridge National Laboratory
PAH	Polycyclic aromatic hydrocarbon
PEL	Probable effects level
PTDI	Provisional tolerable daily intake

Project, the	Diavik Diamond Mine
RfD	Reference dose
ROC	Receptor of concern
SA_H	Surface area of hands
SA_O	Surface area of skin other than hands
SAF	Soil allocation factor
SR	Soil dermal contact rate
SSRBCC	Site-specific Risk-based Risk Closure Criteria
SSWQO	Site-specific water quality objective
TDI	Tolerable daily intake
TRV	Toxicity reference value
UF	Uncertainty factor
US EPA	United States Environmental Protection Agency
WHO	World Health Organization
ww	Wet weight

1. METHODOLOGY FOR DEVELOPING SITE-SPECIFIC RISK-BASED CLOSURE CRITERIA

Diavik Diamond Mines (2012) Inc. (DDMI) requested Environmental Resource Management Consultants Canada Ltd. (ERM)'s assistance in developing Site-specific Risk-based Closure Criteria (SSRBCC) as part of the development of the Final Closure and Reclamation Plan for the Diavik Diamond Mine (the Project). The Phase I report (ERM 2016) presented the Problem Formulation for the development of SSRBCCs including the identification of receptors of concern (ROCs), contaminants of potential concern (COPCs), and potential exposure pathways. This Phase II report contains the derivation of SSRBCCs for the applicable environmental media and ROCs. This report summarizes the outcome of the second phase.

1.1 RECEPTORS OF CONCERN AND CONTAMINANTS OF POTENTIAL CONCERN IN ENVIRONMENTAL MEDIA

Site-specific Risk-based Closure Criteria were derived for COPCs identified in soil, water, sediment, and fish tissue for the ROCs. The ROCs and the COPCs in soil, water, sediment, and fish tissue and were selected in the Phase I report (ERM 2016). The SSRBCCs are media-specific concentrations derived using site- and receptor-specific exposure considerations and chemical-specific toxicological information.

Tables 1.1-1 to 1.1-4 list the COPCs for each environmental media type and the applicable ROCs.

Table 1.1-1. Contaminants of Potential Concern in Soil and the Applicable Receptors of Concern

Soil COPCs	Applicable Receptors of Concern							
	Terrestrial Plants	Terrestrial Invertebrates	Caribou	Grizzly Bear	Red Fox	Northern Red-backed Vole	Willow Ptarmigan	Humans[b]
Aluminum[a]	-	-	X	X	X	X	X	X
Barium	X	X	X	X	X	X	X	X
Chromium	X	X	X	X	X	X	X	X
Manganese	X	X	X	X	X	X	X	X
Molybdenum	X	X	X	X	X	X	X	X

Notes:
COPC = contaminant of potential concern
(-) = not applicable
[a] *Aluminum is only toxic to plants if the pH is less than 5.5. It was assumed that the pH of Type 1 soil is neutral.*
[b] *Includes adults and toddlers.*

Table 1.1-2. Contaminants of Potential Concern in Water and the Applicable Receptors of Concern

Water COPCs	Applicable Receptors of Concern											
	Aquatic Primary Producers	Zooplankton & Benthic Invertebrates	Caribou	Grizzly Bear	Red Fox	Northern Red-backed Vole	Semi-palmated Sandpiper	Long-tailed Duck	Willow Ptarmigan	Peregrine Falcon	Bald Eagle	Humans[a]
Nutrients and Anions												
Nitrate	X	X	-	-	-	-	-	-	-	-	-	X
Nitrite	X	X	-	-	-	-	-	-	-	-	-	X
Fluoride	X	X	-	-	-	-	-	-	-	-	-	-
Sulphate	X	X	-	-	-	-	-	-	-	-	-	X
Metals												
Aluminum	X	X	-	-	-	-	-	-	-	-	-	-
Antimony	-	-	-	-	-	-	-	-	-	-	-	X
Arsenic	X	X	-	-	-	-	-	-	-	-	-	X
Cadmium	X	X	-	-	-	-	-	-	-	-	-	-
Chromium	X	X	X	X	X	X	X	X	X	X	X	X
Cobalt	-	-	X	X	X	X	X	X	X	X	X	-
Copper	X	X	-	-	-	-	-	-	-	-	-	-
Iron	X	X	-	-	-	-	-	-	-	-	-	-
Lead	X	X	-	-	-	-	-	-	-	-	-	-
Manganese	-	-	X	X	X	X	X	X	X	X	X	X
Mercury	X	X	-	-	-	-	-	-	-	-	-	-
Molybdenum	X	X	X	X	X	X	X	X	X	X	X	-
Nickel	X	X	X	X	X	X	X	X	X	X	X	-
Potassium	X	X	-	-	-	-	-	-	-	-	-	-
Selenium	X	X	-	-	-	-	-	-	-	-	-	X
Silver	X	X	-	-	-	-	-	-	-	-	-	-
Uranium	X	X	X	X	X	X	X	X	X	X	X	X
Zinc	X	X	-	-	-	-	-	-	-	-	-	-

Notes:
COPC = contaminant of potential concern
(-) = not applicable or not a COPC
[a] Includes adults and toddlers.

Table 1.1-3. Contaminants of Potential Concern in Sediment and the Applicable Receptors of Concern

Sediment COPCs	Applicable Receptors of Concern		
	Zooplankton & Benthic Invertebrates	Semi-palmated Sandpiper	Long-tailed Duck
Metals			
Arsenic	X	X	X
Chromium	X	X	X
Copper	X	X	X
Polycyclic Aromatic Hydrocarbons			
Naphthalene	X	X	X
2-Methylnaphthalene	X	X	X
Acenaphthylene	X	X	X
Acenaphthene	X	X	X
Pyrene	X	X	X

Notes:
COPC = contaminant of potential concern

Table 1.1-4. Contaminants of Potential Concern in Fish Tissue and the Applicable Receptors of Concern

Fish Tissue COPCs	Applicable Receptors of Concern			
	Grizzly Bear	Peregrine Falcon	Bald Eagle	Humans [a]
Methylmercury	X	X	X	X

Notes:
COPC = contaminant of potential concern
[a] *Includes adults, sensitive adults (women of child-bearing age and pregnant women), and toddlers.*

1.2 EQUATIONS USED TO DERIVE SITE-SPECIFIC RISK-BASED CLOSURE CRITERIA

The Canadian Council of Ministers of the Environment (CCME) provides protocols for deriving the Canadian environmental quality guidelines in technical documents for water (CCME 1999, 2007), soil (CCME 2006), sediment (CCME 1995), and tissue (CCME 2000). The CCME states that their protocols can be used to derive site-specific guidelines/objectives for environmental media (CCME 2006). Therefore, the CCME protocols were followed to derive soil, water, sediment, and fish tissue SSRBCCs for the ROCs. The protocol used to derive each of the media- and ROC-specific SSRBCCs are provided in Appendix A and are summarized in Table 1.2-1.

1.3 RECEPTOR-SPECIFIC PARAMETERS

The calculation of SSRBCCs for wildlife and human ROCs requires the incorporation of receptor-specific parameters such as body weight (BW), food ingestion rates (IR_F), soil or sediment ingestion rates (IR_S), water ingestion rates (IR_W), and the exposure time on-site (ET). The receptor-specific parameters used in the SSRBCC calculations are discussed in Sections 1.3.1 and 1.3.2 below.

Table 1.2-1. Equations Used in Calculation of Site-specific Risk-based Closure Criteria

Receptor of Concern	Media	Site-specific Risk-based Closure Criteria Equations	Reference
Aquatic primary producers	Water	$SSRBCC_{water} = TRV$	CCME (2007)
Terrestrial Plants	Soil	$SSRBCC_{soil} = TRV$	CCME (2006)
	Water	$SSRBCC_{water} = TRV$	CCME (1999)
Zooplankton and Benthic Invertebrates	Water	$SSRBCC_{water} = TRV$	CCME (2007)
	Sediment	$SSRBCC_{sediment} = TRV$	CCME (1995)
Terrestrial Invertebrates	Soil	$SSRBCC_{soil} = TRV$	CCME (2006)
Fish	Water	$SSRBCC_{water} = TRV$	CCME (2007)
Mammalian Terrestrial Herbivore: Caribou (*Rangifer tarandus*)	Soil	$SSRBCC_{soil} = \frac{0.80 \times TRV \times BW}{[IR_S \times BF] + [IR_F \times BCF]}$	CCME (2006)
	Water	$SSRBCC_{water} = \frac{0.20 \times TRV \times BW}{IR_W}$	CCME (1999)
Mammalian Aquatic/ Terrestrial Omnivore: Grizzly bear (*Ursus arctos*)	Soil	$SSRBCC_{soil} = \frac{0.80 \times TRV \times BW}{[IR_S \times BF] + [IR_F \times BAF]}$	CCME (2006)
	Water	$SSRBCC_{water} = \frac{0.20 \times TRV \times BW}{IR_W}$	CCME (1999)
Mammalian Terrestrial Carnivore: Red fox (*Vulpes vulpes*)	Soil	$SSRBCC_{soil} = \frac{0.80 \times TRV \times BW}{[IR_S \times BF] + [IR_F \times BAF]}$	CCME (2006)
	Water	$SSRBCC_{water} = \frac{0.20 \times TRV \times BW}{IR_W}$	CCME (1999)
Mammalian Terrestrial Omnivore: Northern red-backed vole (*Myodes rutilus*)	Soil	$SSRBCC_{soil} = \frac{0.80 \times TRV \times BW}{[IR_S \times BF] + [IR_F \times BAF]}$	CCME (2006)
	Water	$SSRBCC_{water} = \frac{0.20 \times TRV \times BW}{IR_W}$	CCME (1999)
Mammalian Fish Consumer: Grizzly bear (*Ursus arctos*)	Fish tissue	$SSRBCC_{fish} = \frac{TRV}{\left(\frac{IR_{Fi}}{BW}\right)}$	CCME (2000)
Avian Aquatic Insectivore: Semi-palmated sandpiper (*Calidris pusilla*)	Water	$SSRBCC_{water} = \frac{0.20 \times TRV \times BW}{IR_W}$	CCME (1999)
	Sediment	$SSRBCC_{sediment} = \frac{0.80 \times TRV \times BW}{[IR_S \times BF] + [IR_F \times BAF]}$	CCME (1995, 2006)

(continued)

Table 1.2-1. Equations Used in Calculation of Site-specific Risk-based Closure Criteria (continued)

Receptor of Concern	Media	Site-specific Risk-based Closure Criteria Equations	Reference
Avian Aquatic Omnivore: Long-tailed Duck (*Clangula hyemalis*)	Water	$SSRBCC_{water} = \frac{0.20 \times TRV \times BW}{IR_W}$	CCME (1999)
	Sediment	$SSRBCC_{sediment} = \frac{0.80 \times TRV \times BW}{[IR_S \times BF] + [IR_F \times BAF]}$	CCME (1995, 2006)
Avian Terrestrial Herbivore: Willow Ptarmigan (*Lagopus lagopus*)	Soil	$SSRBCC_{soil} = \frac{0.80 \times TRV \times BW}{[IR_S \times BF] + [IR_F \times BCF]}$	CCME (2006)
	Water	$SSRBCC_{water} = \frac{0.20 \times TRV \times BW}{IR_W}$	CCME (1999)
Avian Terrestrial Carnivore: Peregrine falcon (*Falco peregrinus*)	Water	$SSRBCC_{water} = \frac{1.0 \times TRV \times BW}{IR_W}$	CCME (1999)
Avian Aquatic/terrestrial Carnivore: Bald eagle (*Haliaeetus leucocephalus*)	Water	$SSRBCC_{water} = \frac{1.0 \times TRV \times BW}{IR_W}$	CCME (1999)
Avian Fish Consumer: Peregrine falcon and Bald eagle	Fish tissue	$SSRBCC_{fish} = \frac{TRV}{\left(\frac{IR_{Fi}}{BW}\right)}$	CCME (2000)
Human (toddler, adult, sensitive adult)	Soil Ingestion and Contact	$SSRBCC_{soil} = \left(\frac{(TDI - EDI) \times SAF \times BW}{[(AF_G \times IR_S) + (AF_S \times SR) \times ET_2] \times ET_1}\right) + BSC$	CCME (2006)
	Food Ingestion	$SSRBCC_{soil} = \left(\frac{(TDI - EDI) \times SAF \times BW}{(P_h \times IR_P \times BCF_P) + (B_h \times IR_B \times BTF_B \times IR_{SB}) + (L_h \times IR_L \times BTF_L \times IR_{SL})}\right) + BSC$	CCME (2006)
	Water Ingestion	$SSRBCC_{water} = \left(\frac{0.20 \times (TDI - EDI) \times BW}{(IR_W \times ET_2) \times ET_1}\right) + BWC$	CCME (1999)
	Fish Tissue	$SSRBCC_{fish} = \frac{TRV}{\left(\frac{IR_{Fi}}{BW}\right)}$	CCME (2000)

Notes: see next page

Table 1.2-1. Equations Used in Calculation of Site-specific Risk-based Closure Criteria (completed)

Notes:

SSRBCC =	*Site-specific risk-based closure criteria*
TRV =	*toxicity reference value (mg/L; mg/kg; mg/kg BW/day)*
BW =	*body weight (kg)*
IR_S =	*soil or sediment ingestion rate (kg/day dry weight)*
BF =	*bioavailability factor (assume 1; unitless)*
IR_F =	*food ingestion rate (kg/day dry weight)*
BCF =	*bioconcentration factor in plants (Cplants/Csoil; unitless)*
BAF =	*bioaccumulation factor in prey (Cprey/Csoil; unitless)*
IR_W =	*water ingestion rate (L/day)*
IR_{Fi} =	*fish ingestion rate (kg/day)*
TDI =	*tolerable daily intake (mg/kg BW/day)*
EDI =	*estimated daily intake (mg/kg BW/day)*
SAF =	*soil allocation factor (unitless)*
AF_G =	*relative absorption factor for the gut (assume 1; unitless)*
AF_S =	*relative absorption factor for skin (unitless)*
SR =	*soil dermal contact rate (kg/day)*
ET_1 =	*exposure term 1 (days per week/7 × weeks per year/52; unitless)*
ET_2 =	*exposure term 2 (hours per day/24; unitless)*
BSC =	*background soil concentration (mg/kg)*
P_h =	*percent of plants consumed that are traditionally harvested (assume 100%)*
IR_P =	*plant ingestion rate (kg/day)*
BCF_p =	*bioconcentration factor for plants*
B_h =	*percentage of bird meat traditionally harvested (assume 100%)*
IR_B =	*bird ingestion rate (kg/day)*
BTF_B =	*biotransfer factor for birds (chicken; day/kg)*
IR_{SB} =	*soil ingestion rate by birds (ptarmigan; kg/day)*
L_h =	*percentage of land animal meat traditionally harvested (assume 100%)*
IR_L =	*land animal ingestion rate (kg/day)*
BTF_L =	*biotransfer factor for land animals (beef; day/kg)*
IR_{SL}=	*soil ingestion rate by land animals (caribou; kg/day)*
BWC =	*background water concentration (mg/L)*

1.3.1 Wildlife-specific Parameters

The parameters for wildlife ROCs are provided in Table 1.3-1. The BWs of the wildlife ROCs are for the upper range of either males or females (whichever is larger) obtained from Environment Canada (2012b), published literature, or online resources for birds and wildlife (see Table 1.3-1). The food and water ingestion rates for the wildlife ROCs are based on allometric equations for mammals and birds provided by the Oak Ridge National Laboratory (ORNL 1997). The IR_S were set to the default value of 2% of the IR_F recommended by Environment Canada (2012b), unless species-specific information was available in the literature (as indicated by references for soil ingestion that are not from Environment Canada).

It was conservatively assumed that caribou may spend up to two months of the year on-site while they migrate through the area (i.e., 60 days out of 365 days; ET = 0.164). It was assumed that smaller animals could spend their entire lives on-site, thus the exposure time for red fox, northern red-backed vole, and willow ptarmigan were set to 1 (i.e., 365 days out of 365 days).

Table 1.3-1. Wildlife Parameters

	Body Weight Parameter		Dietary Parameters			Soil Parameter			
Wildlife Species	Body Weight (kg)	Reference	Diet Item	% of Diet	Reference	Soil Ingestion Rate[a] (IR_S; kg-dw/day)	Reference	Food Ingestion Rate[b] (IR_F; kg-dw/day)	Water Ingestion Rate[b] (IR_W; L/day)
Caribou	150	Environment Yukon (2015)	Vegetation	100	Environment Yukon (2015)	0.0668	Environment Canada (2012b)	3.34	9.00
Grizzly Bear	640	State of Alaska (2015)	Caribou	35.3	Gau et al. (2002)	0.390	Gau et al. (2002)	4.91	33.2
			Northern Red-backed Vole	5.04				0.702	
			Long-tailed Duck	5.04				0.702	
			Ptarmigan	5.04				0.702	
			Vegetation	46.8				6.51	
			Fish	2.80				0.390	
Red Fox	4.10	Environment Canada (2012b)	Northern Red-backed Vole	40.0	Environment Canada (2012b)	0.00614	US EPA (1993)	0.0876	0.352
			Long-tailed Duck	10.0				0.0219	
			Ptarmigan	10.0				0.0219	
			Vegetation	15.0				0.0329	
			Terrestrial Invertebrates	25.0				0.0548	
Northern Red-backed Vole	0.0400	Smithsonian National Museum of Natural History (2015)	Vegetation	80.0	IUCN (2015)	0.000120	Beyer and Fries (2003)	0.00398	0.00546
			Terrestrial Invertebrates	20.0				0.00100	
Semi-palmated Sandpiper	0.0320	Cornell Lab of Ornithology (2015b)	Terrestrial Invertebrates	50.0	Cornell Lab of Ornithology (2015b)	0.00186 [c]	Beyer and Fries (2003)	0.00310	0.00588
			Aquatic Invertebrates	50.0				0.00310	
Long-tailed Duck	1.10	Cornell Lab of Ornithology (2015a)	Benthic invertebrates	90.0	(Cornell Lab of Ornithology 2015a); BC MOE (2001)	0.00124 [c]	Environment Canada (2012b)	0.0557	0.0629
			Fish	5.00				0.00310	
			Aquatic plants	5.00				0.00310	
Willow Ptarmigan	0.810	Cornell Lab of Ornithology (2015c)	Vegetation	100	Cornell Lab of Ornithology (2015c)	0.00507	Beyer and Fries (2003)	0.0507	0.0512

(continued)

Table 1.3-1. Wildlife Parameters (completed)

Wildlife Species	Body Weight Parameter		Dietary Parameters			Soil Parameter		Food Ingestion Rate[b] (IR_F; kg-dw/day)	Water Ingestion Rate[b] (IR_W; L/day)
	Body Weight (kg)	Reference	Diet Item	% of Diet	Reference	Soil Ingestion Rate[a] (IR_S; kg-dw/day)	Reference		
Peregrine Falcon	1.19	Environment Canada (2012b)	Northern Red-backed Vole	10.0	Environment Canada (2012b)	0.00130	Environment Canada (2012b)	0.00652	0.0663
			Long-tailed Duck	28.3				0.0184	
			Ptarmigan	28.3				0.0184	
			Semi-palmated Sandpiper	28.3				0.0184	
			Fish	5.00				0.00326	
Bald Eagle	6.40	Environment Canada (2012b)	Caribou	10.0	Environment Canada (2012b)	0.00390	Environment Canada (2012b)	0.0195	0.205
			Northern Red-backed Vole	10.0				0.0195	
			Semi-palmated Sandpiper	5.00				0.00974	
			Long-tailed Duck	5.00				0.00974	
			Ptarmigan	5.00				0.00974	
			Fish	65.0				0.127	

Notes:

dw = dry weight

[a] *Not all references cited had soil ingestion for the specific wildlife receptor, therefore soil ingestion rates for closely related species were used (e.g., meadow vole represents northern red-backed vole), or the default value of 2% of the food ingestion rate.*

[b] *The food and water ingestion rates were obtained from ORNL (1997) and are based on equations for mammals and birds.*

[c] *Semi-palmated sandpiper and Long-tailed duck ingest sediment rather than soil.*

Grizzly bears hibernate during cold months, thus it was conservatively assumed that they would be on-site for six months of the year (i.e., 180 days out of 365; ET = 0.493). Semi-palmated sandpiper, long-tailed duck, peregrine falcon, and bald eagles spend the summer months in the arctic and migrate to locations further south for the winter months. Thus it was conservatively assumed that these migratory birds spend six months of the year on-site (i.e., 180 days out of 365; ET = 0.493).

1.3.2 Human Parameters

The parameters for human ROCs (adults and toddlers) are provided in Table 1.3-2. The BW, IR_S, IR_W, skin surface areas (SA_H and SA_O), and dermal loadings (DL_H and DL_O) are standard values Health Canada (2010a) recommends for use in human health risk assessments.

Table 1.3-2. Adult and Toddler Parameters

Parameter	Adult	Toddler	Reference
Body Weight (BW; kg)	70.7	16.5	Health Canada (2010a)
Soil Ingestion Rate (IR_S; kg/day)	0.0000200	0.0000800	Health Canada (2010a)
Water Ingestion Rate (IR_W; L/day)	1.50	0.600	Health Canada (2010a)
Fish Ingestion Rate [a] (IR_{Fi}; kg/day ww)	0.113	0.0565	Batal et al. (2005)
Land Animal Ingestion Rate [a] (IR_L; kg/day ww)	0.242	0.121	Batal et al. (2005)
Bird Ingestion Rate [a] (IR_B; kg/day ww)	0.0340	0.0170	Batal et al. (2005)
Plant Ingestion Rate [a] (IR_P; kg/day ww)	0.355	0.178	Batal et al. (2005)
Exposure Time (ET; number of days on-site/365; unitless)	0.230	0.230	Golder Associates Ltd. (2015a)
Surface area of hands (SA_H; cm^2)	890	430	Health Canada (2010a)
Surface area of body other than hands (SA_O; cm^2)	2,055	645	Health Canada (2010a)
Dermal loading of soil to hands (DL_H; kg/cm^2-event)	1.00×10^{-7}		Health Canada (2010a)
Dermal loading of soil to body other than hands (DL_O; kg/cm^2-event)	1.00×10^{-8}		Health Canada (2010a)

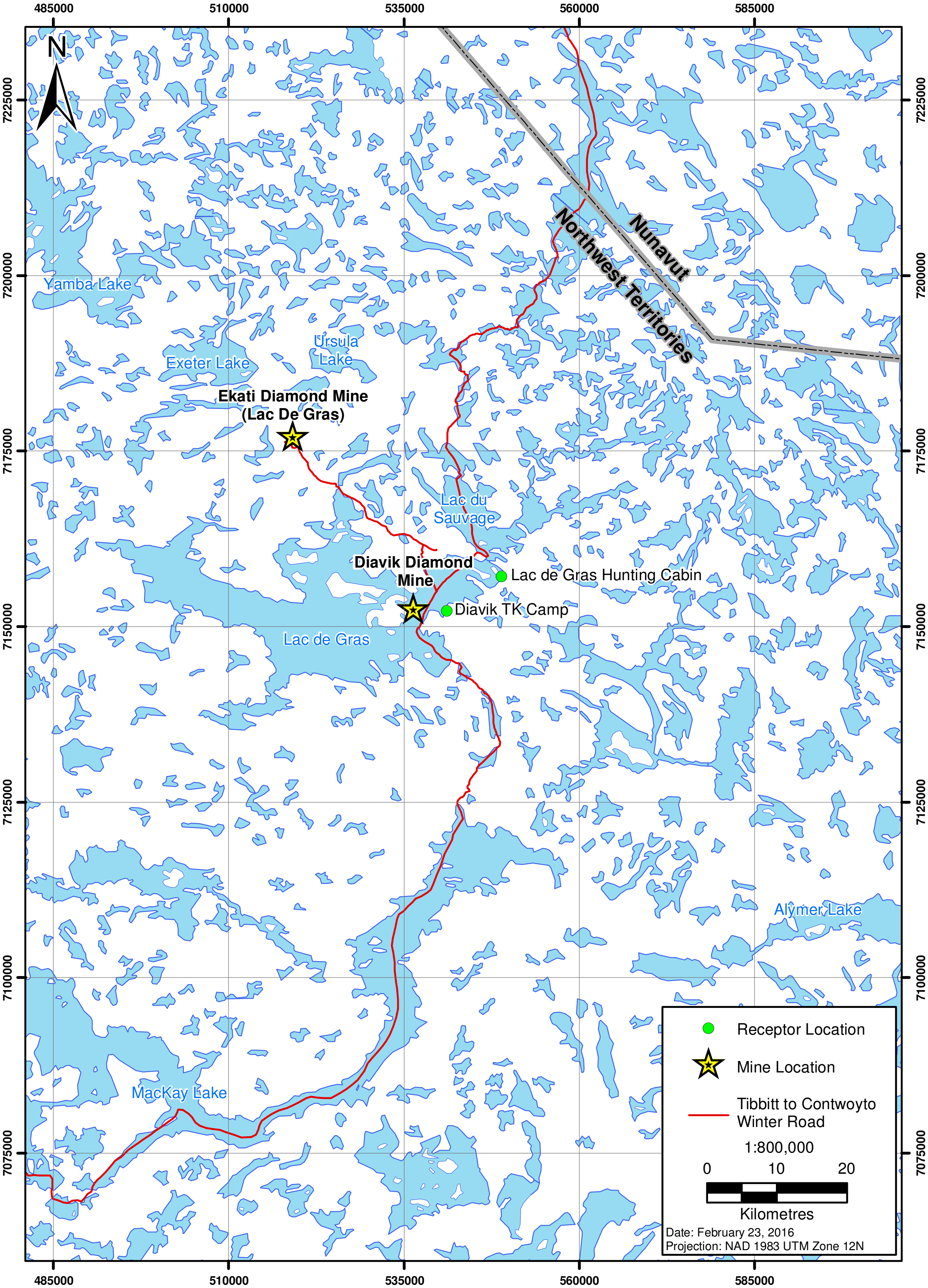
Notes:
ww = wet weight
[a] *Per capita food consumption in Denendeh (NT), showing the highest consumption amount (season and sex dependent).*

The ingestion rate of traditional foods was obtained from a 24-hour recall questionnaire conducted by Batal et al. (2005) in the McKenzie basin of the Northwest Territories. The study reported the per capita intake of traditional foods (i.e., fish, land animals, birds, and plants) for men and women during summer and winter.

The adult traditional food ingestion rates shown in Table 1.3-2 are the total amount (in kilograms) of fish, land animals, birds, and plants consumed per day by indigenous people in Denendeh (Northwest Territories not including the survey responses from the Yukon; Batal et al. 2005). The highest consumption rate was adopted, which was either for men (i.e., land animals, birds, plants) or women (i.e., fish) in either summer (i.e., fish and birds) or winter (i.e., land animals and plants). It is assumed that the daily consumption rate is representative of foods consumed every day of the year. The study reported the per capita ingestion rates in wet weight, which is what is required in the calculation of the soil SSRBCC for humans due to food ingestion (CCME 2006). It was conservatively assumed that toddlers (age one to four years old) consume 50% of the food that adults do (Health Canada 2007).

The exposure time for humans to be present at the Project site was assumed to be three months of the year. The human health risk assessment for the Jay Project (which is an expansion of the nearby Ekati Mine; Figure 1.3-1), assumed that a hunting guide could spend three months of the year at hunting camps near the Jay project (Golder Associates Ltd. 2015a). It was assumed that other hunters, fishers, and community members would only be in the area for one to two weeks since hunting, trapping, and plant gathering far from city centers occurs less often than it did in the past (Golder Associates Ltd. 2015b). There are two hunting camps/cabins along Lac de Gras near the Project (Golder Associates Ltd. 2015a): the Diavik TK camp and the Lac de Gras hunting cabin (Figure 1.3-1). Therefore, it was conservatively assumed that people (i.e., hunting guides, including their families with children) could spend up to three months of the year at hunting camps near the Project site.

Figure 1.3-1
Diavik Project Location and Hunting Camp Locations



2. TOXICITY REFERENCE VALUES

A database and literature search provided appropriate toxicity reference value (TRV) for each COPC identified in the different environmental media. A toxicity reference value is the concentration of a COPC that is considered to be safe for chronic exposure of ROCs. The database and literature search for TRVs considered the following sources:

- technical appendices included in the CCME guidelines (CCME 2015);
- United States Environmental Protection Agency (US EPA) Ecotox Database (US EPA 2016a);
- US EPA Integrated Risk Information System (IRIS; US EPA 2016b);
- US EPA Ecological Soil Screening Level (Eco SSL) documents (US EPA 2003);
- Agency for Toxic Substances and Disease Registry (ATSDR 2016);
- Health Canada guidance documents for human health risk assessments (Health Canada 2010b, 2010a, 2011);
- Oak Ridge National Laboratory (ORNL) toxicological benchmarks for wildlife (Sample, Opresko, and Suter II 1996); and
- primary literature.

TRVs were derived from toxicity assessment and measurement endpoints in the following order of preference:

1. Effect concentrations (EC_x) or effect dose (ED_x). These concentrations relate to toxicity endpoints other than mortality (i.e., reproduction and growth) where a percentage of individuals exposed to a COPC exhibit a response over a specific time period. For example, an EC_{10} indicates that 10% of the individuals or population tested at a certain concentration have exhibited a specific toxicological effect other than mortality (e.g., decreased growth) or that the performance of an organism has decreased by 10% relative to the control group (e.g., 10% decrease in weight gain). Toxicity reference values from toxicity studies considering acute exposures were included only if chronic exposure data were not available.
2. Lethal concentrations (LC_x) or lethal doses (LD_x). These endpoints are similar to EC_x and ED_x except that the endpoint is lethality (for example, an LC_{50} refers to the concentration at which mortality occurs in 50% of exposed organisms). If EC_x or ED_x were not available, LC_x and LD_x would be used in combination with a modifying factor (i.e., a safety/uncertainty factor to convert from a lethal to a sub-lethal endpoint) to derive an appropriate long-term TRV.
3. Although not preferred by Environment Canada (2010) and the CCME (2007), if the above toxicity threshold concentrations are not available, then the following concentrations for defining toxicity endpoints were considered:
   - no observed effect concentration (NOEC);
   - lowest observed effect concentration (LOEC); and
   - maximum acceptable toxicant concentration (MATC), which is a geometric mean of LOEC and NOECs.

Available toxicological data on algae, phytoplankton, aquatic plants, zooplankton, benthic invertebrates, and fish species identified in Lac de Gras were included in the TRV search. The aquatic species that have been observed in Lac de Gras are presented in Appendices B, C, D, and E. Available toxicological data on terrestrial plants observed on-site at the Project (Appendix F) were also included in the TRV search.

The TRVs for wildlife and human ROCs are based on daily exposures that could occur over a lifetime without causing any measurable adverse effects to individuals that could lead to a reduction in population. The toxicity studies on which the TRVs were based for use in the SSRBCC calculations and their rationale for selection are described in Appendix G. Tables 2-1 to 2-5 provide a summary of the TRVs selected for use in the development of SSRBCCs for the various ROCs and environmental media.

Table 2-1. Toxicity Reference Values for Aquatic Life Receptors

COPCs in Water	Aquatic Plant and Algae TRV (mg/L)	Zooplankton and Benthic Invertebrate TRV (mg/L)	Fish TRV (mg/L)
Aluminum	-	0.100[a]	0.175
Arsenic	0.048	0.520	0.550
Cadmium	0.005	0.000150	0.000150
Chromium	40	0.300	0.0890
Copper	0.009	0.00228	0.00400
Fluoride	437	75.1	0.270
Iron	-	0.960	0.410[a]
Lead	-	37.6	0.00600
Mercury	0.005	0.000675	0.000470
Molybdenum	-	741	0.0730
Nickel	0.1	0.0950	0.134
Nitrate	-	358	190
Nitrite	46	100	0.0600
Potassium	-	53.0	950
Selenium	17	0.0771	23.8
Silver	5.1	0.00212	0.000240[b]
Sulphate	1,900	380	176[a]
Uranium	0.172	0.0120	0.35
Zinc	-	0.0560[a]	0.0880
COPCs in Sediment		**Zooplankton and Benthic Invertebrate TRV (mg/kg)**	
Arsenic	N/A	174	N/A
Chromium	N/A	16.7	N/A
Copper	N/A	69.6	N/A
2-Methylnaphthalene	N/A	0.201 [c]	N/A

(continued)

Table 2-1. Toxicity Reference Values for Aquatic Life Receptors (completed)

COPCs in Sediment		Zooplankton and Benthic Invertebrate TRV (mg/kg)	
Acenaphthene	N/A	0.0889 [c]	N/A
Acenaphthylene	N/A	0.128 [c]	N/A
Naphthalene	N/A	0.391 [c]	N/A
Pyrene	N/A	59.1	N/A

Notes:
COPC = contaminant of potential concern
TRV = toxicity reference value
(-) = not available
N/A = exposure route is not applicable and a TRV is not required
Grey shading indicates the lowest aquatic life TRV, which was considered in the selection of a SSRBCC for water or sediment.
[a] *Based on an LC_X thus was not adopted as the aquatic life TRV as EC_X values are preferred.*
[b] *Based on a maximum acceptable toxicant concentration (MATC) for growth thus was not adopted as the aquatic life TRV as EC_X values are preferred.*
[c] *The CCME probable effects level was adopted as the TRV (CCME 2015).*

Table 2-2. Toxicity Reference Values for Terrestrial Plant and Invertebrate Receptors

COPCs in Soil	Terrestrial Plant TRV (mg/kg)	Terrestrial Invertebrate TRV (mg/kg)
Aluminum	-	-
Barium	-	330
Chromium	67.6	671
Manganese	220	450
Molybdenum	9.79	220

Notes:
COPC = contaminant of potential concern
TRV = toxicity reference value
(-) = not available
Grey shading indicates the lowest terrestrial plant or invertebrate TRV, which was considered in the selection of a SSRBCC for soil.

Table 2-3. Toxicity Reference Values for Mammalian Wildlife Receptors

COPCs in Water, Soil, and Fish Tissue	TRV (mg/kg BW/day)	COPCs in Water, Soil, and Fish Tissue *(cont'd)*	TRV (mg/kg BW/day)
Aluminum	1.93	Mercury	1.01
Barium	51.8	Methylmercury	0.0220
Chromium	2.40	Molybdenum	0.260
Cobalt	7.33	Nickel	1.70
Manganese	51.5	Uranium	3.07

Notes:
COPC = contaminant of potential concern
TRV = toxicity reference value
BW = body weight

Table 2-4. Toxicity Reference Values for Avian Wildlife Receptors

COPCs in Water, Sediment, Soil, and Fish Tissue	TRV (mg/kg BW/day)	COPCs in Water, Sediment, Soil, and Fish Tissue *(cont'd)*	TRV (mg/kg BW/day)
Aluminum	110	Molybdenum	3.50
Arsenic	2.24	Nickel	6.71
Barium	20.8	Uranium	16.0
Chromium	2.66	2-Methylnaphthalene	1,653
Cobalt	7.61	Acenaphthene	175
Copper	4.05	Acenaphthylene	180
Manganese	179	Naphthalene	1,653
Mercury	0.450	Pyrene	125
Methylmercury	0.0310		

Notes:
COPC = contaminant of potential concern
TRV = toxicity reference value
BW = body weight

Table 2-5. Toxicity Reference Values for Human Receptors

COPCs in Water, Sediment, Soil, and Fish Tissue	TRV (mg/kg BW/day)		COPCs in Water, Sediment, Soil, and Fish Tissue *(cont'd)*	TRV (mg/kg BW/day)	
	Adult	Toddler		Adult	Toddler
Aluminum	0.300	0.300	Methylmercury [b]	0.000470	0.000230
Antimony	0.00300	0.00300	Molybdenum	0.0280	0.0230
Arsenic	0.000300	0.000300	Nitrate	1.60	1.60
Barium	0.200	0.200	Nitrite	0.0100	0.0100
Chromium	0.00100	0.00100	Selenium	0.00570	0.00620
Manganese	0.156	0.136	Sulphate	14.0	60.6
Mercury [a]	0.000300	0.000300	Uranium	0.000600	0.000600

Notes:
COPC = contaminant of potential concern
TRV = toxicity reference value
BW = body weight
[a] *Total mercury TRV for adults and toddlers eating biota other than fish.*
[b] *Methylmercury TRV for general public eating fish is 0.00047 mg/kg BW/day, while that for children, women of child-bearing age, and pregnant women eating fish is 0.00023 mg/kg BW/day.*

3. SITE-SPECIFIC RISK-BASED CLOSURE CRITERIA

A SSRBCC was calculated for each ROC in the applicable environmental media, using the equations described in Section 1.2 and detailed in Appendix A. The lowest SSRBCC from each of the ROCs for COPCs in soil, water, sediment, and fish tissue are presented in the sections that follow. In cases where the SSRBCCs were lower than the guidelines and benchmarks, the guidelines and/or benchmarks were adopted as the SSRBCC. Defaulting to the guideline or benchmark is appropriate as the SSRBCCs are conservative due to the assumptions used in their calculations (Section 4).

The SSRBCCs for aquatic life (i.e., primary producers, zooplankton, benthic invertebrates, and fish) are equivalent to the TRVs, which are provided in Table 2-1 and Appendix G. The SSRBCCs for terrestrial plants and invertebrates are also equivalent to the TRVs, which are provided in Table 2-2 and Appendix G. Appendices H, I, and J show the calculated SSRBCCs for mammals, birds, and humans, respectively.

3.1 SITE-SPECIFIC RISK-BASED CLOSURE CRITERIA FOR SOIL

The COPCs identified in soil for human and ecological ROCs were: aluminum, barium, chromium, manganese, and molybdenum. The lowest $SSRBCC_{soil}$ for each of these COPCs is presented in Table 3.1-1.

Table 3.1-1. Site-specific Risk-based Closure Criteria for Soil

Soil COPCs	CCME Soil Quality Guideline (Residential/Parkland or Agricultural; mg/kg dw) [a]	$SSRBCC_{soil}$ (mg/kg dw)	Receptor of Concern the $SSRBCC_{soil}$ is Based On
Aluminum	-	-	-
Barium	500	500 [b]	Toddler
Chromium	64	66.9	Toddler
Manganese	220 [c]	220	Terrestrial Plant
Molybdenum	5	5 [b]	Toddler

Notes:
COPC = contaminant of potential concern
CCME = Canadian Council of Ministers of the Environment
dw = dry weight
$SSRBCC_{soil}$ = site-specific risk-based closure criteria for soil
(-) = not available
[a] CCME (2015)
[b] The $SSRBCC_{soil}$ for barium and molybdenum have been defaulted to the CCME Soil Quality Guideline (CCME 2015).
[c] No CCME guideline. Value listed is the US EPA Eco SSL value for plants for manganese (US EPA 2007).

A SSRBCC for aluminum was not calculated as the CCME soil quality guideline for aluminum only applies to soil with a pH less than 5.5, and it is assumed that the type 1 soil has a neutral pH. Thus calculation of an aluminum $SSRBCC_{soil}$ is not necessary.

3.2 SITE-SPECIFIC RISK-BASED CLOSURE CRITERIA FOR WATER

The COPCs identified in water for human ROCs were: antimony, arsenic, chromium, iron, manganese, mercury, nitrate, nitrite, selenium, sulphate, and uranium. The COPCs identified in water for ecological ROCs were: aluminum, arsenic, cadmium, chromium, cobalt, copper, fluoride, iron, lead, manganese, mercury, molybdenum, nickel, nitrate, nitrite, potassium, selenium, silver, sulphate, uranium, and zinc. The lowest $SSRBCC_{water}$ for each of these COPCs is presented in Table 3.2-1.

The phase I report also screened in molybdenum (ERM 2016). However, the most recent Aquatic Effects Monitoring Plan (Golder Associates Ltd. 2014) removed the Diavik Benchmark for molybdenum in water for humans because it does not have a Health Canada drinking water quality guideline (DWQG ; Health Canada 2015). Therefore, a SSRBCC for molybdenum in drinking water for humans was not calculated.

As described in Appendix G, iron was excluded as a COPC for humans because it is an essential element for humans and environmental exposure to iron from food or water consumption is not likely to lead to adverse health effects.

3.3 SITE-SPECIFIC RISK-BASED CLOSURE CRITERIA FOR SEDIMENT

The COPCs identified in sediment for ecological ROCs were: arsenic, chromium, copper, 2-methylnaphthalene, acenaphthene, acenaphthylene, naphthalene, and pyrene. The lowest $SSRBCC_{sediment}$ for each of these COPCs is presented in Table 3.3-1.

Due to the lack of data on sediment toxicity in the literature and CCME guidance (CCME 1995), there is too much uncertainty to develop a reliable $SSRBCC_{sediment}$ at this time. Because of the incomplete science, there is little confidence that the values calculated are protective of aquatic species. Furthermore, studies have shown that sediment toxicity depends on whether the organism is exposed to whole-sediment, pore water, and/or elutriate (e.g., Ankley, Schubauer-Berigan, and Dierkes 1991; Harkey, Landrum, and Klaine 1994; Chapman et al. 2002). Therefore, the $SSRBCC_{sediment}$ were defaulted to the CCCME PELs (CCME 2015).

3.4 SITE-SPECIFIC RISK-BASED CLOSURE CRITERIA FOR FISH TISSUE

Methylmercury was identified in fish tissue as a COPC for ecological and human receptors. The lowest $SSRBCC_{fish}$ for methylmercury was 0.0672 mg/kg wet weight (ww), which was for toddlers consuming fish. However, this methylmercury fish tissue residue concentration is lower than the British Columbia Ministry of Environment (BC MOE) tissue residue guideline for fish/shellfish consumption by humans for high fish consumers (the guideline is 0.1 mg/kg ww at a consumption rate of 1,050 grams ww; BC MOE 2015). Therefore, BC MOE tissue residue guideline for fish/shellfish consumption by humans for high fish consumers was adopted as the $SSRBCC_{fish}$ (Table 3.4-1).

Table 3.2-1. Site-specific Risk-based Closure Criteria for Water

Water COPCs	Diavik Water Quality Benchmark (mg/L) [a]	CCME Water Quality Guideline for the Protection of Aquatic Life (mg/L) [b]	CCME Water Quality Guideline for the Protection of Agriculture - Irrigation (mg/L) [b]	CCME Water Quality Guideline for the Protection of Agriculture - Livestock (mg/L) [b]	Health Canada Drinking Water Quality Guideline (mg/L) [c]	$SSRBCC_{water}$ (mg/L)	Receptor of Concern the $SSRBCC_{water}$ is Based On
Aluminum	0.1 or 0.2	0.1	5	5	0.1	0.175	Fish
Antimony	0.006	-	-	-	0.006	0.066	Toddler
Arsenic	0.005	0.005	0.1	0.025	0.01	0.01 [d]	Toddler
Cadmium	0.0001	0.00009	0.0051	0.08	0.005	0.00015	Fish
Chromium	0.001	0.001	0.008	0.05	0.05	0.05 [d]	Toddler
Cobalt	-	-	0.05	1	-	8.28	Semi-palmated Sandpiper
Copper	0.002	0.002	0.2	0.5	1	0.0023	Zooplankton
Fluoride	0.12	0.12	1	2	1.5	0.27	Fish
Iron	0.3	0.3	5	-	0.3	0.96	Zooplankton
Lead	0.001	0.001	0.2	0.1	0.01	0.006	Fish
Manganese	0.05	-	0.2	-	0.05	0.3	Toddler
Mercury	0.000026	0.000026	-	0.003	0.001	0.00047	Fish
Molybdenum	0.073	0.073	0.01	0.5	-	0.073	Fish
Nickel	0.025	0.025	0.2	1	-	0.095	Zooplankton
Nitrate	3	13	-	-	10	17.6	Toddler
Nitrite	0.06	0.06	-	10	1	0.06	Fish
Potassium	64 [e]	-	-	-	-	64.0 [f]	Zooplankton
Selenium	0.001	0.001	0.02	0.05	0.05	0.005	Benthic Invertebrate
Silver	0.0001	0.00025	-	-	-	0.0021	Zooplankton
Sulphate	100	-	-	1,000	500	380	Benthic Invertebrate

(continued)

Table 3.2-1. Site-specific Risk-based Closure Criteria for Water (completed)

Water COPCs	Diavik Water Quality Benchmark (mg/L) [a]	CCME Water Quality Guideline for the Protection of Aquatic Life (mg/L) [b]	CCME Water Quality Guideline for the Protection of Agriculture - Irrigation (mg/L) [b]	CCME Water Quality Guideline for the Protection of Agriculture - Livestock (mg/L) [b]	Health Canada Drinking Water Quality Guideline (mg/L) [c]	$SSRBCC_{water}$ (mg/L)	Receptor of Concern the $SSRBCC_{water}$ is Based On
Uranium	0.015	0.015	0.01	0.2	0.02	0.015 [g]	Benthic Invertebrate
Zinc	0.03	0.03	5	50	5	0.088	Fish

Notes:
COPC = contaminant of potential concern
CCME = Canadian Council of Ministers of the Environment
$SSRBCC_{water}$ = site-specific risk-based closure criteria for water
(-) = not available
[a] Golder Associates Ltd. (2014)
[b] CCME (2015)
[c] Health Canada (2015)
[d] The $SSRBCC_{water}$ for arsenic and chromium have been defaulted to the Health Canada Drinking Water Quality Guidelines.
[e] The value listed is the site-specific water quality objective from a nearby project.
[f] The $SSRBCC_{water}$ for potassium has been defaulted to the site-specific water quality objective from a nearby project.
[g] The $SSRBCC_{water}$ for uranium has been defaulted to the CCME Water Quality Guideline for the Protection of Aquatic Life.

Table 3.3-1. Site-specific Risk-based Closure Criteria for Sediment

Sediment COPCs	CCME Sediment Quality Guideline for the Protection of Aquatic Life (mg/kg dw) [a]		$SSRBCC_{sediment}$[b] (mg/kg dw)	Receptor of Concern the $SSRBCC_{sediment}$ is Based On
	Interim Sediment Quality Guideline	Probable Effects Limit		
Arsenic	5.9	17	17	Semi-palmated Sandpiper
Chromium	37.3	90	90	Semi-palmated Sandpiper
Copper	35.7	197	197	Semi-palmated Sandpiper
2-Methylnaphthalene	0.0202	0.201	0.201	Semi-palmated Sandpiper
Acenaphthene	0.00671	0.0889	0.0889	Semi-palmated Sandpiper
Acenaphthylene	0.00587	0.128	0.128	Semi-palmated Sandpiper
Naphthalene	0.0346	0.391	0.391	Semi-palmated Sandpiper
Pyrene	0.053	0.875	0.875	Benthic Invertebrate

Notes:
COPC = contaminant of potential concern
CCME = Canadian Council of Ministers of the Environment
dw = dry weight
$SSRBCC_{sediment}$ = site-specific risk-based closure criteria for sediment
[a] CCME (2015)
[b] The $SSRBCC_{sediment}$ for the metals and PAHs have been defaulted to the CCME probable effects level (CCME 2015) due to the high level of uncertainty in their derivation.

Table 3.4-1. Site-specific Risk-based Closure Criteria for Fish Tissue

Fish Tissue COPC	CCME Tissue Residue Guideline for the Protection of Wildlife Consumers of Aquatic Biota (mg/kg ww) [a]	BC MOE Tissue Residue Guideline for Fish/Shellfish Consumption by Humans (mg/kg ww) [b]	$SSRBCC_{fish}$ (mg/kg ww)	Receptor of Concern the $SSRBCC_{fish}$ is Based On
Methylmercury	0.033	0.1	0.1 [c]	Toddler

Notes:
COPC = contaminant of potential concern
CCME = Canadian Council of Ministers of the Environment
ww = wet weight
$SSRBCC_{fish}$ = site-specific risk-based closure criteria for fish tissue
[a] CCME (2015)
[b] BC MOE (2015)
[c] The BC MOE tissue residue guideline for fish/shellfish consumption by humans was adopted as the $SSRBCC_{fish}$ (BC MOE 2015).

4. UNCERTAINTIES AND ASSUMPTIONS

There is some uncertainty associated with the derivation of SSRBCCs. These uncertainties apply in several areas, including the ROC characteristics and exposure times used in calculations and the selection of TRVs. These uncertainties could result in either an over- or under-estimation of acceptable SSRBCC concentrations. However, for the derivation of SSRBCCs, where uncertainties existed a conservative approach was taken to overestimate rather than underestimate potential risks (i.e., the SSRBCC is considered to be adequately protective, rather than under-protective).

The following uncertainty analysis is a qualitative discussion of the key sources of uncertainty associated with the derivation of SSRBCCs. There may be sources of uncertainty other than those evaluated here; however, their effect on the calculation of the SSRBCCs is considered to be less significant.

4.1 Site-specific Risk-based Closure Criteria Equations

The equations used to derive SSRBCCs were obtained from CCME protocol documents for the derivation of Canadian environmental quality guidelines for water (CCME 1999, 2007), soil (CCME 2006), sediment (CCME 1995), and tissue (CCME 2000). Some modifications of the equations were necessary to render them more site-specific and applicable to relevant exposure times. Standard methodologies for application of the equations have been used and clearly described throughout this report and Appendix A.

The results of the SSRBCC calculations are dependent on the accuracy of the literature-based input parameters and the quality of the equations themselves. It was assumed that the BCFs, BAFs, BSAFs, and BTFs obtained from the literature apply to conditions on-site at the Project. This is a reasonable assumption since the values reported in the literature are typically derived from several studies, thus account for a range of environmental conditions.

To mitigate uncertainty, conservative assumptions were used in the calculations in order to overestimate rather than underestimate potential risks to receptors from exposure to COPCs concentrations approaching the SSRBCCs. These assumptions included:

- simplified diets of the ROCs which attributes higher consumption of food items than is likely realistic (e.g., grizzly bear only consume caribou, northern red-backed vole, long-tailed duck, ptarmigan, vegetation, and fish);
- 100% absorption of COPCs into the body;
- conservative assumptions regarding exposure times of ROCs on-site;
- upper-end estimates of parameters for ROCs (e.g., body weight, ingestion rate, skin surface areas);
- 100% of COPC exposure to the ROCs come from on-site media via the exposure pathways considered (i.e., soil/sediment ingestion, food ingestion, dermal contact, and water ingestion); and

- the upper limit of background media concentrations used in the equations are representative of background environmental media quality.

Overall, it is anticipated that the input parameters for the ROCs (e.g., food ingestion rates, body weights, exposure times) have been overestimated, which would result in conservatism in the SSRBCC calculations. For example, as a conservative approach, it was assumed that toddlers ranging from six months to four years old consumed food at a rate of 50% of an adult consumption frequency. It is unlikely that toddlers consume half the amount of food that an adult would. It is probable that actual ingestion of traditional foods is lower for toddlers thus this assumption adds conservatism to the assessment of SSRBCCs for toddlers.

4.2 Toxicity Reference Values

There is uncertainty associated with estimating TRVs by extrapolating potential effects on aquatic life, wildlife, and humans from studies in the laboratory. However, it was assumed that the adoption of TRVs obtained from toxicity tests on sensitive species are protective of all aquatic life, wildlife, and human ROCs present on-site at the Project. This is consistent with federal guidance (e.g., Health Canada 2010a; Environment Canada 2012a).

For aquatic life, uncertainty was addressed with the use of uncertainty factors, which were applied to acutely lethal concentrations/doses to convert from a lethal to a sub-lethal endpoint to derive an appropriate long-term (chronic) TRV. An uncertainty factor of 10 was used to convert toxicity thresholds between lethal and sub-lethal endpoints (i.e., for chromium in sediment, fluoride in water, and molybdenum in water).

For some media, there is very little chemical-specific toxicological data available for the COPCs (e.g., sediment for individual PAHs), which contributes a high level of uncertainty in attempting to derive SSRBCCs for the Project. For these parameters with higher uncertainty, the CCME probable effects level (PEL) guideline was adopted as the SSRBCC. These SSRBCCs could be revisited in the future if new toxicological data becomes available.

It is standard practice in human health risk assessment to assume that humans are more sensitive to the toxic effects of a substance than laboratory animals. Therefore, the toxicity benchmarks for human health are set at much lower levels than the animal benchmarks (typically 100 to 1,000 times lower due to the application of safety factors). This large margin ensures that doses less than the TRV are safe and that minor exceedances of these benchmarks are unlikely to cause adverse health effects to humans.

5. CONCLUSIONS

The Phase I report (ERM 2016) determined the COPCs present at Diavik in soil, water, sediment, and fish tissue and also determined the ROCs. Site-specific Risk-based Closure Criteria were calculated for each of the COPCs and applicable ROCs using the protocols used for deriving the Canadian environmental quality guidelines (CCME 1995, 1999, 2000, 2006, 2007).

The CCME equations required species-specific input parameters (Section 1.3) and TRVs (Section 2 and Appendix G). Where uncertainty existed in the calculations, conservative assumptions were made to overestimate the risk (i.e., lower concentrations for SSRBCCs) rather than underestimate the risk (i.e., higher SSRBCCs).

As shown in Tables 3.1-1, 3.2-1, 3.3-1, and 3.4-1, the lowest derived SSRBCC for each COPC and media type were compared to:

- CCME environmental quality guidelines for soil, water, sediment, and tissue residue (CCME 2015);
- existing Diavik benchmarks for water quality (Golder Associates Ltd. 2014); and
- BC MOE tissue residue guidelines for fish/shellfish consumption by humans (BC MOE 2015).

Because the calculated SSRBCCs tend to overestimate the risk, the calculated SSRBCCs for soil, water, sediment, and fish tissue are considered protective for the aquatic life, wildlife, and human ROCs considered.

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Appendix A

Equations Used in Calculation of Site-specific Risk-based Closure Criteria and Sample Calculations

APPENDIX A. EQUATIONS USED IN CALCULATION OF SITE-SPECIFIC RISK-BASED CLOSURE CRITERIA AND SAMPLE CALCULATIONS

1.1 SOIL

1.1.1 Terrestrial Plants and Invertebrates

The Canadian Council of Ministers of the Environment (CCME) document *A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines* (CCME 2006) describes how toxicity test information on primary producers (i.e., plants) and soil-dependent invertebrates is used to derive soil quality guidelines. The primary exposure route to soil for plants and soil-dependent organisms is via direct exposure, thus a soil guideline specific to these organisms is simply the lowest applicable toxicity reference value (TRV) based on soil concentrations for those organisms. Therefore, for terrestrial plants and invertebrates, the SSRBCC for soil is equivalent to the TRV as shown in Equation 1:

$$SSRBCC_{soil} = TRV \qquad \text{[Equation 1]}$$

where:
$SSRBCC_{soil}$ = site-specific risk-based closure criteria for soil (mg/kg dry weight)
TRV = toxicity reference value (mg/kg dry weight)

The TRVs selected for terrestrial plants and invertebrates are discussed in Appendix G.

1.1.2 Herbivorous Mammals and Birds (Primary Consumers)

The CCME (2006) document describes the protocol used for deriving Canadian soil quality guidelines for the protection of wildlife health. For these organisms, the soil exposure routes include soil ingestion (i.e., incidental or intentional direct consumption) and food ingestion (uptake of soil contaminants via the food chain from soil). Thus, the procedure to derive a soil quality guideline for mammals and birds involves the evaluation of toxicity studies to derive a TRV and the rearranging of exposure dose equations to solve for the soil concentration. The CCME equation for exposure to substances by primary consumers (i.e., herbivorous wildlife) incorporates soil and food ingestion rates, bioavailability factors, bioconcentration factors from soil to plants, body weights, and a daily effects threshold dose (DETD; CCME 2006). The DETD is equivalent to the TRV.

The proportion of contaminants taken in via all exposure routes must add up to 100% and it is often assumed that each of five potential exposure routes (i.e., ingestion of soil, ingestion of water, ingestion of food, inhalation, and dermal contact) contributes 20% each to the overall exposure. For herbivorous mammals and birds (e.g., caribou and ptarmigan), it was assumed that exposure via the inhalation or dermal contact routes was negligible (Sample et al. 1997; Environment Canada 2012; BC MOE 2013; ERM 2016). The fraction of exposure usually attributed to air inhalation and dermal contact was transferred to the soil and food ingestion exposure routes, as recommended by the CCME (2006). Therefore, it was assumed that 80% of the ROC's intake of the COPC is obtained from soil and food (plant) ingestion, with the remaining 20% from water ingestion. The equation for calculating a SSRBCC for soil for herbivorous mammals and birds is shown as Equation 2:

$$SSRBCC_{soil} = \frac{0.80 \times TRV \times BW}{[IR_S \times BF] + [IR_F \times BCF]} \quad \text{[Equation 2]}$$

where:
$SSRBCC_{soil}$ = site-specific risk-based closure criteria for soil (mg/kg dry weight)
0.80 = proportion of COPC exposure attributed to soil and food ingestion (unitless)
TRV = toxicity reference value (mg/kg BW/day)
BW = body weight (kg)
IR_S = ingestion rate of soil (kg/day dry weight)
BF = bioavailability factor (assume 1; unitless)
IR_F = ingestion rate of food (kg/day dry weight)
BCF = bioconcentration factor (unitless)

The BW, IR_S, and IR_F for birds and mammals are provided in Table 1.3-1 of the main document. The bioconcentration factors (BCFs; soil-to-plant) used for mammals are birds are presented in Table A-1. The TRVs for mammals and birds are discussed in Appendix G.

Table A-1. Bioconcentration Factors for Herbivorous Mammals and Birds

COPC	BCF	Reference
Aluminum	0.00400	Baes et al. (1984)
Barium	0.156	CHPPM (2004)
Chromium	0.105	CHPPM (2004)
Manganese	0.700	Staven et al. (2003)
Molybdenum	1.25	CHPPM (2004)

Notes:
COPC = contaminant of potential concern
BCF = bioconcentration factor (unitless; BCF = concentration in plant/concentration in soil)

The SSRBCCs were not adjusted for the bioavailability (BF) of COPCs. Bioavailability describes the amount the ingested COPC is absorbed into the blood and distributed to target organs. However, due to a lack of information on the bioavailability of contaminants from ingested soil for wildlife species, the CCME (2006) recommends assuming a BF of one (i.e., 100% absorption of the COPC into the body from soil or dietary items).

A sample calculation of the barium $SSRBCC_{soil}$ for caribou using Equation 2 is as follows:

$$SSRBCC_{soil} = \frac{0.80 \times \dfrac{51.8 \frac{mg}{kg\ BW}}{day} \times 150\ kg\ BW}{[0.0668\ kg/day \times 1] + [3.34\ kg/day \times 0.156]}$$

$$SSRBCC_{soil} = 10{,}574 \frac{mg}{kg}\ dry\ weight$$

Note that the barium $SSRBCC_{soil}$ shown in the sample calculation is slightly different than what is shown in Appendix H (10,567 mg/kg dry weight) due to rounding of the ingestion rate parameters. The sample calculation is shown here for illustrative purposes only and the values shown for the SSRBCCs in Appendix H are the true values.

1.1.3 Carnivorous and Omnivorous Mammals (Secondary or Tertiary Consumers)

The CCME (2006) equation for exposure to COPCs by secondary and tertiary consumers (i.e., grizzly bear, red fox, and northern red-backed vole) is almost the same as that for primary consumers; however, instead of a bioconcentration factor for food ingestion, a bioaccumulation factor for food ingestion is applied instead that accounts for movement of the COPC through multiple levels of the food chain.

For carnivorous and omnivorous mammals (i.e., grizzly bear, red fox, and northern red-backed vole), it was assumed that 80% of the ROC's intake of the COPC is obtained from soil and food ingestion, with the remaining 20% from water ingestion. This is a conservative assumption as the ROCs can also intake COPCs via air or dermal contact; however, since those exposure routes are considered to be negligible (see Section 1.1.2), the fraction usually attributed to air inhalation and dermal contact was transferred to soil and food ingestion, as recommended by the CCME (2006). The equation for calculating a SSRBCC for soil for carnivorous and omnivorous mammals is shown in Equation 3:

$$\mathrm{SSRBCC_{soil}} = \frac{0.80 \times \mathrm{TRV} \times \mathrm{BW}}{[\mathrm{IR_S} \times \mathrm{BF}] + [\mathrm{IR_F} \times \mathrm{BAF}]} \qquad \text{[Equation 3]}$$

where:
$SSRBCC_{soil}$ = site-specific risk-based closure criteria for soil (mg/kg dry weight)
0.80 = proportion of COPC exposure attributed to soil and food ingestion (unitless)
TRV = toxicity reference value (mg/kg BW/day)
BW = body weight (kg)
IR_S = ingestion rate of soil (kg/day dry weight)
BF = bioavailability factor (assume 1; unitless)
IR_F = ingestion rate of food (kg/day dry weight)
BAF = bioaccumulation factor (unitless)

The BW, IR_S, and IR_F for carnivorous and omnivorous mammals are provided in Table 1.3-1 of the main document. The bioaccumulation factors (BAFs; soil-to-prey) used for carnivorous and omnivorous mammals are presented in Table A-2. The TRVs for mammals are discussed in Appendix G.

Table A-2. Bioaccumulation Factors for Omnivorous and Carnivorous Mammals

COPC	BAF	Reference
Aluminum	0.00150	RAIS (2016)
Barium	0.00100	CHPPM (2004)
Chromium	0.0846	CHPPM (2004)
Manganese	0.0205	CHPPM (2004)
Molybdenum	0.00600	RAIS (2016)

Notes:
COPC = contaminant of potential concern
BAF = bioaccumulation factor (unitless; BAF = concentration in prey/concentration in soil)

The SSRBCCs were not adjusted for the BF of COPCs. Bioavailability describes the amount the ingested COPC is absorbed into the blood and distributed to target organs. However, due to a lack of information on the bioavailability of contaminants from ingested soil for wildlife species, the CCME (2006) recommends assuming a BF of one (i.e., 100% absorption of the COPC into the body from soil or dietary items).

A sample calculation of the barium $SSRBCC_{soil}$ for grizzly bear using Equation 3 is provided below:

$$SSRBCC_{soil} = \frac{0.80 \times \dfrac{51.8 \dfrac{mg}{kg\ BW}}{day} \times 640\ kg\ BW}{[0.390\ kg/day \times 1] + [13.9\ kg/day \times 0.001]}$$

$$SSRBCC_{soil} = 65{,}663 \frac{mg}{kg}\ dry\ weight$$

Note that the barium $SSRBCC_{soil}$ shown in the sample calculation is slightly different than what is shown in Appendix H (65,687 mg/kg dry weight) due to rounding of the ingestion rate parameters. The sample calculation is shown here for illustrative purposes only and the values shown for the SSRBCCs in Appendix H are the true values.

1.1.4 Humans

The CCME (2006) describes the procedure used for deriving Canadian human health soil quality guidelines from several exposure routes: incidental soil ingestion, dermal contact, and food ingestion (food grown on soil, which includes beef). The CCME provides two equations for the calculation of soil guidelines for humans: the first equation derives the soil guideline due to exposure from soil ingestion and dermal contact, and the second equation derives the soil guideline due to exposure from food (CCME 2006).

The CCME (2006) guidance document refers to human TRVs as tolerable daily intakes (TDIs), which is adopted here. The CCME (2006) soil equations include the estimated daily intake (EDI) of COPCs to account for background exposures and it was assumed that 80% of exposure to COPCs could come from background sources with 20% from the Project site (Health Canada 2010a). Thus the TDI was multiplied by 0.8 to obtain the EDI. The equation for the human soil guideline due to the exposure from soil ingestion and dermal contact is shown in Equation 4 (CCME 2006):

$$\mathrm{SSRBCC_{soil}} = \left(\frac{(\mathrm{TDI}-\mathrm{EDI})\times \mathrm{SAF}\times \mathrm{BW}}{[(\mathrm{AF_G}\times \mathrm{IR_S})+(\mathrm{AF_S}\times \mathrm{SR})\times \mathrm{ET_2}]\times \mathrm{ET_1}}\right) + \mathrm{BSC} \qquad \text{[Equation 4]}$$

where:
$SSRBCC_{soil}$ = site-specific risk-based closure criteria for soil (mg/kg dry weight)
TDI = tolerable daily intake (mg/kg BW/day)
EDI = estimated daily intake (mg/kg BW/day)
SAF = soil allocation factor (unitless)
BW = body weight (kg)
AF_G = relative absorption factor for the gut (unitless; assumed to be 1)
IR_S = soil ingestion rate (kg/day)

AF_S = relative absorption factor for skin (unitless; from Health Canada 2010b)
SR = soil dermal contact rate (kg/day)
ET_1 = exposure term 1 (unitless; ET_1 = days per week/7 days x weeks per year/52 weeks)
ET_2 = exposure term 2 (unitless; ET_2 = hours per day/24 hours)
BSC = background soil concentration (mg/kg dry weight)

Appendix G discusses the TDIs for adults and toddlers for the different COPCs. The soil allocation factor (SAF) is the relative proportion that soil constitutes of the TDI from the various exposure pathways (i.e., water, air, soil, food, consumer products). The CCME (2006) recommends that the SAF for soil ingestion and dermal contact is 20%, which was adopted in this assessment. The BW and IR_S for adults and toddlers are provided in Table 1.3-2 of the main document. The relative absorption factor for the gut (AF_G) was assumed to be one as recommended by the CCME (2006), which assumes 100% absorption of the COPC into the body from soil or dietary items. The relative absorption factors for the skin (AF_S) were obtained from Health Canada (2010b).

The exposure term 1 (ET_1) is the ratio of the days per week exposed multiplied by the ratio of the weeks per year exposed. As described in Section 1.2.2 of the Phase II report, it is conservatively assumed that a human receptor could be on-site for three months of the year. Thus ET_1 is:

$$\mathrm{ET}_1 = \frac{7\ \text{days}}{7\ \text{days}} \times \frac{12\ \text{weeks}}{52\ \text{weeks}} \qquad \text{[Equation 5]}$$

$$ET_1 = 0.231$$

The exposure term 2 (ET_2) is the ratio of the hours per day exposed in 24 hours. It was assumed that a person could be outside of the hunting cabins for 12 hours a day. Thus the ET_2 is:

$$\mathrm{ET}_2 = \frac{12\ \text{hours}}{24\ \text{hours}} \qquad \text{[Equation 6]}$$

$$ET_2 = 0.5$$

The background soil concentration (BSC) was assumed to be equivalent to the upper limit of the normal range (i.e., 97.5th percentile) of reference site concentrations. The BSCs are also provided in Appendix A of the Phase I report (ERM 2016).

The soil dermal contact rate (SR) was calculated as shown in Equation 7 (CCME 2006):

$$\mathrm{SR} = (\mathrm{SA_H} \times \mathrm{DL_H} + \mathrm{SA_O} \times \mathrm{DL_O}) \times \mathrm{EF} \qquad \text{[Equation 7]}$$

where:
SR = soil dermal contact rate (kg/day)
SA_H = exposed surface area of hands (cm^2)
DL_H = dermal loading of soil to hands (kg/cm^2-event)
SA_O = area of exposed body surfaces other than hands (cm^2)
DL_O = dermal loading of soil to other surfaces (kg/cm^2-event)
EF = exposure frequency (events/day)

The exposed surface area of hands and body surfaces other than hands (SA_H and SA_O), and the dermal loading of soil to hands and body surfaces other than hands (DL_H and DL_O) for toddlers and adults were obtained from Health Canada (2010a) and are provided in Table 1.3-2 of the main document. The exposure frequency (EF) was assumed to be one event per day. The SR for adults and toddlers were calculated to be 0.000110 and 0.0000495 kg/day, respectively.

A sample calculation of the barium $SSRBCC_{soil}$ for adults for soil ingestion and dermal exposure using Equation 4 is provided below:

$$SSRBCC_{soil} = \left(\frac{(TDI - EDI) \times SAF \times BW}{[(AF_G \times IR_S) + (AF_S \times SR) \times ET_2] \times ET_1}\right) + BSC$$

$$SSRBCC_{soil} = \left(\frac{\left(\frac{0.2 \frac{mg}{kg\,BW}}{day} - 0.16 \frac{mg}{kg} BW/day\right) \times 0.2 \times 70.7 kg\,BW}{[(1 \times 0.00002\,kg/day) + (0.1 \times 0.000110\,kg/day) \times 0.5] \times 0.231}\right) + 79.0\,mg/kg$$

$$SSRBCC_{soil} = 96{,}098 \frac{mg}{kg} dry\ weight$$

Note that the barium $SSRBCC_{soil}$ shown in the sample calculation is slightly different than what is shown in Appendix H (96,279 mg/kg dry weight) due to rounding of the ingestion rate and exposure time parameters. The sample calculation is shown here for illustrative purposes only and the values shown for the SSRBCCs in Appendix H are the true values.

The CCME (2006) equation for the soil guideline due to the exposure from food ingestion for humans incorporates the ingestion of plants and beef. Since the human ROCs considered in this assessment could also hunt birds on-site, the SSRBCC for soil was modified to include bird consumption (i.e., ptarmigan). It was assumed that instead of beef consumption it was caribou consumption. The equation to calculate the human SSRBCC for soil due to food ingestion is shown in Equation 8 (CCME 2006):

$$\mathrm{SSRBCC_{soil}} = \left(\frac{(\mathrm{TDI}-\mathrm{EDI})\times\mathrm{SAF}\times\mathrm{BW}}{(\mathrm{P_h}\times\mathrm{IR_P}\times\mathrm{BCF_P})+(\mathrm{B_h}\times\mathrm{IR_B}\times\mathrm{BTF_B}\times\mathrm{IR_{SB}})+(\mathrm{L_h}\times\mathrm{IR_L}\times\mathrm{BTF_L}\times\mathrm{IR_{SL}})}\right) + \mathrm{BSC} \quad \text{[Equation 8]}$$

where:
$SSRBCC_{soil}$ = site-specific risk-based closure criteria for soil (mg/kg dry weight)
TDI = tolerable daily intake (mg/kg BW/day)
EDI = estimated daily intake (mg/kg BW/day)
SAF = soil allocation factor (unitless)
BW = body weight (kg)
P_h = percentage of plants consumed that are traditionally harvested from the Project site (assumed 100%)
IR_P = plant ingestion rate (kg/day wet weight)
BCF_P = bioconcentration factor for plants (unitless)
B_h = percentage of bird meat traditionally harvested from the Project site (assumed 100%)

IR_B = bird ingestion rate (kg/day wet weight)
BTF_B = biotransfer factor for birds (chicken; day/kg)
IR_{SB} = soil ingestion rate by birds (kg/day)
L_h = percentage of land animal meat traditionally harvested from the Project site (assumed 100%)
IR_L = land animal ingestion rate (kg/day wet weight)
BTF_L = biotransfer factor for land animals (beef; day/kg)
IR_{SL} = soil ingestion rate by land animals (kg/day)
BSC = background soil concentration (mg/kg dry weight)

The CCME (2006) soil equations included the estimated daily intake (EDI) of COPCs to account for background exposures and it was assumed that 80% of exposure to COPCs could come from background sources with 20% from the Project site (Health Canada 2010a). Thus, the TDI was multiplied by 0.8 to obtain the EDI.

Appendix G discusses the TDIs for adults and toddlers for the different COPCs. The SAF is the relative proportion that soil constitutes of the TDI from the various exposure pathways (i.e., water, air, soil, food, consumer products). The CCME (2006) recommends that the SAF for food ingestion is 20%; however, for this assessment the SAF for food ingestion was assumed to be 60% since 20% of the exposure is from soil ingestion and dermal contact, and 20% is from ingesting water and thus the total adds up to 100%.

The human BWs and food ingestion rates (i.e., IR_P, IR_B, and IR_L) for adults and toddlers are provided in Table 1.3-2 of the main document. It is worth noting that the ingestion rates for plants, birds, and land animals in the human SSRBCC equations are for fresh food (wet weight), whereas those in the wildlife SSRBCC equation calculations are dry weights, as specified by CCME (2006).

It was conservatively assumed that 100% of the plants and meat (caribou and ptarmigan) consumed by an individual (i.e., P_h, B_h, and L_h) were traditionally harvested from the Project site. Biotransfer factors are not available for wildlife (i.e., caribou and ptarmigan), thus the biotransfer factors for birds (BTF_B) were assumed to be equivalent to those of chicken and the biotransfer factors for land animals (BTF_L) were assumed to be equivalent to those of beef. The bioconcentration factors for plants (BCF_P) and the biotransfer factors for chicken and beef (BTF_{beef} and $BTF_{chicken}$) are provided in Table A-3. The soil ingestion rate of ptarmigan and caribou are presented in Table 1.3-1 of the main document. The BSC was assumed to be equivalent to the upper limit of the normal range (i.e., 97.5th percentile) of reference site concentrations. The BSCs are provided in Appendix A of the Phase I report (ERM 2016).

A sample calculation of the barium $SSRBCC_{soil}$ for adults for food ingestion using Equation 8 is provided below:

$$SSRBCC_{soil} = \left(\frac{\left(\frac{0.2 \frac{mg}{kg\ BW}}{day} - 0.16 \frac{mg}{kg\ BW}/day \right) \times 0.6 \times 70.7 kg\ BW}{\left(1 \times 0.355\ \frac{kg}{day} \times 0.0375\right) + \left(1 \times 0.034 \frac{kg}{day} \times \frac{0.009\ day}{kg} \times 0.00507 \frac{kg}{day}\right) + \left(1 \times 0.242 \frac{kg}{day} \times \frac{0.00015\ day}{kg} \times 0.0668 \frac{kg}{day}\right)} \right) + 79.0\ \frac{mg}{kg}$$

$$SSRBCC_{soil} = 206 \frac{mg}{kg}\ dry\ weight$$

Table A-3. Biotransfer Factors for Plants, Chicken, and Beef

COPC	BTF_{plants} (day/kg)	$BTF_{chicken}$ (day/kg)	BTF_{beef} (day/kg)
Aluminum	0.00100	0.800	0.00150
Barium	0.0375	0.00900	0.000150
Chromium	0.00188	0.200	0.00550
Manganese	0.0625	0.0500	0.000400
Molybdenum	0.0625	0.180	0.00600

Notes:
COPC = contaminant of potential concern
BTF_{plants} *= biotransfer factor for plants*
$BTF_{chicken}$ *= biotransfer factor for chicken*
BTF_{beef} *= biotransfer factor for beef*
The $BTF_{chicken}$ *for aluminum was not available thus the* $BTF_{chicken}$ *for gallium was used instead.*
The BTF_{plants} *and* BTF_{beef} *values were obtained from RAIS (2016).*
The $BTF_{chicken}$ *values were obtained from Staven et al. (2003).*

1.2 WATER

1.2.1 Aquatic and Terrestrial Primary Producers, Aquatic Invertebrates, and Fish

The CCME (2007) describes the protocol used for deriving Canadian water quality guidelines for the protection of aquatic life. The protocol involves the evaluation of toxicity studies with short-term and long-term exposures to determine acute and chronic concentrations of substances that are not harmful to aquatic plants and animals. Many of the water quality guidelines take into account modifying factors that affect the actual toxicity of a particular substance, such as pH and hardness (CCME 2007). The Canadian water quality guidelines are equivalent to the most sensitive or most appropriate toxicity test results (i.e., are equivalent to the TRV in mg/L; CCME 2007).

The primary exposure route to water for aquatic and terrestrial primary producers, aquatic invertebrates, and fish is via direct contact. Thus the SSRBCC for water for these organisms is equivalent to the TRV (CCME 2007):

$$\mathrm{SSRBCC_{water}} = \mathrm{TRV} \quad \text{[Equation 9]}$$

where:
$SSRBCC_{water}$ = site-specific risk-based closure criteria for water (mg/L)
TRV = toxicity reference value (mg/L)

The TRVs for aquatic life (i.e., primary producers, zooplankton, benthic invertebrates, and fish) are discussed in Appendix G.

1.2.2 Mammals and Birds

The CCME (1999) describes the protocols used to derive Canadian water quality guidelines for the protection of agricultural water uses, which include irrigation and livestock watering. The CCME protocol for developing guidelines for livestock watering were adopted for developing mammalian and bird SSRBCCs for water.

For mammals and birds, it was assumed that 20% of the ROC's intake of the COPC is contributed from water ingestion, with the remaining 80% from soil and food ingestion. However, water was the only exposure route that affected peregrine falcon and bald eagle, thus it was assumed that 100% of their exposure came from water ingestion. Methylmercury was identified as a COPC in fish tissue and peregrine falcon and bald eagle consume fish, but mercury was not a COPC in water, thus proportioning the exposure from different pathways was not required. The CCME (1999) equation for calculating a livestock watering guideline is:

$$\mathrm{SSRBCC_{water}} = \frac{0.20 \times \mathrm{TRV} \times \mathrm{BW}}{\mathrm{IR_W}} \qquad \text{[Equation 10]}$$

where:
SSRBCC_{water} = site-specific risk-based closure criteria for water (mg/L)
0.20 = proportion of COPC exposure attributed to water ingestion (unitless)
TRV = toxicity reference value (mg/kg BW/day)
BW = body weight (kg)
IR_W = ingestion rate of water (L/day)

The TRVs for mammals and birds are discussed in Appendix G. The BW and IR_W for the mammalian and avian ROCs are presented in Table 1.3-1 of the main document.

A sample calculation of the chromium $SSRBCC_{water}$ for caribou using Equation 10 is provided below:

$$SSRBCC_{water} = \frac{0.20 \times \dfrac{2.40\,\dfrac{mg}{kg\ BW}}{day} \times 150kg\ BW}{9.00\ L/day \times 0.164}$$

$$SSRBCC_{water} = 8.00\ mg/L$$

1.2.3 Humans

The CCME does not provide drinking water quality guidelines (DWQGs) for humans, thus the DWQGs produced by Health Canada (2015) were used for screening COPCs (see Section 2.4.5.2 of the Phase I report; ERM 2016). The Health Canada guidance document on the derivation of DWQGs (Health Canada 1995) describes the toxicity studies on which the guidelines are based, but equations for deriving site-specific guidelines are not provided. Thus the CCME (1999) protocol used to derive Canadian water quality guidelines for the protection of livestock watering were adopted for deriving human SSRBCCs for water (Equation 10). The equation was modified to include EDI, ET_1, ET_2, and background water quality (BWQ), as the CCME guidelines for soil for humans did. The CCME (1999) equation for calculating a livestock watering guideline with the addition of EDI, ET_1, ET_2, and BWC is:

$$\mathrm{SSRBCC_{water}} = \left(\frac{0.20 \times (\mathrm{TDI} - \mathrm{EDI}) \times \mathrm{BW}}{(\mathrm{IR_W} \times \mathrm{ET_2}) \times \mathrm{ET_1}}\right) + \mathrm{BWC} \qquad \text{[Equation 11]}$$

where:
$SSRBCC_{water}$ = site-specific risk-based closure criteria for water (mg/L)
0.20 = proportion of COPC exposure attributed to water ingestion (unitless)
TDI = tolerable daily intake (mg/kg BW/day)
EDI = estimated daily intake (mg/kg BW/day)
BW = body weight (kg)
IR_W = ingestion rate of water (L/day)
ET_1 = exposure term 1 (unitless; ET_1 = days per week/7 days × weeks per year/52 weeks)
ET_2 = exposure term 2 (unitless; ET_2 = hours per day/24 hours)
BWC = background water concentration (mg/L)

The CCME (2006) soil equations included the estimated daily intake (EDI) of COPCs to account for background exposures and it was assumed that 80% of exposure to COPCs could come from background sources with 20% from the Project site (Health Canada 2010a). Thus the TDI was multiplied by 0.8 to obtain the EDI. The TDIs for adults and toddlers are discussed in Appendix G. The BW, IR_W, and ET for adults and toddlers are presented in Table 1.3-2 of the main document. The BWC is the upper limit of normal concentration from Lac de Gras near- and mid-field stations during the open-water season (see Appendix B of the Phase I report; ERM 2016), which was obtained from (DDMI 2015).

The proportion of COPC exposure attributed to water ingestion was assumed to be 20% for all COPCs except for nitrate, nitrite, and sulphate. Exposure to nitrate, nitrite, and sulphate is entirely from ingesting drinking water; therefore, it was assumed that the proportion of exposure attributed to water for nitrate, nitrite, and sulphate was 100%.

A sample calculation of the antimony $SSRBCC_{water}$ for adults using Equation 11 is provided below:

$$SSRBCC_{water} = \left(\frac{0.20 \times \left(\frac{0.003 \frac{mg}{kg\ BW}}{day} - \frac{0.0024 \frac{mg}{kg\ BW}}{day} \right) \times 70.7\ kg\ BW}{(1.5\ L/day \times 0.5) \times 0.231} \right) + 0.0000200\ mg/L$$

$$SSRBCC_{water} = 0.0113\ mg/L$$

1.3 SEDIMENT

1.3.1 Aquatic Invertebrates

The CCME protocol for deriving sediment quality guidelines (CCME 1995) describes how toxicity test information on benthic invertebrates is used to derive sediment quality guidelines. The primary sediment exposure route for benthic organisms is via direct exposure, thus a sediment guideline specific to these organisms is simply the lowest applicable TRV for those organisms. Likewise, for benthic invertebrates, the SSRBCC for sediment is equivalent to the TRV as shown in Equation 12 below:

$$\text{SSRBCC}_{\text{sediment}} = \text{TRV} \qquad \text{[Equation 12]}$$

where:
$SSRBCC_{sediment}$ = site-specific risk-based closure criteria for sediment (mg/kg dry weight)
TRV = toxicity reference value (mg/kg dry weight)

The TRVs for benthic invertebrates are discussed in Appendix G.

1.3.2 Aquatic Birds

For aquatic birds (i.e., semi-palmated sandpiper and long-tailed duck), it was assumed that 80% of the ROC's intake of the COPC is contributed from sediment and food ingestion, with the remaining 20% from water ingestion. This is a conservative assumption as the ROCs can also intake COPCs via air or dermal contact; however, since these exposure routes are considered to be negligible in this assessment (see Section 1.1), the fraction usually attributed to air inhalation or dermal contact was transferred to sediment and food ingestion, as recommended by the CCME (2006).

The CCME protocol for deriving sediment quality guidelines (CCME 1995) states that additional procedures can be used for the protection of wildlife, such as tissue residue guidelines and bioaccumulation factors; however, those procedures and equations are not provided. Therefore, the CCME (2006) equation for deriving soil quality guidelines for secondary and tertiary consumers was adopted to derive sediment SSRBCCs for aquatic birds, as shown in Equation 13:

$$\text{SSRBCC}_{\text{sediment}} = \frac{0.80 \times \text{TRV} \times \text{BW}}{[\text{IR}_\text{S} \times \text{BF}] + [\text{IR}_\text{F} \times \text{BAF}]} \qquad \text{[Equation 13]}$$

where:
$SSRBCC_{sediment}$ = site-specific risk-based closure criteria for sediment (mg/kg dry weight)
0.80 = proportion of COPC exposure attributed to sediment and food ingestion (unitless)
TRV = toxicity reference value (mg/kg BW/day)
BW = body weight (kg)
IR_S = ingestion rate of sediment (kg/day dry weight)
BF = bioavailability factor (assume 1; unitless)
IR_F = ingestion rate of food (kg/day dry weight)
$BSAF$ = biota-sediment accumulation factor (unitless)

The TRVs for birds are discussed in Appendix G. The BW, IR_S, and IR_F for aquatic birds (i.e., semi-palmated sandpiper and long-tailed duck) are provided in Table 1.3-1 of the main document. The biota-sediment bioaccumulation factors (BSAFs) for aquatic birds are presented in Table A-4. The BSAF for each of the five polycyclic aromatic hydrocarbons (PAHs) is 1.5 (Kwok et al. 2013), which was the highest aquatic bird BSAF for total PAHs found in the literature. A literature search was unable to find BSAF values for birds for individual PAHs.

The SSRBCCs were not adjusted for the BF of COPCs. Bioavailability describes the amount the ingested COPC is absorbed into the blood and distributed to target organs. However, due to a lack of information on the bioavailability of contaminants from ingested sediment for wildlife species, the CCME (2006) recommends assuming a BF of one (i.e., 100% absorption of the COPC into the body from sediment).

Table A-4. Biota-sediment Availability Factors for Aquatic Birds

COPC	BSAF	Reference
Arsenic	17.0	US EPA (1985a) in Sample, Opresko, and Suter II (1996)
Chromium	3.00	US EPA (1985b) in Sample, Opresko, and Suter II (1996)
Copper	290	US EPA (1985c) in Sample, Opresko, and Suter II (1996)
2-Methylnaphthalene	1.50	Kwok et al. (2013)
Acenaphthene	1.50	Kwok et al. (2013)
Acenaphthylene	1.50	Kwok et al. (2013)
Naphthalene	1.50	Kwok et al. (2013)
Pyrene	1.50	Kwok et al. (2013)

Notes:
COPC = contaminant of potential concern
BSAF = biota-sediment accumulation factor (unitless; BSAF = concentration in prey/concentration in sediment)

A sample calculation of the arsenic $SSRBCC_{sediment}$ for semi-palmated sandpiper using Equation 13 is provided below:

$$SSRBCC_{sediment} = \frac{0.80 \times \frac{2.24 \frac{mg}{kg\ BW}}{day} \times 0.032\ kg\ BW}{[0.00186\ kg/day \times 1] + [0.00619\ kg/day \times 17.0]}$$

$$SSRBCC_{sediment} = 0.535 \frac{mg}{kg} dry\ weight$$

1.4 FISH TISSUE

Grizzly bears, peregrine falcons, bald eagles, and humans consume fish and methylmercury was identified as a COPC in fish tissue. The CCME (2000) outlines the protocol for deriving a tissue residue guideline for the protection of wildlife that consume aquatic biota for methylmercury. This protocol was adopted to calculate a SSRBCC for fish ingestion for grizzly bears, peregrine falcons, bald eagles, and humans. The $SSRBCC_{fish}$ equation is (CCME 2000):

$$\mathrm{SSRBCC_{fish}} = \frac{\mathrm{TRV}}{\left(\frac{\mathrm{IR_{Fi}}}{\mathrm{BW}}\right)} \qquad \text{[Equation 14]}$$

where:
$SSRBCC_{fish}$ = site-specific risk-based closure criteria for fish tissue (mg/kg wet weight)
TRV = toxicity reference value or tolerable daily intake (mg/kg BW/day)
IR_{Fi} = fish ingestion rate (kg/day; wet weight)
BW = body weight (kg)

Since 100% of methylmercury exposure is assumed to come from fish ingestion (Health Canada 2007), no adjustment of the proportion of the TRV was required. The methylmercury TRVs for mammals and birds, and TDI for humans are provided in Appendix G. The BW and IR_{Fi} for grizzly bears, peregrine falcons, and bald eagles are provided in Table 1.3-1 of the main document. The BW and IR_{Fi} values for adults and toddlers are provided in Table 1.3-2 of the main document. The fish ingestion rate (IR_{Fi}) for mammals and birds in Table 1.2-1 of the main document are in dry weight and required conversion into wet weight for the calculation of the $SSRBCC_{fish}$ using Equation 15 (Sample et al. 1997):

$$\mathrm{IR}_{\text{wet weight}} = \frac{\mathrm{IR}_{\text{dry weight}}}{1 - \%\ \text{moisture}} \qquad \text{[Equation 15]}$$

where:
$IR_{wet\ weight}$ = the ingestion rate of wet food (kg/day wet weight)
$IR_{dry\ weight}$ = the ingestion rate of dry food (kg/day dry weight)
% moisture = the moisture content of the food item

It was assumed that the percent moisture of fish was 75% as recommended by Sample et al. (1997) for bony fish. A sample calculation of the fish wet weight ingestion rate for grizzly bear using Equation 15 is provided below:

$$IR_{wet\ weight} = \frac{0.39\,\frac{kg}{day}\,dry\ weight}{1 - 0.75}$$

$$IR_{wet\ weight} = 1.56\,\frac{kg}{day}\,wet\ weight$$

A sample calculation of the methylmercury $SSRBCC_{fish}$ for grizzly bear using Equation 14 is provided below:

$$SSRBCC_{fish} = \frac{0.0220\,\frac{mg}{kg}\,BW/day}{\left(\frac{1.56\,\frac{kg}{day}\,ww}{640\ kg\ BW}\right)}$$

$$SSRBCC_{fish} = 9.03\,\frac{mg}{kg}\,wet\ weight$$

A $SSRBCC_{fish}$ for humans was calculated for toddlers, adults, and sensitive adults. This is because pregnant women and women of child-bearing age are considered especially sensitive to the effects of methylmercury. Therefore, the methylmercury TRVs for toddlers, adults, and sensitive adults by Health Canada (2010b) were used in the calculations (see Appendix G).

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Appendix B

Phytoplankton Taxa Identified in Lac de Gras in 1995 and from 1997 to 2013

Appendix B. Phytoplankton Taxa Identified in Lac de Gras in 1995 and from 1997 to 2013

Major Taxonomic Group	1995	1997	1997 to 2013
Bacillariophyta	*Asterionella* sp.	*Achnanches* sp.	*Achnanthes minutissima* Kuetzing
	Rhizosolenia sp.	*Asterionella formosa*	*Asterionella formosa* Hansall
	Synedra sp.	*Navicula* sp.	*Aulacoseira* sp.
	Tabellaria sp.	*Nitzschia acicularis*	*Cocconeis* sp.
	-	*Nitzschia* sp.	*Cocconeis pediculus* Ehrenberg
	-	*Tabellaria fenestrate*	*Cyclotella bodanica* Grunow
	-	-	*Cyclotella/Stephanodiscus* sp.
	-	-	*Cyclotella ocellata* Pantocsek
	-	-	*Cymbella* sp.
	-	-	*Diatoma tenue* Agardh
	-	-	*Diatoma vulgaris* Bory
	-	-	*Epithemia sorex* Kuetzing
	-	-	*Eunotia naegeli* Migula
	-	-	*Fragilaria capucina* Desmazieres
	-	-	*Fragilaria crotonensis* Kitton
	-	-	*Frustulia rhomboides* (Ehrenberg) de Toni
	-	-	*Gomphonema* sp.
	-	-	*Gomphonema parvulum* (Kuetzing) Kuetzing
	-	-	*Melosira varians* (C.Agardh)
	-	-	*Navicula* sp.
	-	-	*Nitzschia* sp.
	-	-	*Nitzschia acicularis* (Kuetzing) W. Smith
	-	-	*Nitzschia/Synedra* spp.
	-	-	*Ophiocytium parvulum* (Perty) A. Braun
	-	-	*Rhoicosphenia abbreviata* (Agardh) Lange-Bertalot
	-	-	*Rhizosolenia eriensis* Smith
	-	-	*Rhizosolenia longiseta* Ehrenberg
	-	-	*Surirella* sp.
	-	-	*Synedra* sp.
	-	-	*Synedra ulna* (Nitzsch) Ehr.
	-	-	*Tabellaria flocculosa* (Roth) Kuetzing
	-	-	Centric diatom (*Cyclotella ocellata* Pantocsek)
Cyanobacteria	*Anabaena* sp.	*Anabaena* sp.	*Anabaena* sp.
	Aphanocapsa sp.	*Chroococcus* sp.	*Anabaena circinalis* Rabenhorst

(continued)

Appendix B. Phytoplankton Taxa Identified in Lac de Gras in 1995 and from 1997 to 2013

Major Taxonomic Group	1995	1997	1997 to 2013
Cyanobacteria	*Coelosphaerium* sp.	*Gomphosphaeria* sp.	*Anabaena cylindricum* Lemmermann
(cont'd)	*Gloeocapsa* sp.	*Lyngbya limnetica* Lemm.	*Anabaena flos-aquae* Brebisson
	Gloeothece sp.	*Lyngbya* sp.	*Anabaena inaequalis* (Kuetzing) Bornet & Flahault
	Merismopedia sp.	*Oscillatoria* sp.	*Anabaena* cf. *miniata* Skuja
	Microcystis sp.	*Cyanobacteria* sp.	*Anabaena solitaria* f. *planctonica* (Brunnthaler) Komarek
	Oscillatoria sp.	-	*Anabaena solitaria* Klebahn
	Cyanobacteria sp.	-	*Aphanizomenon flos-aquae* (Linne) Ralfs
	-	-	*Aphanizomenon flos-aquae* f. *gracile* (Lemmermann)
	-	-	*Aphanocapsa sp.*
	-	-	*Aphanocapsa delicatissima* West & West
	-	-	*Aphanocapsa elachista* West & West
	-	-	*Aphanothece* sp.
	-	-	*Aphanothece clathrata* West & West
	-	-	*Aphanothece nidulans* P. Richter
	-	-	*Chroococcus dispersus* (Keissler) Lemmermann
	-	-	*Chroococcus limneticus* Lemmermann
	-	-	*Cyanodictyon* sp. (sphere)
	-	-	*Cyanodictyon* sp. (rod)
	-	-	*Cylindrospermum minutissimum* Collins
	-	-	*Dactylococcopsis smithii* Chodat & Chodat
	-	-	*Gomphosphaeria* sp.
	-	-	*Gomphosphaeria aponina* Kuetzing
	-	-	*Limnothrix* sp.
	-	-	*Lyngbya* sp.
	-	-	*Merismopedia tenusissima* Lemmermann
	-	-	*Microcystis ichthyoblabe* Kuetzing
	-	-	*Oscillatoria* sp.
	-	-	*Phormidium* sp.
	-	-	*Phormidium formosum* (Bory ex Gomont) Anagnostidis et Komarek
	-	-	*Planktolyngbya contorta* Lemmermann
	-	-	*Planktolyngya limnetica* Lemmermann
	-	-	*Pseudanabaena* sp.
	-	-	*Pseudanabaena limnetica* Komarek
	-	-	*Rhabdoderma* sp.

(continued)

Appendix B. Phytoplankton Taxa Identified in Lac de Gras in 1995 and from 1997 to 2013

Major Taxonomic Group	1995	1997	1997 to 2013
Cyanobacteria	-	-	*Rhabdoderma lineare* Schmidle & Lauterborn
(cont'd)	-	-	*Rhabdoglea* sp.
	-	-	*Snowella arachnoidea* Komarek et Hindak
	-	-	*Snowella lacustris* (Chodat) Komarek et Hindak
Chlorophyta	*Ankistrodesmus* sp.	*Ankistrodesmus falcatus*	*Actinastrum hantzschii* Lagerheim
	Arthrodesmus sp.	*Ankistrodesmus* sp.	*Ankistrodesmus bernardii* Komarek
	Cosmarium sp.	*Arthrodesmus triangularis*	*Ankistrodesmus falcatus* (Corda) Ralfs
	Dictyosphaerium sp.	*Dictyosphaerium pulchellyum*	*Ankistrodesmus falcatus* var. *mirabilis* West
	Kirchneriella sp.	*Elakatothrix gelatinosa*	*Ankistrodesmus fusiformis* Corda
	Lagerheimia sp.	*Monoraphidium contortum*	*Ankistrodesmus gracilis* (Reinsch) Kors.
	Monoraphidium sp.	*Oocystis submarina*	*Ankistrodesmus spiralis* (Turner) Lemmermann
	Oocystis sp.	*Spondylosium planum*	*Ankistrodesmus stipitatus* (Chod.)
	Pediastrum sp.	*Tetraedron caudatum* var. *longispina*	*Ankyra lanceolata* (Kors) Fott
	Spondylosium sp.	*Tetraedron limneticum*	*Arthrodesmus convergens* Ehrenberg
	Staurastrum sp.	*Tetraedron minimum*	*Arthrodesmus cuspidatus* (Brebisson) Teiling
	Tetraspora sp.	*Chlorophyta* sp.	*Arthrodesmus incus* (Brebisson) Hassall
	Tetraedron sp.	-	*Arthrodesmus incus* var. *ralfsii* (West & West) Teiling
	Chlorophyta sp.	-	*Arthrodesmus octocornis* Ehrenberg
	-	-	*Arthrodesmus triangularis* Lagerheim
	-	-	*Botryococcus* sp.
	-	-	*Botryococcus braunii* Kuetzing
	-	-	*Botryococcus sudeticus* Lemmermann
	-	-	*Bulbochaete* sp.
	-	-	*Carteria Kebsii* (Dang.) Dill
	-	-	*Chlamydomonas* sp.
	-	-	*Chlamydomonas angulosa* Dill
	-	-	*Chamydomonas frigida* Skuja
	-	-	*Chlamydomonas globosa* Snow
	-	-	*Chlamydomonas sagitula* Skuja
	-	-	*Chlorogonium* sp.
	-	-	*Chlorogonium minimum* Playfair
	-	-	*Choricystis* sp.
	-	-	*Coelastrum* sp.
	-	-	*Coelastrum astroideum* de Notaris

(continued)

Appendix B. Phytoplankton Taxa Identified in Lac de Gras in 1995 and from 1997 to 2013

Major Taxonomic Group	1995	1997	1997 to 2013
Chlorophyta	-	-	*Coelastrum microporum* Naegeli
(cont'd)	-	-	*Coenocystis* sp.
	-	-	*Cosmarium* sp.
	-	-	*Cosmaruim bioculatum* Brebisson
	-	-	*Cosmarium depressum Nageli* (Lund)
	-	-	*Cosmarium depressum* var. *achondrum* (Boldt) West & West
	-	-	*Cosmarium granatum* Brebisson
	-	-	*Cosmarium lundelli var. ellipticum* West
	-	-	*Cosmarium ochthodes* var. *amoebum* West & West
	-	-	*Cosmarium phaseolus* Brebisson
	-	-	*Cosmarium regnesii* Reinsch
	-	-	*Cosmarium subcrenatum* Hantz
	-	-	*Crucegenia* sp.
	-	-	*Crucegenia apiculata* (Lemmermann) Schmidle
	-	-	*Crucigenia fenestrata* (Schmidle) Schmidle
	-	-	*Crucegenia quadrata* Morren
	-	-	*Crucegenia tetrapedia* (Kirchner) West & West
	-	-	*Dictyosphaerium ehrenbergianum* Naegeli
	-	-	*Dictyosphaerium elegans* Bachmann
	-	-	*Dictyosphaerium pulchellum* Skuja
	-	-	*Dictyosphaerium subsolitarium* Van Goor
	-	-	*Elakatothrix gelatinosa* Wille
	-	-	*Elakatothrix genevensis* (Reverdin) Hindak
	-	-	*Euastrum* sp.
	-	-	*Euastrum ansatum* Ehrenberg
	-	-	*Euastrum bidentatum* Naegeli
	-	-	*Euastrum denticulatum* (Kirchner) Gay
	-	-	*Euastrum insulare* (Wittrock) Roy
	-	-	*Eudorina* sp.
	-	-	*Franceia Droescheri* (Lemm.) Smith
	-	-	*Gloeocystis* sp.
	-	-	*Gloeocystis planctonica* (West & West) Lemmermann
	-	-	*Gloeotilia* sp.
	-	-	*Golenkinia radiata* (Chodat) Wille

(continued)

Appendix B. Phytoplankton Taxa Identified in Lac de Gras in 1995 and from 1997 to 2013

Major Taxonomic Group	1995	1997	1997 to 2013
Chlorophyta	-	-	*Gonatozygon* sp.
(cont'd)	-	-	*Hormotila* sp.
	-	-	*Isthmochloron trispinatum* (West & West) Skuja
	-	-	*Kirchneriella* sp.
	-	-	*Kirchneriella contorta* (Schmidle) Bohlin
	-	-	*Korshikoviella* sp.
	-	-	*Lagerheimia chodatii* Bernard
	-	-	*Lagerheimia genevensis* (Chod.) Chod.
	-	-	*Monoraphidium braunii* Naegeli
	-	-	*Monoraphidium circinale* (Nygaard) Nygaard
	-	-	*Monoraphidium contortum* (Thuret) Komarkova-Legenerova
	-	-	*Monoraphidiu dybowskii* (Wolosz) Hindak et. Komarkova-Legenerova
	-	-	*Monoraphidium* cf. *flexuosum* Komarkova
	-	-	*Monoraphidium griffithii* (Berkeley) Komarkova-Legenerova
	-	-	*Monoraphidium irregulare* (Smith) Komarkova-Legenerova
	-	-	*Monoraphidium minutum* (Nag.) Komarkova-Legenerova
	-	-	*Monoraphidium setiforme* Komarkova-Legenerova
	-	-	*Monoraphidium skujae* Fott
	-	-	*Monoraphidium* cf. *subclavatum* Nygaard
	-	-	*Mougeotia* sp.
	-	-	*Nephrocytium limneticum* (Smith) Smith
	-	-	*Oocystis* sp.
	-	-	*Oocystis borgei* Snow
	-	-	*Oocystis/Eremosphaeria* sp.
	-	-	*Oocystis gigas* Archer
	-	-	*Oocystis gloeocystiformis* Borge
	-	-	*Oocystis parva* West & West
	-	-	*Oocystis pusilla* Hansgirg
	-	-	*Oocystis rhomboidea* Fott
	-	-	*Oocystis solitaria* Wittrock
	-	-	*Oocystis submarina* Lagerheim
	-	-	*Pandorina* sp.
	-	-	*Phacomyxa* sp.
	-	-	*Quadrigula chodatii* (Tanner-Fullman) Smith

(continued)

Appendix B. Phytoplankton Taxa Identified in Lac de Gras in 1995 and from 1997 to 2013

Major Taxonomic Group	1995	1997	1997 to 2013
Chlorophyta	-	-	*Quadrigula closteriodes* (Bohlin) Printz
(cont'd)	-	-	*Quadrigula lacustris* (Chodat) Smith
	-	-	*Scenedesmus* sp.
	-	-	*Scenedesmus acutus* Meyen
	-	-	*Scenedesmus arcuatus* Lemmermann
	-	-	*Scenedesmus quadricauda* (Turpin) Brebisson
	-	-	*Schroderia indica* Philip
	-	-	*Schroderia setigera* (Schroed.) Lemmermann
	-	-	*Sphaerocystis schroeteri* Chodat
	-	-	*Spondylosium planum* (Wolle) West & West
	-	-	*Spondylosium pygaeum* Rabenhorst
	-	-	*Staurastrum* sp.
	-	-	*Staurastrum anatinum* Cooke & Wills
	-	-	*Staurastrum* cf *furgicerum* Brebisson
	-	-	*Staurastrum planctonicum* Teiling
	-	-	*Staurastrum muticum* Brebisson
	-	-	*Stichogloea doederleinii* (Schmidle) Wille
	-	-	*Stichogloea globosa* Starmach
	-	-	*Stigeoclonium* sp.
	-	-	*Tetraedron caudatum* (Corda) Hansgirg
	-	-	*Tetraedron limneticum* Borge
	-	-	*Tetraedron minimum* (Braun) Hansgirg
	-	-	*Tetraedron mimimum var. tetralobulatum* Reins
	-	-	*Tetraedron trigonum* (Naeg.) Hansgirg
	-	-	*Tetradesmus wisconsinensis* Smith
	-	-	Unidentified colonial green (*Willea* sp.)
Chrysophyta	*Bitrychia* sp.	*Bitrychia chodatii*	*Bitrichia chodatii* (Rev.) Chod.
	Chromulina sp.	*Chromulina* sp.	*Bitrichia ollula* (Fott) Bourrelly
	Dinobryon sp.	*Dinobryon bavaricum*	*Chromulina* sp.
	Mallomonas sp.	*Dinobryon cylindricum* var. *palustre*	*Chrysolykos planctonicus* Mack
	Stichogloea sp.	*Dinobryon sociale*	*Chrysolykos skujae* (Nauwerck) Bourrelly
	-	*Dinobryon sociale* var. *americanum*	*Chrysococcus* sp.
	-	*Isthmochloron trispinatum*	*Desmarella moniliformis* Kent
	-	*Mallomonas* sp.	*Dicronema* cf. *vlklanum* Prauser

(continued)

Appendix B. Phytoplankton Taxa Identified in Lac de Gras in 1995 and from 1997 to 2013

Major Taxonomic Group	1995	1997	1997 to 2013
Chrysophyta	-	*Ochromonas* sp.	*Dinobryon* sp.
(cont'd)	-	-	*Dinobryon acuminatum* Ruttner
	-	-	*Dinobryon balticum* (Schutt) Lemmermann
	-	-	*Dinobryon bavaricum* Imhof
	-	-	*Dinobryon bavaricum* var. *Vanhoffenii* (Bachm.) Krieg.
	-	-	*Dinobryon bavaricum* var. *medium* (Lemmermann) Krieger
	-	-	*Dinobryon borgei* Lemmermann
	-	-	*Dinobryon cylindricum* Imhof
	-	-	*Dinobryon cylindricum* var *alpina* (Imhof) Bachmann
	-	-	*Dinobryon cylindricum* var *palustre* (Lemmermmann)
	-	-	*Dinobryon dilatatum* Hillard
	-	-	*Dinobryon divergens* Imhof
	-	-	*Dinobryon eurystoma* (Stokes) Lemmermann
	-	-	*Dinobryon setularia* Ehrenberg
	-	-	*Dinobryon sociale* Ehrenberg
	-	-	*Dinobryon sociale* var. *americana* (Brunthaler) Bachmann
	-	-	*Dinobryon sociale* var. *stipitatum* (Stein) Lemmermann
	-	-	*Epipyxis* sp.
	-	-	*Kephyrion* sp.
	-	-	*Kephyrion boreale* Skuja
	-	-	*Kephyrion cupuliforme* Conrad
	-	-	*Kephyrion littorale* Lund
	-	-	*Kephyrion mastigophorum* Schmid
	-	-	*Kephyrion skujae* Ettl
	-	-	*Mallomonas* sp.
	-	-	*Mallomonas pseudocoronata* Prescott
	-	-	*Monosiga* sp.
	-	-	*Monosiga varians* Skuja
	-	-	*Ochromonas* sp.
	-	-	*Pedinella* sp.
	-	-	*Pseudokephyrion alaskanum* Hilliard
	-	-	*Pseudokephyrion attenuatum* Hilliard
	-	-	*Pseudokephyrion auroreum* Nicholls
	-	-	*Pseudokephyrion ellipsoideum* (Pascher) Schmid

(continued)

Appendix B. Phytoplankton Taxa Identified in Lac de Gras in 1995 and from 1997 to 2013

Major Taxonomic Group	1995	1997	1997 to 2013
Chrysophyta	-	-	*Pseudokephyrion minutissimum* Conrad
(cont'd)	-	-	*Spiniferomonas* sp.
	-	-	*Spiniferomonas bourrellyi* Takahashi
	-	-	*Spiniferomonas conica* Takahashi
	-	-	*Spiniferomonas cornuta* Balonov
	-	-	*Stichogloea doederleinii* (Schmidle) Wille
	-	-	*Stichogloea globosa* Starmach
	-	-	*Stichogloea olivacea* Chodat
	-	-	*Synura* sp.
	-	-	*Uroglena* sp.
	-	-	*Uroglena* cf. *botrys* (Pascher) Conrad
	-	-	Large unidentified naked chrysophyte (*Ochromonas/Chromulina* sp.)
	-	-	Small unidentified naked chrysophyte (*Ochromonas/Chromulina* sp.)
	-	-	Unidentified haptophyte/chrysophyte (*Erkenia/Chrysochromulina* sp.)
Cryptophyta	*Cryptomonas* sp.	*Chroomonas* sp.	*Cryptomonas* sp.
	Rhodomonas sp.	*Cryptomonas* sp.	*Cryptomonas erosa* Ehrenberg
	-	*Rhodomonas* sp.	*Cryptomonas marsonii* Skuja
	-	-	*Cryptomonas ovata* Ehrenberg
	-	-	*Cyrptomonas phaseolus* Skuja
	-	-	*Cryptomonas pyrenoidifera* Geitler
	-	-	*Cryptomonas reflexa* Skuja
	-	-	*Cryptomonas rostratiformis* Skuja
	-	-	*Cryptomonas tenuis* Pascher
	-	-	*Katablepharis ovalis* Skuja
	-	-	*Rhodomonas* sp.
	-	-	*Rhodomonas lacustris* Pascher & Ruttner
	-	-	*Rhodomonas lens* Pascher & Ruttner
	-	-	*Rhodomonas minuta* Skuja
Euglenophyta	*Trachelomonas* sp.	*Euglena* sp.	*Euglena cf minuta* Prescott
	Phacus sp.	*Phacus* sp.	*Phacus* sp.
	-	-	*Phacus acuminatus* Stokes
	-	-	*Trachemolomas* sp.
	-	-	*Trachemolomas volvocina* Ehrenberg

(continued)

Appendix B. Phytoplankton Taxa Identified in Lac de Gras in 1995 and from 1997 to 2013

Major Taxonomic Group	1995	1997	1997 to 2013
Pyrrophyta	-	-	*Amphidinium* sp.
	-	-	*Ceratium hirundinella* (Muller) Schrank
	-	-	*Glenodinium* sp.
	-	-	*Glenodinium gymnodinium* Penard
	-	-	*Gymnodinium* sp.
	-	-	*Gymnodinium aeroginosum* Stein
	-	-	*Gymnodinium goslaviense* Woloszynska
	-	-	*Gymnodinium helveticum* Pen.
	-	-	*Gymnodinium lantzschii* Utermohl
	-	-	*Gymnodinium* cf. *mitratum* Schiller
	-	-	*Gymnodinium ordinatum* Skuja
	-	-	*Gymnodinium profundum* Schiller
	-	-	*Peridinium* sp.
	-	-	*Peridinium aciculiferum* Lemmermann
	-	-	*Peridinium africanum* f. *tatricum* (Woloszynska) Lefevre
	-	-	*Peridinium cinctum* (Muller) Ehrenberg
	-	-	*Peridinium goslaviense* Woloszynska
	-	-	*Peridinium inconspicum* Lemmermann
	-	-	*Peridinium pusillum* (Penard) Lemmermann
Xanthophyta	-	-	*Ophiocytium* sp.
	-	-	*Ophiocytium cochleare* Braun
	-	-	*Ophiocytium parvulum* (Perty) A. Braun

Note:
sp. = species

Appendix C

Zooplankton Taxa Identified at Diavik and Lac de Gras from 1995 to 2013

Appendix C. Zooplankton Taxa Identified at Diavik and in Lac de Gras from 1995 to 2013

Genera	Diavik	Lac de Gras 1995 to 2013
Cladocera	*Bosmina longirostris*	*Alona* sp.
	Bosmina sp.	*Bosmina* sp.
	Bosmina coregoni	*Bosmina coregoni*
	Daphnia middendorffiana	*Bosmina longirostris*
	Daphnia longiremi	*Chydorus sphaericus*
	Daphnia rosea	*Daphnia* sp.
	Daphnia sp.	*Daphnia longiremis*
	Holopedium gibberum	*Daphnia middendorffiana*
	Holopedium sp.	*Daphnia rosea*
	-	*Eubosmina longispina*
	-	*Eurycercus lamellatus*
	-	*Holopedium* sp.
	-	*Holopedium gibberum*
Copepoda	*Cyclops scutifer*	*Diaptomus* sp.
	Leptodiaptomus ashlandi	*Diaptomus ashlandi*
	Mesocyclops sp.	*Diaptomus minutus*
	Heterocope septentrionalis	*Diaptomus pribilofensis*
	Copepod nauplii	*Diaptomus sicilis*
	Immature calanoid	*Leptodiaptomus ashlandi*
	Immature cyclopoid	*Epischura nevadensis*
	Diaptomus sp.	*Heterocope septentrionalis*
	-	*Cyclops bicuspidatus thomasi*
	-	*Cyclops capillatus*
	-	*Cyclops scutifer*
	-	*Cyclops vernalis*
	-	*Mesocyclops sp.*
Rotifera	*Conochilus* sp.	*Kellicottia* sp.
	Conochilus unicornis	*Asplanchna* sp.
	Kellicottia sp.	*Brachionus* sp.
	Kellicottia longispina	*Collotheca* sp.
	Keratella cochlearis	*Conochilus* sp.
	Keratella hiemalis	*Conochilus unicornis*
	Keratella quadrata	*Filinia* sp.
	Keratella sp.	*Gastropus* sp.
	Polyarthra sp.	*Kellicottia longispina*
	-	*Keratella* sp.
	-	*Keratella cochlearis*
	-	*Keratella hiernalis*
	-	*Keratella quadrata*
	-	*Lecane* sp.
	-	*Monostyla* sp.
	-	*Notholca* sp.
	-	*Phompholyx* sp.
	-	*Polyarthra* sp.
	-	*Synchaeta* sp.
	-	*Trichotria* spp.

Note:

sp. = species

Appendix D

Benthic Invertebrate Taxa Identified in Lac de Gras from 1996 to 2013

Appendix D. Benthic Invertebrate Taxa Identified in Lac de Gras from 1996 to 2013

Major Group	Family	Subfamily	Tribe	Genus / Species
Coelenterata	Hydridae	-	-	*Hydra* sp.
Microturbellaria	-	-	-	-
Nematoda	-	-	-	-
Oligochaeta	Enchytraeidae	-	-	-
	Lumbriculidae	-	-	-
	Naididae	Naidinae	-	-
		Tubificinae	-	-
Pelecypoda	Pisidiidae	-	-	*Sphaerium* sp.
		-	-	*Pisidium* sp.
Gastropoda	Valvatidae	-	-	*Valvata sincera*
Hydracarina	-	-	-	-
Notostraca	Triopsidae	-	-	*Lepidurus* sp.
Amphipoda	Hyalellidae	-	-	*Hyalella azteca*
Copepoda - Harpacticoida	-	-	-	-
Ostracoda	-	-	-	-
Trichoptera	Apataniidae	-	-	*Apatania* sp.
Diptera	Chironomidae	Tanypodinae	Pentaneurini	*Ablabesmyia* sp.
				Thienemannimyia group
			Procladiini	*Procladius* sp.
		Diamesinae	Diamesini	*Potthastia longimana* group
				Pseudodiamesa sp.
			Protanypini	*Protanypus* sp.
		Prodiamesinae	-	*Monodiamesa* sp.
		Orthocladiinae	-	*Abiskomyia* sp.
			-	*Corynoneura* sp.
			-	*Cricotopus* sp.
			-	*Euryhapsis* sp.
			-	*Heterotrissocladius* sp.
			-	*Hydrobaenus* sp.
			-	*Mesocricotopus* sp.
			-	*Orthocladius* sp.
			-	*Paracladius* sp.
			-	*Pseudosmittia* sp.
			-	*Psectrocladius* sp.
			-	*Thienemanniella* sp.
			-	*Zalutschia* sp.
		Chironominae	Chironomini	*Chironomus* sp.
				Cryptochironomus sp.
				Dicrotendipes sp.
				Microtendipes sp.
				Phaenopsectra sp.
				Polypedilum sp.
				Sergenta sp.
				Stictochironomus sp.
			Tanytarsini	*Cladotanytarsus* sp.
				Constempellina sp.
				Corynocera sp.
				Micropsectra sp.
				Micropsectra / Tanytarsus sp.
				Paratanytarsus sp.
				Stempellinella sp.
				Tanytarsus sp.
	Empididae	Hemerodromiinae	Hemerodromiini	*Chelifera* sp.

Note: sp. = species

Appendix E

Fish Species Identified in Lac de Gras from 1995 to 2004

Appendix E. Fish Species Identified in Lac de Gras from 1995 to 2004

Common Name	Scientific Name
Arctic Grayling	*Thymallus arcticus*
Burbot	*Lota lota*
Cisco	*Coregonus artedii*
Lake Trout	*Salvelinus namaycush*
Lake Whitefish	*Coregonus clupeaformis*
Longnose Sucker	*Catostomus catostomus*
Ninespine Stickleback	*Pungitius pungitius*
Round Whitefish	*Prosopium cylindraceum*
Slimy Sculpin	*Cottus cognatus*

Appendix F

Plant Species Identified at Diavik in the 2013 Comprehensive Monitoring Program

Appendix F. Plant Species Identified at Diavik in the 2013 Comprehensive Monitoring Program

Lichen Species	Bryophyte (Moss) Species	Forb Species	Shrub Species	Graminoid Species
Alectoria ochroleuca	*Aulacomnium palustre*	*Astragalus agrestis*	*Andromeda plifolia*	*Calamagrostis inexpansa*
Arctoparmelia centrifuga	*Aulacomnium turgidium*	*Astragalus alpinus*	*Actostaphylos rubra*	*Carex aquatilis*
Arctoparmelia incurva	*Barbilophozia hatcheri*	*Astragalus* spp.	*Betula glandulosa*	*Carex saxatilis*
Arctoparmelia separata	*Bryum pseudotriquetrum*	*Equisetum arvense*	*Empetrum nigrum*	*Carex* sp.
Asahinea scholanderi	*Calliergon stramineum*	*Equisetum scirpoides*	*Ledum decumbens*	*Eleocharis palustris*
Baeomyces carneus	*Calypogeia sphagnicola*	*Huperzia selago*	*Loiseleuria procumbens*	*Eriophorum angustifolium*
Bryocaulon divergens	*Cephalozia bicuspidata*	*Minuartia dawsonensis*	*Oxycoccus microcarpus*	*Eriophorum vaginatum*
Bryoria glabra	*Cephalozia pleniceps*	*Oxytropis maydelliana*	*Salix fuscenscens*	*Hierochloe alpina*
Bryoria nadvornikiana	*Ceratodon purpureus*	*Pedicularis labradorica*	*Salix glauca*	*Scirpus microcarpus*
Bryoria nitidula	*Cladopodiella fluitans*	*Pedicularis lapponica*	*Salix planifolia*	-
Bryoria simplicior	*Cratoneuron filicinum*	*Pinguicula villosa*	*Salix* sp.	-
Bryoria vulgaris	*Dicranum elongatum*	*Rubus chamaemorus*	*Vaccinium uliginosum*	-
Cetraria delisei	*Dicranum fuscescens*	*Stellaria* sp.	*Vaccinium vitis-idaea*	-
Cetraria ericetorum	*Dicranum groenlandicum*	*Tofieldia glutinosa*	-	-
Cetraria fastigiata	*Dicranum scoparium*	*Tofieldia pusilla*	-	-
Cetraria islandica ssp. *crispiformis*	*Dicranum* sp.	-	-	-
Cetraria islandica ssp. *islandica*	*Dicranum undulatum*	-	-	-
Cetraria laevigata	*Drepanocladus* sp.	-	-	-
Cetraria nigricans	*Gymnocolea inflata*	-	-	-
Cetraria sepincola	*Hamatocaulis vernicosus*	-	-	-
Cladina ciliata	*Hylocomium splendens*	-	-	-
Cladonia amaurocraea	*Lophozia binsteadii*	-	-	-
Cladonia bacilliformis	*Lophozia ventricosa*	-	-	-
Cladonia bellidiflora	*Mylia anomala*	-	-	-
Cladonia borealis	*Pleurozium schreberi*	-	-	-
Cladonia carneola	*Pholia nutans*	-	-	-
Cladonia cenotea	*Pholia* sp.	-	-	-
Cladonia cervicornis	*Polytrichum commune*	-	-	-
Cladonia chlorophaea	*Polytrichum juniperinum*	-	-	-
Cladonia coccifera	*Polytrichum piliferum*	-	-	-
Cladonia coniocraea	*Polytrichum* sp.	-	-	-
Cladonia cornuta	*Polytrichum strictum*	-	-	-
Cladonia deformis	*Ptilidium ciliare*	-	-	-
Cladonia fimbriata	*Ptilidium pulcherrimum*	-	-	-
Cladonia gracilis spp. e*longata*	*Racomitrium lanuginosum*	-	-	-
Cladonia gracilis spp. *gracilis*	*Rhytidium rugosum*	-	-	-
Cladonia macrophylla	*Sanionia uncianata*	-	-	-
Cladonia metacorallifera	*Scapania* sp.	-	-	-
Cladonia mitis	*Scorpidium revolvens*	-	-	-
Cladonia pleurota	*Scorpidium scorpioides*	-	-	-
Cladonia pyxidata	*Sphagnum angustifolium*	-	-	-
Cladonia rangiferina	*Sphagnum aongstroemii*	-	-	-
Cladonia rei	*Sphagnum capillifolium*	-	-	-
Cladonia sp.	*Sphagnum fuscum*	-	-	-
Cladonia squamosa	*Sphagnum lenense*	-	-	-
Cladonia stellaris	*Sphagnum magellanicum*	-	-	-
Cladonia stricta	*Sphagnum obtusum*	-	-	-
Cladonia stygia	*Sphagnum* sp.	-	-	-
Cladonia subfurcata	*Sphagnum subsecundum*	-	-	-
Cladonia uncialis	*Sphagnum warnstorfii*	-	-	-
Cladonia wainioi	*Sphagnum wulfianum*	-	-	-
Coelocaulon aculeata	*Telaranea* sp.	-	-	-
Dactylina arctica	*Tetralophozia setiformis*	-	-	-
Flavocetraria cucullata	*Warnstorfia exannulata*	-	-	-
Flavocetraria nivalis	*Warnstorfia fluitans*	-	-	-

Appendix F. Plant Species Identified at Diavik in the 2013 Comprehensive Monitoring Program

Lichen Species	Bryophyte (Moss) Species	Forb Species	Shrub Species	Graminoid Species
Gowardia nigricans	-	-	-	-
Hypogymnia physodes	-	-	-	-
Hypogymnia subobscura	-	-	-	-
Icmadophila ericetorum	-	-	-	-
Masonhalea richardsonii	-	-	-	-
Melanelia hepatizon	-	-	-	-
Melanelia stygia	-	-	-	-
Melanohalea septentrionalis	-	-	-	-
Nephroma exallidum	-	-	-	-
Ophioparam lapponica	-	-	-	-
Parmelia fraudans	-	-	-	-
Parmelia omphalodes	-	-	-	-
Parmelia saxatilis	-	-	-	-
Parmelia skultii	-	-	-	-
Parmelia sulcata	-	-	-	-
Parmeliopsis ambigua	-	-	-	-
Peltigera aphthosa	-	-	-	-
Peltigera didactyla	-	-	-	-
Peltigera kristinssonii	-	-	-	-
Peltigera leucophlebia	-	-	-	-
Peltigera malacea	-	-	-	-
Peltigera polydactyla	-	-	-	-
Peltigera scabrosa	-	-	-	-
Peltigera sp.	-	-	-	-
Pertusaria dactylina	-	-	-	-
Psoroma hypnorum	-	-	-	-
Rhizocarpon geographicum	-	-	-	-
Sphaerophorus globosus	-	-	-	-
Stereocaulon paschale	-	-	-	-
Stereocaulon rivulorum	-	-	-	-
Stereocaulon tomentosum	-	-	-	-
Thamnolia vermicularis	-	-	-	-
Umbilicaria hyperborea	-	-	-	-
Umbilicaria proboscidea	-	-	-	-
Umbilicaria sp.	-	-	-	-
Xanthoparmelia chlorochroa	-	-	-	-
Xanthoparmelia sp.	-	-	-	-

Notes:

sp. = species

spp. = more than one species

Appendix G

Toxicity Reference Values

APPENDIX G. TOXICITY REFERENCE VALUES

1.1 AQUATIC LIFE TOXICITY REFERENCE VALUES

The aquatic primary producer (algae and aquatic plants), zooplankton, benthic invertebrate, and fish species that have been observed at Diavik during monitoring programs are provided in Appendices B, C, D, and E. The species or genus were considered in the selection of TRVs for aquatic life. When data for a species present at the Project site was not available, toxicity data for related species were used. For example, if TRV information was not available on the fish species present in Lac de Gras, the preference was for TRV data from other salmonids of the *Salvelinus* or *Oncorhynchus* genera including Bull Trout (*S. confluentus*), Brook Trout (*S. fontinalis*), Dolly Varden (*S. malma*), and Rainbow Trout (*O. mykiss*).

The TRVs selected for aquatic life receptors are summarized in Table G-1 and are described below.

Table G-1. Toxicity Reference Values for Aquatic Life Receptors

COPCs in Water	Aquatic Plant and Algae TRV (mg/L)	Zooplankton and Benthic Invertebrate TRV (mg/L)	Fish TRV (mg/L)
Aluminum	-	0.100 [a]	0.175
Arsenic	0.048	0.520	0.550
Cadmium	0.005	0.000150	0.000150
Chromium	40	0.300	0.0890
Copper	0.009	0.00228	0.00400
Fluoride	437	75.1	0.270
Iron	-	0.960	0.410 [a]
Lead	-	37.6	0.00600
Mercury	0.005	0.000675	0.000470
Molybdenum	-	741	0.0730
Nickel	0.1	0.0950	0.134
Nitrate	-	358	190
Nitrite	46	100	0.0600
Potassium	-	53.0	950
Selenium	17	0.0771	23.8
Silver	5.1	0.00212	0.000240 [b]
Sulphate	1,900	380	176 [a]
Uranium	0.172	0.0120	0.35
Zinc	-	0.0560 [a]	0.0880

(continued)

Table G-1. Toxicity Reference Values for Aquatic Life Receptors (completed)

COPCs in Sediment	Aquatic Plant and Algae TRV (mg/kg)	Zooplankton and Benthic Invertebrate TRV (mg/kg)	Fish TRV (mg/kg)
Arsenic	N/A	174	N/A
Chromium	N/A	16.7	N/A
Copper	N/A	69.6	N/A
2-Methylnaphthalene	N/A	0.201 [c]	N/A
Acenaphthene	N/A	0.0889 [c]	N/A
Acenaphthylene	N/A	0.128 [c]	N/A
Naphthalene	N/A	0.391 [c]	N/A
Pyrene	N/A	59.1	N/A

Notes:
COPC = contaminant of potential concern
TRV = toxicity reference value
(-) = not available
N/A = exposure route is not applicable and a TRV is not required
Grey shading indicates the lowest aquatic life TRV, which was considered in the selection of a SSRBCC for water or sediment.
[a] *Based on an LC_X thus was not adopted as the aquatic life TRV as EC_X values are preferred.*
[b] *Based on a maximum acceptable toxicant concentration (MATC) for growth thus was not adopted as the aquatic life TRV as EC_X values are preferred.*
[c] *The CCME probable effects level was adopted as the TRV (CCME 2015a).*

1.1.1 Aluminum

Toxicity of aluminum is pH-dependent, thus, consideration of the pH reported in toxicity studies is important to ensuring that the selection of toxicity thresholds is as representative as possible. The mean open-water and ice-covered pH of Lac de Gras is 6.85 and 6.83, respectively (Appendix B of ERM 2016). Therefore, aluminum toxicity studies conducted at similar pH levels for aquatic life were considered.

Toxicity studies on aquatic plants with pH levels in the range of those of Lac de Gras could not be found. The BC MOE (1988) provides results of a toxicity study done on *Daphnia* and *Cyclops* species that determined a 72-hour threshold for aluminum of 0.100 mg/L that resulted in 25-30% mortality of the organisms at a pH of 6 to 7.2. Since this was an acute mortality study it was not considered in the selection of an aluminum TRV for aquatic life.

The United Stated Environmental Protection Agency (US EPA) Ecotox database ('Ecotox') provided the most conservative LOEC and NOEC within the indicated pH range for Brook Trout eyed embryo and eyed egg life stages. Other aquatic invertebrate toxicological data from Ecotox either do not indicate the pH at which the tests were conducted or the pH values were outside of the pH range indicated above. Brook Trout eyed embryos and eyed eggs were exposed for 30 and 60 days to total aluminum concentrations with pH ranging from 6.5 to 6.6 with the reported LOECs for growth and length ranging from 0.088 mg/L to 0.350 mg/L (Cleveland et al. 1989). A TRV of 0.175 mg/L was selected for aluminum in water for aquatic aquatic life based on a geometric mean from LOECs of 0.088 mg/L and 0.350 mg/L.

1.1.2 Arsenic

1.1.2.1 Water

The CCME water quality guideline for the protection of aquatic life for arsenic is based on a 14-day toxicity test on the algae *Scenedesmus obliquus*, as all other aquatic life species were less sensitive (CCME 2001). A search of the Ecotox database did not find any studies indicating other aquatic life were more sensitive than the algae. For example, a 21-day EC_{16} for production of 0.520 mg/L was found for *Daphnia magna* (Biesinger and Christensen 1972) and a 28-day LC_{50} for Rainbow Trout was 0.550 mg/L (Birge, Hudson, et al. 1979).

The study by Vocke et al. (1980) with the algae *S. obliquus* determined a 14-day EC_{50} for growth of 0.048 mg/L arsenic. *Scenedesmus* species are found in Lac de Gras (Appendix B), thus, 0.048 mg/L was adopted as the TRV for arsenic in water for aquatic life.

1.1.2.2 Sediment

Benthic invertebrates and zooplankton were the only aquatic life organisms with exposure routes to sediment. A literature search found an arsenic 10-day EC_{50} for growth of the midge *Chironomus dilutus* of 174 mg/kg dry weight (dw; Liber, Doig, and White-Sobey 2011), which was the lowest TRV available. *Chironomus* species have been found in Lac de Gras (Appendix D). Thus the EC_{50} for *C. dilutus* of 174 mg/kg dw was adopted as the TRV for arsenic in sediment for aquatic life.

1.1.3 Cadmium

The toxicity of cadmium is hardness-dependent, so consideration of the hardness reported in the toxicity studies is important to ensure the selection of representative toxicity thresholds. The mean open-water and ice-covered hardness of Lac de Gras is 6.57 and 7.04 mg/L $CaCO_3$, respectively (Appendix B of ERM 2016). Therefore, cadmium toxicity studies conducted at similar (low) hardness levels were considered.

An Ecotox database search found a 7-day LC_{50} for cadmium of 0.00015 mg/L for *Hyalella azteca* at a water hardness of 18 mg/L $CaCO_3$ (Borgmann et al. 2005). The Ecotox database provided the most conservative EC_X within the indicated hardness range for algae and Rainbow Trout. Vocke et al. (1980) determined a 14-day EC_{50} for growth of the algae *Scenedesmus acutus* of 0.005 mg/L. Mebane, Hennessy, and Dillon (2008) determined a 62-day EC_{10} for growth of Rainbow Trout of 0.00015 mg/L. The more conservative EC_{10} for Rainbow Trout of 0.00015 mg/L was adopted as the TRV in this assessment for cadmium in water for aquatic life.

1.1.4 Chromium

1.1.4.1 Water

A 14-day LC_{50} for chromium was obtained for *Anabaena doliolum* (cyanobacteria) of 40 mg/L (Dubey and Rai 1987).

According to CCME factsheet for chromium (CCME 1999c), "invertebrates are the most sensitive group of organisms to hexavalent chromium". The freshwater CCME guideline for hexavalent chromium is 0.001 mg/L (CCME 1999c) based on a 14-day LOEC for reproduction of 0.01 mg/L for the water flea *Ceriodaphnia dubia* (Hickey 1989); however, *Ceriodaphnia* species have not been identified in Lac de Gras (Appendix C).

An Ecotox database search found a study that used a 2-day exposure of the water flea *Daphnia magna* to hexavalent chromium and an LC_{50} of 0.022 mg/L was reported (Mount and Norberg 1984). *D. magna* often lives in hard waters and is not very tolerant of soft water (Pennak 1978; Greence et al. 1988; Environment Canada 1996), and *D. magna* have not been identified in Lac de Gras (Appendix C). However, apart from a 24-hour chromium LC_{50} of 0.3 mg/L for *D. pulex*, there was no other available relevant chromium toxicity data for the *Daphnia* species present at Diavik (i.e., *D. longiremi, D. rosea,* and *D. middendorffiana*).

The trivalent chromium CCME guideline is 0.0089 mg/L based on 102-day study finding a LOEC for mortality of Rainbow Trout of 0.089 mg/L (CCME 1999c). Most of the studies within the Ecotox database do not distinguish among the form of chromium used in the toxicity study. However, all the chromium NOECs and LOECs within unknown oxidation state reported for the species present at Diavik were greater than the Rainbow Trout LOEC of 0.089 mg/L (Snell and Moffat 1992; Perez-Legaspi and Rico-Martinez 2001). Therefore, 0.089 mg/L was used as the TRV for chromium in water for aquatic life.

1.1.4.2 Sediment

Benthic invertebrates and zooplankton were the only aquatic life organisms with exposure routes to sediment. The CCME guideline for chromium in sediment includes a 48-hour exposure test that obtained a LC_{50} for *D. magna* of 167 mg/kg for hexavalent chromium and 195 mg/kg for trivalent chromium (Dave 1992). *Daphnia* species have been found in Lac de Gras (Appendix C). Thus a UF of 10 was applied to the LC_{50} for hexavalent chromium (for conversion from lethal to sublethal) for *D. magna* to obtain a TRV of 16.7 mg/kg, which was adopted as the TRV for chromium in sediment for aquatic life.

1.1.5 Copper

1.1.5.1 Water

The toxicity of copper is hardness-dependent, so consideration of the hardness reported in the toxicity studies is important to ensure the selection of representative toxicity thresholds. The Lac de Gras receiving environment has soft water, with mean hardness of 6.57 mg/L $CaCO_3$ during the open-water season and 7.04 mg/L $CaCO_3$ during the ice-covered season (Appendix B of ERM 2016). Since toxicity is elevated at lower hardness levels, to be conservative only toxicity tests using soft water were considered.

A toxicity study on *Chlamydomonas reinhardtii* (Chlorophyta) determined a copper LOEC for growth of 0.009 mg/L at a water hardness of 76 mg/L $CaCO_3$ (Garvey, Owen, and Winner 1991).

D. magna are among the most sensitive organisms within the 41 genera considered by the US EPA for development of ambient water quality criteria for copper (US EPA 1985). Among data that the

US EPA used to calculate the ambient water quality criteria for copper, the EC_{50} or LC_{50} ranged from 0.0098 mg/L at hardness of 45.3 mg/L $CaCO_3$ to 0.20 mg/L at hardness of 226 mg/L $CaCO_3$. However due to the soft water characteristics at Lac de Gras, *D. magna* are unlikely to be present. At a hardness of 45 mg/L $CaCO_3$, the EC_{50} for *D. pulex* was reported at 0.053 mg/L (Mount and Norberg 1984).

Bosmina longirostris (a freshwater zooplankton) is present in Lac de Gras and was found to have a two-day EC_{50} for growth that ranged from 0.0014 to 0.0037 mg/L at a water hardness of 33.8 mg/L $CaCO_3$ (Koivisto, Ketola, and Walls 1992). The geometric mean of these values was 0.00228 mg/L. NOECs and LOECs for other invertebrates present in the Lac de Gras receiving environment at appropriate hardness levels were not available.

Among fish species, Brook Trout eggs were exposed to copper for 60-days in soft water (hardness of 37.5 mg/L $CaCO_3$), and a MATC of 0.003 to 0.005 mg/L was estimated for reduced total length and wet weight of fry (Sauter et al. 1976). The geometric mean of these values was 0.004 mg/L.

Based on the above information, *B. longirostris* were the most sensitive organisms of those present at the Diavik site with toxicological information available. Therefore, a geometric mean of the EC_{50} values for this organism of 0.00228 mg/L was used as the TRV for copper in water for aquatic life.

1.1.5.2 Sediment

Benthic invertebrates and zooplankton were the only aquatic life organisms with exposure routes to sediment. A literature search obtained an copper 28-day EC_{10} for biomass (growth) for *Lumbriculus variegatus* (benthic worm) of 69.6 mg/kg (Roman et al. 2007). The Lumbriculidae family has been found in Lac de Gras (Appendix D). This value is in between the interim sediment quality guideline (ISQG; 35.7 mg/kg dw) and probable effects limit (PEL; 197 mg/kg dw) for copper provided by the CCME (2015a). The CCME (1999a) states that the chance of biological effects occurring in the concentration ranges between the ISQG and PEL values cannot be precisely predicted since these guidelines are not based on lab-based toxicological information. Thus, the EC_{10} for *L. variegatus* of 69.6 mg/kg was adopted as the TRV for copper in sediment for aquatic life.

1.1.6 Fluoride

A literature search resulted in limited data on the toxicity of fluoride to aquatic life. Only one toxicity study on freshwater algal species (*Scenedesmus* sp.) present at Lac de Gras was found, which determined a TRV for mortality of 437 mg/L of fluoride.

Some invertebrate toxicity data on *D. magna* and *C. dubia* were reported. A toxicological study reported an EC_{10} for reproduction of 75.1 mg/L for *C. dubia* after a 24-hour exposure to sodium fluoride (Hickey 1989). However, the only reported NOEC for invertebrates was for *D. magna*, where a NOEC for mortality of 110 mg/L of fluoride based on a 48-hour exposure to sodium fluoride (LeBlanc 1980).

Fish appear to be more sensitive to toxicity due to fluoride than invertebrates. Among studies on fish, a 20-day exposure of fluoride to juvenile Rainbow Trout resulted in LC_{50} values ranging from

2.70 mg/L to 4.70 mg/L (Neuhold and Sigler 1960). Since these data represents the lowest concentration at which toxicity occurred in a species relevant for this risk assessment, these data were used to calculate the TRV for fluoride. A UF of 10 was applied to the Rainbow Trout LC_{50} of 2.70 mg/L to account for conversion from a lethal to sublethal endpoint, resulting in a TRV of 0.27 mg/L for fluoride in water for aquatic life.

1.1.7 Iron

A search for iron toxicity studies did not find any studies on aquatic plants. An Ecotox database search found a 4-day LC_{50} for Brook Trout for iron of 0.41 mg/L (Decker and Menendez 1975).

The CCME iron guideline for protection of aquatic life is based on reproduction and growth of *Gammarus minus* (CCREM 1987), an amphipod crustacean sensitive to iron. However, *Gammarus* species have not been observed in Lac de Gras (Appendix D). Fish are not considered to be particularly sensitive to iron; therefore, the iron TRV is based on primary or secondary producers.

The CCME guideline (CCREM 1987) indicates that a 3-week LC_{50} for *D. magna* is 5.9 mg/L, based on a study conducted by Biesinger and Christensen (1972). However, because of the soft water in Lac de Gras, it is unlikely that this species of *Daphnia* would be present. A 3 week exposure of iron chloride to *D. pulex* (which is more tolerant of soft water) found a NOEC and LOEC for survival of 0.700 mg/L and 1.31 mg/L of iron, respectively (Birge et al. 1985). Birge et al. (1985) calculated an MATC for *D. pulex* as 0.960 mg/L (Birge et al. 1985). Therefore, the 0.960 mg/L MATC for *D. pulex* was selected as the iron TRV for iron in water for aquatic life.

1.1.8 Lead

The toxicity of lead is hardness-dependent, thus, consideration of the hardness reported in the toxicity studies is important to ensuring the selection of representative toxicity thresholds. The Lac de Gras receiving environment has soft water, with mean hardness of 6.57 mg/L $CaCO_3$ during the open-water season and 7.04 mg/L $CaCO_3$ during the ice-covered season (Appendix B of ERM 2016). Since lead toxicity is elevated at lower hardness levels, to be conservative only toxicity tests using soft water were considered.

A search for lead toxicity studies did not find any studies on aquatic plants with water hardness within the range of that at Lac de Gras. An Ecotox database search found a two-day study conducted by Sharma and Selvaraj (1994) which determined a LOEC for survival of 0.45 mg/L and a MATC of 0.045 mg/L at a water hardness of 37.6 mg/L $CaCO_3$ for *D. carinata*. This species is not present in Lac de Gras; however, other *Daphnia* species are.

Fish appear to be more sensitive to the effects of lead than invertebrates. Rainbow Trout fry exposed to lead at a water hardness of 28 mg/L $CaCO_3$ for the duration of 354 days had a LOEC for developmental endpoints of 0.0074 mg/L and a MATC for developmental endpoints of 0.004 to 0.008 mg/L (Goettl, Sinley, and Davies 1973). Therefore, the geometric mean MATC of 0.006 mg/L for Rainbow Trout was selected as the TRV for lead in water for aquatic life.

1.1.9 Mercury

An Ecotox database search found a 30-day toxicity study on *Scenedesmus quadricauda* that determined a mortality threshold of 0.005 mg/L for mercury (Angadi and Mathad 1998). An Ecotox database search also found a 28-day EC_{50} for growth for *Brachionus patulus* (rotifer) for total mercury of 0.000675 mg/L (Sarma, Brena-Bustamante, and Nandini 2008). No other studies reporting NOELs, LOELs, or EC_X values were found. However, a 4-day LC_{50} for total mercury was obtained for Rainbow Trout, which was 0.0047 mg/L (Birge, Black, et al. 1979). With application of a UF of 10, the TRV for Rainbow Trout is 0.00047 mg/L, which was adopted as the TRV for mercury in water for aquatic life.

Mercury bioaccumulates in the aquatic environment, yet the TRV described above only accounts for direct exposure, not exposure via the food chain. The CCME (2003) states that the water quality guideline for mercury does not address exposure via food or bioaccumulation of mercury to higher trophic levels. Since the CCME (2007) protocol was followed in deriving TRVs and SSRBCCs, the mercury $SSRBCC_{water}$ for aquatic life may not be protective of higher trophic level organisms. However, a methylmercury $SSRBCC_{fish}$ was derived for grizzly bear, peregrine falcon, bald eagle, and humans. The $SSRBCC_{fish}$ incorporates methylmercury TRVs for those species thus mercury bioaccumulation in fish is accounted for with the $SSRBCC_{fish}$.

1.1.10 Molybdenum

A search for molybdenum toxicity studies did not find any studies on aquatic plants. An Ecotox database search found a 96-hour LC_{50} for molybdenum for *H. azteca* that was great than 741 mg/L (Liber, Doig, and White-Sobey 2011).

The most sensitive species to molybdenum determined with an Ecotox database search was Rainbow Trout, with a LC_{50} being the most sensitive endpoint. A 28-day study determined an LC_{50} of 0.73 mg/L for total molybdenum (Birge, Black, and Westerman 1979). A UF of 10 was applied to the Rainbow Trout LC_{50} of 0.73 mg/L to convert from a lethal to sublethal endpoint, resulting in a TRV of 0.073 mg/L. This is equivalent to the CCME aquatic life guideline for molybdenum (CCME 2015a).

1.1.11 Nickel

The toxicity of nickel is hardness-dependent, thus consideration of the hardness reported in the toxicity studies is important to ensuring the selection of representative toxicity thresholds. The Lac de Gras receiving environment has soft water, with mean hardness of 6.57 mg/L $CaCO_3$ during the open-water season and 7.04 mg/L $CaCO_3$ during the ice-covered season (Appendix B of ERM 2016). Since toxicity is elevated at lower hardness levels, to be conservative only toxicity tests using soft water were considered.

A 14-day toxicity study on *Navicula pelliculosa* (Bacillariophyta) found a 82% reduction in growth at a nickel concentration of 0.1 mg/L and a water hardness of 14.96 mg/L $CaCO_3$ (Fezy, Spencer, and Greene 1979).

The Ecotox database search for nickel found a 21-day EC_{50} for *D. magna* of 0.095 mg/L at a water hardness of 45.3 mg/L $CaCO_3$ (Biesinger and Christensen 1972). A fish study on Rainbow Trout eggs and larval fish reported an acute nickel NOEL of 0.134 mg/L at water hardness between 27 to 39 mg/L $CaCO_3$ (Nebeker, Savonen, and Stevens 2009).

The chronic *D. magna* EC_{50} of 0.095 mg/L was adopted as the TRV for nickel in water for aquatic life.

1.1.12 Nitrate

A search for nitrate toxicity studies did not find any studies on aquatic plants. The Ecotox database search for nitrate obtained a 7-day LOEC and NOEC for reproduction for *D. magna* of 717 and 358 mg/L, respectively (Scott and Crunkilton 2000). A 120-day study on Lake Trout (*Salvelinus namaycush*) fry determined a nitrate EC_{50} for growth and development of 189.6 mg/L (McGurk et al. 2006). Thus, the more conservative nitrate EC_{50} of 189.6 mg/L (rounded up to 190 mg/L) for Lake Trout was used as the TRV in this assessment for nitrate in water for aquatic life.

1.1.13 Nitrite

A search for nitrite toxicity studies did not find any studies on aquatic plants. The Ecotox database search for nitrite only found studies on fish as the one study on benthic worms did not determine a threshold. The most sensitive test was from an 96-hour study that determined LC_{50}s for four sizes of Rainbow Trout that ranged from 0.19 to 0.39 mg nitrite/L (Russo, Smith, and Thurston 1974). Russo, Smith, and Thurston (1974) also determined the nitrite concentration at which there was no mortality for Rainbow Trout, which was 0.06 mg/L. This nitrite concentration was adopted directly by the CCME as the aquatic life guideline for nitrite, with no UF applied (CCREM 1987; CCME 2015a). Thus, the CCME guideline for nitrite of 0.06 mg/L was adopted in this assessment as the TRV for aquatic life.

1.1.14 Potassium

A search for potassium toxicity studies did not find any studies on aquatic plants. The CCME does not provide a water quality guideline for the protection of aquatic life for potassium (CCME 2015a).

The Ecotox database search for potassium determined that *D. magna* are the most sensitive aquatic species, with a 21-day EC_{16} for reproductive impairment of 53 mg/L (Biesinger and Christensen 1972); however, this particular species of *Daphnia* is not likely to be present in Lac de Gras due to the low hardness of the waters. A study on Rainbow Trout determined a 7-day EC_{25} for growth of fry for potassium that ranged from 700 to 1,200 mg/L with a mean value of 950 mg/L (Lazorchak and Smith 2007).

The screening criteria used for potassium was 70 mg/L (see Section 2.4.3.2 of the Phase I report; ERM 2016), which is the site-specific water quality objective (SSWQO) from a nearby project. This SSWQO for potassium for the nearby project was recently updated to 64 mg/L (Wek'èezhìi Land and Water Board 2016). Thus, the potassium SSWQO of 64 mg/L was adopted in this assessment as the TRV for potassium in water for aquatic life.

1.1.15 Selenium

The Ecotox database search indicated that zooplankton and benthic invertebrates are more sensitive to selenium in water (not considering dietary exposures) than fish, algae, and aquatic plants. *Anabaena variabilis* (cyanobacteria) exposed to selenium for 10 to 18 days had an EC_{50} for growth of 17 mg/L (Kumar and Prakash 1971). A 14-day study on *D. magna* determined an LC_{50} of 0.43 mg/L (Halter, Adams, and Johnson 1980), and a (chronic) 10-day test on *C. dilutus* determined an EC_{25} for growth of 0.0771 mg/L (Gallego-Gallegos et al. 2013). *Chironomus* species are present in Lac de Gras (Appendix D). In comparison, a 2-day exposure of Brook Trout to selenium determined an LC_{50} of 23.8 mg/L (Cardwell et al. 1976).

Selenium bioaccumulates in aquatic systems and thus TRVs that are only based on water exposures may underestimate the toxicity from dietary exposure. DeBruyn and Chapman (2007) reviewed the toxicity data for selenium and determined that water concentrations of selenium associated with sublethal effects (due to internal selenium concentrations in benthic invertebrates) ranged from 0.005 to 0.01 mg/L (assuming a bioaccumulation factor of 1,000). Therefore a water concentration of selenium of 0.005 mg/L was adopted as the TRV for selenium in this assessment to account for potential bioaccumulation in higher trophic level organisms.

1.1.16 Silver

An Ecotox database search found a 16-day LC_{100} for *Stigeoclonium tenue* (Chlorophyta) for silver of 5.1 mg/L (Rao and Manohar 1979).

The long-term CCME water quality guideline for the protection of aquatic life for silver is based on chronic toxicity tests in nine species (CCME 2015b); however, only five of those species were observed to be present at Lac de Gras. The endpoints for the different species were MATCs (for growth for Rainbow Trout and for reproduction for *C. dubia*), NOECs (for reproduction for *H. azteca* and for growth for *Chironomus tentans* [midge]), and an EC_{20} (for reproduction for *D. magna*). Since EC_X concentrations are preferred over MATCs and NOECs (Section 2 of the main report), and since *Daphnid* species are present in Lac de Gras, the EC_{20} for *D. magna* of 0.00212 mg/L was adopted as the TRV for silver in water for aquatic life.

1.1.17 Sulphate

Sulphate does not have a CCME water quality guideline for the protection of aquatic life (CCME 2015a); however, a benchmark for Lac de Gras has been set at 128 mg/L sulphate.

An Ecotox database search found a 14-day EC_{10} for reproduction for *H. azteca* of 380 mg/L sulphate at a water hardness of 80 mg/L $CaCO_3$ (Elphick et al. 2011). A 5-day LC_{50} for *Nitzschia linearis* (diatom) for sulphate was determined to be 1,900 mg/L (Patrick, Cairns, and Scheier 1968).

Singleton (2000) determined a 96-hour LC_{50} for Rainbow Trout of 5,000 mg/L at a water hardness of 25 mg/L $CaCO_3$. However, a much lower sulphate LC_{50} for Rainbow Trout of 176 mg/L with a water hardness of 6 mg/L $CaCO_3$ was obtained in a chronic 21-day toxicity study (Meays and Nordin 2013).

Since the EC_{10} for *H. azteca* of 380 mg/L sulphate was obtained from a study with a relatively high hardness, and because the chronic Rainbow Trout study only obtained LC_{50} values rather than EC_X values, the Lac de Gras benchmark of 128 mg/L was adopted as the TRV in this assessment for sulphate in water for aquatic life.

1.1.18 Uranium

The long-term CCME water quality guideline for the protection of aquatic life for uranium is based on chronic toxicity tests in 13 species (CCME 2011); however, only seven of those species were observed to be present in Lac de Gras or are closely related to species that are present. The thresholds and endpoints for the different species were (CCME 2011): a MATC for survival for Lake Trout of 13.4 mg/L; an EC_{10} for reproduction for Rainbow Trout of 0.35 mg/L; an EC_{10} for growth for *H. Azteca* of 0.012 mg/L; an EC_{10} for reproduction for *D. magna* of 0.53 mg/L; an EC_{10} for growth for *C. tentans* of 0.93 mg/L; an EC_{10} for reproduction for *C. dubia* of 0.073 mg/L; and an EC_{10} for growth for *Cryptomonas erosa* (Cryptophyta) of 0.172 mg/L.

The 28-day EC_{10} for growth for *H. azteca* of 0.012 mg/L uranium was the lowest EC_{10} concentration. However, because this value is lower than the CCME water quality guideline for the protection of aquatic life for uranium (0.015 mg/L; CCME 2011), the CCME guideline was adopted as the TRV for uranium in water for aquatic life.

1.1.19 Zinc

The toxicity of zinc is hardness-dependent, so consideration of the hardness reported in the toxicity studies is important to ensure the selection of representative toxicity thresholds. The mean open-water and ice-covered water hardness of Lac de Gras is 6.57 and 7.04 mg/L $CaCO_3$, respectively (Appendix B of ERM 2016). Therefore, zinc toxicity studies conducted at similar water hardness levels were considered.

A search for zinc toxicity studies did not find any studies on aquatic plants with water hardness within the range of that at Lac de Gras. An Ecotox database search found a 7-day LC_{50} for zinc for *H. azteca* of 0.056 mg/L with a water hardness of 18 mg/L $CaCO_3$ (Borgmann et al. 2005).

A literature search for toxicity studies with soft water found a 69-day LC_{10} for mortality for Rainbow Trout of 0.088 mg/L (Mebane, Hennessy, and Dillon 2008). The LC_{10} for mortality was more sensitive than the EC_{10} growth endpoints reported thus a UF was not applied. This LC_{10} for Rainbow Trout of 0.088 mg/L zinc was adopted as the TRV in this assessment for zinc in water for aquatic life.

1.1.20 Polycyclic Aromatic Hydrocarbons

Benthic invertebrates and zooplankton were the only aquatic organisms with exposure routes to sediment in the North Inlet; therefore, no TRVs were identified for aquatic plants or fish. There were five polycyclic aromatic hydrocarbons (PAHs) that were screened in as COPCs in sediment: 2-methylnaphthalene, acenaphthene, acenaphthylene, naphthalene, and pyrene.

An extensive literature search was conducted to obtain TRVs for the individual PAHs; however, the only appropriate single-chemical TRV found was for pyrene since most toxicity tests are conducted with mixtures of PAHs or are conducted in the field rather than in the laboratory.

The study found a pyrene EC_{25} for reproduction for *Limnodrilus hoffmeisteri* (Oligochaeta family benthic worm) of 59.1 mg/kg (Lotufo and Fleeger 1996). The Oligochaeta family has been found in Lac de Gras (Appendix D). Thus the EC_{25} for *L. hoffmeisteri* of 59.1 mg/kg was adopted as the TRV for pyrene in sediment from the North Inlet for aquatic life.

Since single-chemical sediment toxicity tests for the other four PAHs could not be located, the CCME PEL values were adopted as the TRVs for 2-methylnaphthalene, acenaphthene, acenaphthylene, and naphthalene.

1.2 TERRESTRIAL PLANTS AND INVERTEBRATES

Terrestrial plants and invertebrates are exposed to soil via direct contact and this is their only route of exposure to COPCs from the Project. The terrestrial plant species that have been observed at Diavik during monitoring programs are provided in Appendix F. These species (or genus) were considered in the selection of TRVs for terrestrial plants. Terrestrial invertebrate species have not been monitored at Diavik to our knowledge.

The TRVs for terrestrial plants and invertebrates are summarized in Table G-2 and are described below.

Table G-2. Toxicity Reference Values for Terrestrial Plant and Invertebrate Receptors

COPCs in Soil	Terrestrial Plant TRV (mg/kg)	Terrestrial Invertebrate TRV (mg/kg)
Aluminum	-	-
Barium	-	330
Chromium	67.6	671
Manganese	220	450
Molybdenum	9.79	220

Notes:
COPC = contaminant of potential concern
TRV = toxicity reference value
(-) = not available
Grey shading indicates the lowest terrestrial plant or invertebrate TRV, which was considered in the selection of a SSRBCC for soil.

1.2.1 Aluminum

The CCME does not provide a soil quality guideline for the protection of environmental health for aluminum (CCME 2015a). The US EPA Eco SSL for aluminum (US EPA 2003) also does not provide a guideline for aluminum in soil and states that aluminum should only be identified as a COPC in soils with a soil pH less than 5.5. The pH of the type 1 rock was unavailable; however, it is assumed that the pH of type 1 rock is neutral. Therefore, further assessment of the toxicity of aluminum in soil and the derivation of an SSRBCC for aluminum in soil is not necessary.

1.2.2 Barium

None of the terrestrial plant species present at Diavik (Appendix F) were found in the toxicity search for barium. The updated CCME technical document for the barium soil quality guideline states that there are insufficient data to derive a guideline for barium based on invertebrate toxicity data (CCME 2013). However, the US EPA Eco SSL document for barium used three toxicity studies (Kuperman et al. 2002; Phillips et al. 2002; Simini et al. 2002) on pot worm (*Enchytraeus crypticus*), springtail (*Folsomia candida*), and earthworm (*Eisenia fetida*) to derive an Eco SSL for barium of 330 mg/kg dw (US EPA 2005b). Since this barium concentration is lower that the CCME soil quality guideline for residential/parkland use (CCME 2015a), the CCME guideline of 500 mg/kg was adopted as the TRV for barium in this assessment.

1.2.3 Chromium

None of the terrestrial plant species present at Diavik (Appendix F) were found in the toxicity search for chromium. The CCME technical document for the derivation of the soil quality guideline for chromium (CCME 1999b) lists a toxicity study done on *E. fetida* (earthworm) that obtained an LC_{50} for total chromium of 671 to 1,400 mg/kg. The CCME (1999b) also provided results of toxicity tests on terrestrial plants (tomato, oat, radish, and lettuce) that determined EC_{50}'s (effects on yield and seed germination) for total chromium that ranged from 21 to 397 mg/kg. The geometric mean of the EC_{50} values of 67.6 mg/kg was adopted as the TRV for chromium in this assessment.

1.2.4 Manganese

None of the terrestrial plant species present at Diavik (Appendix F) were found in the toxicity search for manganese. The CCME does not provide soil quality guidelines for manganese (CCME 2015a). The US EPA Eco SSL document for manganese used three toxicity studies (Kuperman et al. 2002; Phillips et al. 2002; Simini et al. 2002) on a pot worm (*E. crypticus*), springtail (*F. candida*), and earthworm (*E. fetida*) to derive an invertebrate Eco SSL for manganese of 450 mg/kg dw (US EPA 2007b). The US EPA Eco SSL document for manganese used four toxicity studies on terrestrial plants (barley, cotton, and nile grass) to derive a plant Eco SSL for manganese of 220 mg/kg dw (US EPA 2007b). The US EPA Eco SSL for plants of 220 mg/kg was adopted as the TRV for manganese in this assessment.

1.2.5 Molybdenum

None of the terrestrial plant species present at Diavik (Appendix F) were found in the toxicity search for molybdenum. A literature search determined that terrestrial plants were more sensitive to molybdenum than terrestrial invertebrates.

A study by van Gestel et al. (2011) investigated the toxicity of molybdenum to three terrestrial invertebrates: *E. crypticus* (pot worm), *F. candida* (springtail), and *Eisenia andrei* (earthworm). The study obtained an EC_{10} for reproduction for each species at three pH levels (7.3, 7.6, and 7.8). A geomean of all of the EC_{10} values for molybdenum was 220 mg/kg.

A study by McGrath et al. (2010) determined EC_{10}'s for shoot yield on oilseed rape (*Brassica napus L.*), red clover (*Trifolium pratense L.),* ryegrass (*Lolium perenne*), and tomato (*Lycopersicon esculentum*

L.). The geometric mean of EC_{10}'s for each species was calculated and the geometric mean of those values was determined to be 9.79 mg/kg. This geometric mean of EC_{10}'s was adopted as the TRV for molybdenum in this assessment.

1.3 Mammalian Toxicity Reference Values

There are no TRVs available for the mammalian wildlife species present at Diavik, thus, TRVs from toxicity tests on laboratory mammals were considered instead. In developing TRVs, Environment Canada (2010, 2012) discourages allometric scaling (i.e., scaling of organism characteristics such as ingestion rate based on influence of organism body size) as well as use of safety/uncertainty factors without support of scientific evidence. Therefore, the lowest available toxicity endpoints for available species that were representative of the wildlife ROCs were adopted as appropriate TRVs. Table G-3 provides a summary of the wildlife TRVs used in this assessment and the following discussion provides the studies used to develop the wildlife TRVs.

Table G-3. Toxicity Reference Values for Mammalian Wildlife Receptors

COPCs in Water, Soil, or Fish Tissue	TRV (mg/kg BW/day)
Aluminum	1.93
Barium	51.8
Chromium	2.40
Cobalt	7.33
Manganese	51.5
Mercury	1.01
Methylmercury	0.0220
Molybdenum	0.260
Nickel	1.70
Uranium	3.07

Notes:
COPC = contaminant of potential concern
TRV = toxicity reference value
BW = body weight

1.3.1 Aluminum

The mammalian TRV for aluminum was obtained from a study on mice (*Mus musculus*; Ondreicka, Ginter, and Kortus 1966) that was reported in the ORNL's document on toxicological benchmarks for wildlife (Sample, Opresko, and Suter II 1996). The study by Ondreicka, Ginter, and Kortus (1966) determined a chronic no observed adverse effects level (NOAEL) based on reproductive effects of 1.93 mg/kg BW/day, which was used as the mammalian TRV in this assessment.

1.3.2 Barium

The mammalian TRV for barium was obtained from several toxicology studies on mammals (i.e., rats and mice) that were reported in the US EPA's Eco SSL document for barium (US EPA 2005b).

The geometric mean of NOAELs for reproduction and growth was 51.8 mg/kg BW/day, which was adopted as the mammalian TRV in this assessment.

1.3.3 Chromium

The mammalian TRV for chromium was obtained from several toxicology studies on mammals (i.e., rats, mice, sheep, pigs, and cows) that were reported in the US EPA's Eco SSL document for chromium III (US EPA 2008). The geometric mean of NOAELs for reproduction and growth was 2.40 mg/kg BW/day, which was adopted as the mammalian TRV used in this assessment.

1.3.4 Cobalt

The mammalian TRV for cobalt was obtained from several toxicology studies on mammals (i.e., rats, mice, guinea pigs, cows, and pigs) that were reported in the US EPA's Eco SSL document for cobalt (US EPA 2005c). The geometric mean of NOAELs for reproduction and growth was 7.33 mg/kg BW/day, which was adopted as the mammalian TRV used in this assessment.

1.3.5 Manganese

The mammalian TRV for manganese was obtained from several toxicology studies on mammals (i.e., rats, mice, hamsters, guinea pigs, rabbits, sheep, pigs, cows, and water buffalo) that were reported in the US EPA's Eco SSL document for manganese (US EPA 2007b). The geometric mean of NOAELs for reproduction and growth was 51.5 mg/kg BW/day, which was adopted as the mammalian TRV used in this assessment.

1.3.6 Mercury and Methylmercury

The mammalian TRV for mercury was obtained from a study on mink (*Neovison vison*; Aulerich, Ringer, and Iwamoto 1974) that was reported in the ORNL document on toxicological benchmarks for wildlife (Sample, Opresko, and Suter II 1996). The study by Aulerich, Ringer, and Iwamoto (1974) determined a chronic NOAEL based on reproductive effects of 1.01 mg/kg BW/day, which was used in this assessment as the mammalian TRV for mercury.

The mammalian TRV for methylmercury was also obtained from a study on mink (Chamberland et al. 1996) that was reported in the CCME technical guidance document for tissue residue guidelines for methylmercury (CCME 2000). The CCME calculated a TRV from the study by Chamberland et al. (1996) of 0.0220 mg/kg BW/day, which was the mean of the LOEC and NOEC divided by a safety factor of five (CCME 2000). This TRV of 0.0220 mg/kg BW/day for methylmercury was adopted in this assessment for mammals.

1.3.7 Molybdenum

The mammalian TRV for molybdenum was obtained from a study on mice (*Mus musculus*; Schroeder and Mitchener 1971) that was reported in the ORNL document on toxicological benchmarks for wildlife (Sample, Opresko, and Suter II 1996). The study by Schroeder and Mitchener (1971) determined a chronic NOAEL based on reproductive effects of 0.26 mg/kg BW/day, which was adopted as the molybdenum TRV for mammals in this assessment.

1.3.8 Nickel

The mammalian TRV for nickel was obtained from a study on mice (Mus musculus; Pandey and Srivastava 2000) that was reported in the US EPA's Eco SSL document for nickel (US EPA 2007c). The TRV was 1.70 mg/kg BW/day, which is based on the highest NOAEL for reproduction, growth, and survival that was lower than the lowest bound lowest observed adverse effects level (LOAEL) reported in the literature. The nickel TRV for mammals was used in this assessment.

1.3.9 Uranium

The mammalian TRV for uranium was obtained from a study on mice (*Mus musculus*; Paternain et al. 1989) that was reported in the ORNL document on toxicological benchmarks for wildlife (Sample, Opresko, and Suter II 1996). The study by Paternain et al. (1989) determined a chronic NOAEL based on reproductive effects of 3.07 mg/kg BW/day, which was used in this assessment.

1.4 Avian Toxicity Reference Values

The TRVs for bird ROCs are presented in Table G-4 and are described below. There are no TRVs available for the avian wildlife species present at Diavik, thus, TRVs from toxicity tests on common bird species were considered instead.

Table G-4. Toxicity Reference Values for Avian Wildlife Receptors

COPCs in Water, Sediment, Soil, or Fish Tissue	TRV (mg/kg BW/day)
Aluminum	110
Arsenic	2.24
Barium	20.8
Chromium	2.66
Cobalt	7.61
Copper	4.05
Manganese	179
Mercury	0.450
Methylmercury	0.0310
Molybdenum	3.50
Nickel	6.71
Uranium	16.0
2-Methylnaphthalene	1,653
Acenaphthene	175
Acenaphthylene	180
Naphthalene	1,653
Pyrene	125

Notes:
COPC = contaminant of potential concern
TRV = toxicity reference value
BW = body weight

1.4.1 Aluminum

The avian TRV for aluminum was obtained from a study on ringed dove (*Streptopelia capicola*; Carriere et al. 1986) that was reported in the ORNL document on toxicological benchmarks for wildlife (Sample, Opresko, and Suter II 1996). The study by Carriere et al. (1986) determined a chronic NOAEL based on reproductive effects of 109.7 mg/kg BW/day (rounded up to 110 mg/kg BW/day), which was used as the TRV in this assessment.

1.4.2 Arsenic

The avian TRV for arsenic was obtained from a study on chicken (*Gallus gallus domesticus*; Holcman and Stibilj 1997) that was reported in the US EPA's Eco SSL document for arsenic (US EPA 2005a). The TRV of 2.24 mg/kg BW/day is based on the lowest NOAEL for reproduction, growth, and survival, which was used in this assessment.

1.4.3 Barium

The avian TRV for aluminum was obtained from a study on 1-day old chicks (*Gallus gallus domesticus*; Johnson, Mehring, and Titus 1960) that was reported in the ORNL document on toxicological benchmarks for wildlife (Sample, Opresko, and Suter II 1996). The study by Johnson, Mehring, and Titus (1960) determined a chronic NOAEL based on mortality effects of 20.8 mg/kg BW/day, which was used as the TRV in this assessment.

1.4.4 Chromium

The avian TRV for arsenic was obtained from several toxicological studies on birds (i.e., chickens, turkeys, and black ducks) reported in the US EPA's Eco SSL document for chromium (US EPA 2008). The TRV of 2.66 mg/kg BW/day is the geometric mean of NOAELs for reproduction and growth, which was used in this assessment.

1.4.5 Cobalt

The avian TRV for cobalt was obtained from several toxicological studies on birds (i.e., chickens and ducks) reported in the US EPA's Eco SSL document for cobalt (US EPA 2005c). The TRV of 7.61 mg/kg BW/day is the geometric mean of NOAELs for growth effects, which was used in this assessment.

1.4.6 Copper

The avian TRV for copper was obtained from a study on chicken (Rangachar and Hegde 1975) reported in the US EPA's Eco SSL document for copper (US EPA 2007a). The TRV of 4.05 mg/kg BW/day is based on the highest bounded NOAEL for reproduction, growth, and survival that was lower than the lowest bound LOAEL reported in the literature. The copper TRV was adopted for birds in this assessment.

1.4.7 Manganese

The avian TRV for manganese was obtained from several toxicological studies on birds (i.e., chickens, Japanese quail, and turkeys) reported in the US EPA's Eco SSL document for manganese (US EPA

2007b). The TRV of 179 mg/kg BW/day is the geometric mean of NOAELs for reproduction and growth effects, which was used in this assessment.

1.4.8 Mercury and Methylmercury

The avian TRV for mercury was obtained from a study on Japanese quail (*Coturnix japonica*; Hill and Schaffner 1976) that was reported in the ORNL document on toxicological benchmarks for wildlife (Sample, Opresko, and Suter II 1996). The study by Hill and Schaffner (1976) determined a chronic NOAEL based on reproductive effects of 0.45 mg/kg BW/day, which was used in this assessment.

The avian TRV for methylmercury was obtained from studies on mallards (Heinz 1976a, 1976b, 1979) that were reported in the CCME guidance document for CCME technical guidance document for tissue residue guidelines for methylmercury (CCME 2000). The TRV of 0.0310 mg/kg BW/day is the geometric mean of LOEC and NOEL values for growth and survival (CCME 2000). This TRV of 0.0310 mg/kg BW/day for methylmercury was adopted in this assessment for birds.

1.4.9 Molybdenum

The avian TRV for molybdenum was obtained from a study on chicken (Lepore and Miller 1965) that was reported in the ORNL document on toxicological benchmarks for wildlife (Sample, Opresko, and Suter II 1996). The study by Lepore and Miller (1965) determined a chronic NOAEL based on reproductive effects of 3.5 mg/kg BW/day, which was used in this assessment.

1.4.10 Nickel

The avian TRV for nickel was obtained from several toxicological studies on birds (i.e., chickens and ducks) reported in the US EPA's Eco SSL document for nickel (US EPA 2007c). The TRV of 6.71 mg/kg BW/day is the geometric mean of NOAELs for reproduction and growth effects, which was used in this assessment.

1.4.11 Uranium

The avian TRV for uranium was obtained from a study on black duck (*Anas rubripes*; Haseltine and Sileo 1983) that was reported in the ORNL document on toxicological benchmarks for wildlife (Sample, Opresko, and Suter II 1996). The study by Haseltine and Sileo (1983) determined a chronic NOAEL based on mortality, body weight, blood chemistry, liver, and kidney effects of 16 mg/kg BW/day, which was used in this assessment.

1.4.12 2-Methylnaphthalene

An avian TRV for 2-methylnaphthalene could not be found in the published literature. Thus avian TRV for naphthalene was used, which was obtained from a study on bobwhite (*Colinus virginianus*; Landis Assoc. Inc. 1985) reported in the US EPA's Eco SSL document for polycyclic aromatic hydrocarbons (PAHs; US EPA 2007d). The TRV of 1,653 mg/kg BW/day is based on an LOAEL for growth, which was used in this assessment.

1.4.13 Acenaphthene

An avian TRV for acenaphthene could not be found in the published literature. Thus, a TRV for acenaphthene for mice (ATSDR 1995) was used, which was based on a minimal LOAEL of 175 mg/kg BW/day for changes in liver weight. The TRV of 175 mg/kg BW/day was used in this assessment.

1.4.14 Acenaphthylene

An avian TRV for acenaphthylene could not be found in the published literature. Thus, a TRV for acenaphthylene for rats (*Rattus norvegicus*; ATSDR 1995) was used, which was based on a LOAEL of 180 mg/kg BW/day for changes in immune responses. The TRV of 180 mg/kg BW/day was used in this assessment.

1.4.15 Naphthalene

The avian TRV for naphthalene was obtained from a study on bobwhite (Landis Assoc. Inc. 1985) reported in the US EPA's Eco SSL document for PAHs (US EPA 2007d). The TRV of 1,653 mg/kg BW/day is based on an LOAEL for growth, which was used in this assessment.

1.4.16 Pyrene

An avian TRV for pyrene could not be found in the published literature. Thus, a TRV for pyrene for mice (US EPA 1989) was used, which was based on a LOAEL of 125 mg/kg BW/day for weight and mortality. The TRV of 125 mg/kg BW/day was used in this assessment.

1.5 HUMAN TOXICITY REFERENCE VALUES

The TRV assessment involves determining the amount of a COPC that can be taken into the human body without experiencing adverse health effects. Toxicity information is typically derived from laboratory studies, where dose-response information is extrapolated from animal test subjects to humans by applying uncertainty or safety factors.

In most cases, for human TRVs UFs of 100 to 1,000 are applied to the laboratory-derived NOAELs. These UFs account for interspecies extrapolation and the protection of the most susceptible portion of the population (i.e., children and the elderly). Therefore, TRVs based on animal studies generally have large margins of safety to ensure that the toxicity or risk of a substance to people is not underestimated. Lowest observed adverse effect levels from human studies have smaller UFs because no extrapolation from animals to humans is required.

The TRVs in this assessment are presented as TDIs or Provisional Tolerable Daily Intakes (PTDIs). The TDI is defined as the amount of contaminant per unit body weight that can be taken into the body each day (e.g., mg/kg BW/day) with no risk of adverse health effects. The term tolerable is used because it signifies permissibility rather than acceptability for the intake of contaminants unavoidably associated with the consumption of otherwise wholesome and nutritious (country) foods (Herrman and Younes 1999). Use of the term "provisional" expresses the tentative nature of the evaluation, in view of the paucity of reliable data on the consequences of human exposure at levels approaching those indicated.

Health Canada TRVs (Health Canada 2010, 2011) were used preferentially (i.e., Health Canada's Bureau of Chemical Safety, Chemical Health Hazard Division) unless they were not available for certain COPCs, in which case alternative sources for TRVs were consulted. Other sources of TRVs included:

- US EPA IRIS guidelines (US EPA 2016);
- Food and Agriculture Organization of the United Nations (FAO)/World Health Organization (WHO) Joint Expert Committee on Food Additives and Contaminants (JECFA) guidelines (JECFA 2007a, 2007b, 2010);
- Health Effects Assessment Summary Table (US EPA 1997); and
- ATSDR toxicological profiles for metals (ATSDR 2016).

The TRVs for adults and toddlers used in this assessment are presented in Table G-5. Methylmercury is the only COPC that also has an additional TRV for sensitive adults (women of child-bearing age and pregnant women). It is noted that the US EPA uses the term reference dose (RfD) rather than TDI, but for consistency RfDs will be reported as TDIs. Toxicity studies on which the TDIs were based and the rationale for their selection are briefly summarized in the sections below.

Table G-5. Toxicity Reference Values for Human Receptors

COPCs in Water, Soil, and Fish Tissue	TRV (mg/kg BW/day)	
	Adult	Toddler
Aluminum	0.300	0.300
Antimony	0.00300	0.00300
Arsenic	0.000300	0.000300
Barium	0.200	0.200
Chromium	0.00100	0.00100
Manganese	0.156	0.136
Mercury [a]	0.000300	0.000300
Methylmercury [b]	0.000470	0.000230
Molybdenum	0.0280	0.0230
Nitrate	1.60	1.60
Nitrite	0.0100	0.0100
Selenium	0.00570	0.00620
Sulphate	14.0	60.6
Uranium	0.000600	0.000600

Notes:
COPC = contaminant of potential concern
TRV = toxicity reference value
BW = body weight
[a] *Total mercury TRV for adults and toddlers eating biota other than fish.*
[b] *Methylmercury TRV for general public eating fish is 0.00047 mg/kg BW/day, while that for children, women of child-bearing age, and pregnant women eating fish is 0.00023 mg/kg BW/day.*

1.5.1 Aluminum

Health Canada (2011) provides a PTDI of 0.3 mg/kg BW/day for aluminum. JECFA provides an estimate for a provisional tolerable weekly intake (PTWI) of 1 mg/kg BW/week which is equivalent to a PTDI of 0.14 mg/kg BW/day (JECFA 2007a). The ATSDR (2008) has derived an intermediate-duration and a chronic-duration oral minimal risk level (MRL) of 1 mg aluminum/kg BW/day. The chronic-duration MRL is based on a LOAEL of 100 mg aluminum/kg BW/day for neurological effects in mice exposed to aluminum lactate in the diet during gestation, lactation, and post-natal until two years of age (Golub et al. 2000). The MRL was derived by dividing the LOAEL by a UF of 300 (3 for the use of a minimal LOAEL, 10 for animal to human extrapolation, and 10 for intra-human variability) and a modifying factor of 0.3 to account for the higher bioavailability of the aluminum lactate used in the principal study compared to the bioavailability of aluminum in the human diet and drinking water. However, the lower Health Canada PTDI of 0.3 mg/kg BW/day was used in this assessment to be conservative.

1.5.2 Antimony

Health Canada (2011) provides a TDI of 0.003 mg/kg BW/day for antimony. IRIS (US EPA 2016) provides a TDI of 0.0004 mg/kg BW/day. This TDI was based on a study in rats conducted in 1970 which determined a LOAEL of 0.35 mg/kg BW/day with a UF of 1,000 applied. The more recent antimony TDI of 0.003 mg/kg BW/day adopted by Health Canada (2011) was used in this assessment.

1.5.3 Arsenic

Health Canada does not provide a TRV for non-carcinogenic risks for arsenic. For assessment of non-cancer risks from arsenic, IRIS (US EPA 2016) provides 0.0003 mg/kg BW/day for a chronic oral TDI, while JECFA recommends a TDI of 0.001 mg/kg BW/week for oral exposures (JECFA 2010). The more conservative US EPA value of 0.0003 mg/kg BW/day was used in the assessment.

1.5.4 Barium

Health Canada (2010) and IRIS (US EPA 2016) provide a TDI for barium of 0.2 mg/kg BW/day. The WHO (2001) lists a NOAEL in humans of 0.21 mg barium/kg BW/day based on a weight-of-evidence approach that focused on four co-principal studies in humans and rats that investigated both cardiovascular and renal end-points. The NOAEL was used as the basis to derive a TDI for barium by dividing the NOAEL by a UF of 10 to account for some database deficiencies and potential differences between adults and children. The resulting TDI was 0.02 mg/kg BW/day for barium and barium compounds (WHO 2001).

The IRIS TDI is an order of magnitude higher than the WHO TDI because of new evidence: a new principal study and critical effect determined by the National Toxicology Program, benchmark dose modelling for the determination of the point of departure, a new evaluation of the literature, and new application of UFs (US EPA 2016). Thus the barium TDI of 0.2 mg/kg BW/day adopted by Health Canada (2010) and IRIS (US EPA 2016) was used in this assessment.

1.5.5 Chromium

Health Canada (2010) provides a TDI of 0.001 mg/kg BW/day for total chromium. This value was based on water intake and was derived from multiplication of the MATC for total chromium of 0.05 mg/L by a water consumption rate of 1.5 L/day, and divided by the body weight of 70 kg. IRIS provides an TDI of 0.03 mg/kg BW/day (US EPA 2016), which was derived from a NOAEL of 2.5 mg/kg BW/day based on a one year chronic toxicity study with rats (MacKenzie et al. 1958). A UF of 900 was applied to the NOAEL: 10 for interspecies extrapolation, 10 for inter-human variability, 3 as modifying factor, and 3 to address concerns from other studies (Zhang and Li 1987). The more conservative Health Canada TDI of 0.001 mg/kg BW/day was used in this assessment.

1.5.6 Iron

Iron was not retained as a COPC for humans despite being measured at concentrations in water that exceed the Canadian Drinking Water Quality aesthetic objective for iron (Health Canada 2015). Iron is an essential element as it is a required component in blood cells for the transportation of oxygen throughout the body (Adriano 2001). Iron is the second most abundant metal in the earth's crust and is abundant in soils and sediment where it is often tightly bound and not available for biological uptake. Iron toxicity in humans is rare and most cases of acute poisoning have occurred when children accidentally consume large amounts of iron supplements (intended for adults) as they mistake the pills for candy (EGVM 2003; Tenenbein 2005). Even with increased oral iron intake there is generally no significant iron overload in adults unless the individual has increased iron absorption because the ingested iron is in a highly bioavailable form, the individuals has an accompanying genetic defect, or the individual has increased demand due to a disorder (EGVM 2003). Furthermore, adverse health effects from the ingestion of large amounts of iron have only been associated with iron supplements and not with iron in food (EGVM 2003). Because iron is an essential element for humans, environmental exposure to iron from food or water consumption is not likely lead to adverse health effects, and the drinking water guideline for iron is actually an aesthetic objective, iron was not considered further in the development of SSRBCCs for human receptors.

1.5.7 Manganese

Manganese is an essential element that is required for normal physiological function in all animal species; however, individual requirements and toxicity can be highly variable (US EPA 2016). Excess intake of manganese can result in symptoms such as lethargy, increased muscle tonus, tremor, and metal disturbances (US EPA 2016), thus, Health Canada (2010) provides a manganese TDI for toddlers of 0.136 mg/kg BW/day and for adults of 0.156 mg/kg BW/day. The IRIS (US EPA 2016) TDI is 0.14 mg/kg/day which is the NOAEL for chronic human consumption of manganese in the diet from a composite of data from several studies. IRIS states that the confidence in the dietary TDI for manganese is medium (US EPA 2016). The Health Canada TDIs for toddlers and adults were adopted in this assessment.

1.5.8 Mercury and Methylmercury

Health Canada (2010) provides a TDI of 0.0003 mg/kg BW/day for inorganic mercury exposure for the general public, based on CCME soil quality guidelines and supporting documentation on health-based guidelines prepared by Health Canada.

For fish, mercury was assumed to be present 100% as methylmercury (Health Canada 2007). For methylmercury, JECFA (2007b) recommends a PTDI of 0.00047 mg/kg BW/day for the general public, and 0.00023 mg/kg BW/day for sensitive groups (i.e., children and women who are pregnant or who are of child-bearing age). This was also adopted by Health Canada (2010) and is used in this assessment.

1.5.9 Molybdenum

Molybdenum is an essential element and required for human nutrition. Health Canada (2010) provides an age- and body weight-adjusted tolerable upper limit for molybdenum that is based on NOAEL of 0.9 mg/kg BW/day and a LOAEL of 1.6 mg/kg BW/day for reproductive effects in rats, with a UF of 30. Molybdenum TDI values of 0.023 and 0.028 mg/kg BW/day were used for toddlers and adults, respectively.

1.5.10 Nitrate

Nitrate is a normal component of the human diet, with an EDI of approximately 75 mg/day in American adults (National Academy of Sciences 1981). At high doses, nitrate can produce toxic effects in infants due to its biotransformation to nitrite, which can ultimately convert hemoglobin to a form incapable of transporting oxygen (called methemoglobin) from the lungs to tissues and results in a condition called methemoglobinemia (National Academy of Sciences 1981).

The US EPA (2016) provides an oral TDI of 1.6 mg/kg BW/day, which is based on epidemiological studies relating known cases of infantile methemoglobinemia to elevated concentrations of nitrate measured in the drinking water supply (Donahoe 1949; Bosch et al. 1950; Walton 1951), as well as controlled exposures of nitrate in drinking water to infants (Simon et al. 1964; Toussaint and Selenka 1970). This value incorporates a UF of 1 due to the availability of a defined NOAEL of 10 mg/kg BW/day for the critical toxic effect in the most sensitive human subpopulation (infants).

The ATSDR (2015) provides a minimal risk level of 4 mg/kg BW/day for chronic-duration oral exposure to nitrate. However, the more conservative TDI provided by the US EPA (2016) of 1.6 mg/kg BW/day will be used in this assessment.

1.5.11 Nitrite

The US EPA (2016) provides an oral TDI of 0.01 mg/kg BW/day, which is based on a NOEL of 1.0 mg/kg BW/day with a UF of 10 applied. The ATSDR (2015) provides a minimal risk level of 0.1 mg/kg BW/day for chronic-duration oral exposure to nitrite. However, the more conservative TDI provided by the US EPA (2016) of 0.01 mg/kg BW/day will be used in this assessment.

1.5.12 Selenium

Selenium is an essential element and is required for human nutrition. Health effects due to an exposure to elevated levels of selenium are described as selenosis (i.e., gastrointestinal disorders, hair loss, sloughing of nails, fatigue, irritability, and neurological damage). Health Canada (2010) provides an age- and body weight-adjusted tolerable upper limit for selenium of 0.0062 to 0.0057 mg/kg

BW/day (toddlers and adults, respectively). This was based on a NOAEL in adults of 0.8 mg/kg/day in a cohort study by Yang and Zhou (1994) and a NOAEL in children of 0.007 mg/kg/day (Shearer and Hadjimarkos 1975). The selenium TRV for toddlers and adults (0.0062 and 0.0057 mg/kg BW/day, respectively) recommended by Health Canada (2010) was used in this assessment.

1.5.13 Sulphate

Sulphate is a normal component of the human diet with an EDI of approximately 500 mg/day for Canadian adults exposed to sulphate in food, drinking water, and air (Health Canada 1987). Although the ingestion of normal levels of sulphate is considered safe, oral doses reaching 14 to 29 mg/kg BW are known to cause gastrointestinal irritation and catharsis in adult humans (McKee and Wolfe 1963). Although not explicitly provided by Health Canada, a conservative approximation of 14 mg/kg BW/day is assumed as a TRV for sulphate in this assessment for adults. The sulphate TRV for adults was modified for toddlers by accounting for their smaller body weight, resulting in a toddler TRV for sulphate of 60.6 mg/kg BW/day.

1.5.14 Uranium

Health Canada (2010) provides an oral TDI for uranium of 0.0006 mg/kg BW/day, which is based on a sub-chronic study done in rats that determined a LOAEL of 0.06 mg/kg BW/day and applied a UF of 100. The US EPA (2016) provides an TDI for uranium of 0.003 mg/kg BW/day, which is based on a study in rabbits that determined a LOAEL 2.8 mg/kg BW/day, with a UF of 1,000 applied. The ATSDR (2013) provides a minimal risk level of 0.0002 mg/kg BW/day for intermediate-duration oral exposure to soluble compounds of uranium. A chronic duration minimal risk level was not derived as the available studies would result in it being higher than the intermediate-duration minimal risk level (ATSDR 2013). The more conservative uranium TDI from Health Canada (2010) of 0.0006 mg/kg BW/day will be used in this assessment.

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Appendix H

Site-specific Risk-based Closure Criteria for Mammals

Appendix H. Site-specific Risk-based Closure Criteria for Mammals

COPC	Soil SSRBCC (mg/kg dw)			
	Caribou	Grizzly Bear	Red Fox	Northern Red-backed Vole
Aluminum	2,887	2,406	979	486
Barium	10,567	65,687	26,739	13,312
Chromium	689	784	319	142
Manganese	2,568	39,049	15,896	7,436
Molybdenum	7.35	281	114	55.7

COPC	Water SSRBCC (mg/L)			
	Caribou	Grizzly Bear	Red Fox	Northern Red-backed Vole
Chromium	8.00	9.25	5.58	3.51
Cobalt	24.4	28.3	17.1	10.7
Manganese	172	199	120	75.4
Molybdenum	0.867 [a]	1.00	0.605 [a]	0.381 [a]
Nickel	5.67	6.55	3.95	2.49
Uranium	10.2	11.8	7.14	4.50

COPC	Fish Tissue SSRBCC (mg/kg ww)
	Grizzly Bear
Methylmercury	9.03

Notes:

SSRBCC = site-specific risk-based closure criteria

COPC = contaminant of potential concern

dw = dry weight

ww = wet weight

[a] *SSRBCC is lower than the CCME water quality guideline for livestock for molybdenum (1 mg/L; CCME 2015). Thus the CCME guideline of 1 mg/L is adopted as the SSRBCC for caribou, red fox, and northern red-backed vole.*

Appendix I

Site-specific Risk-based Closure Criteria for Birds

Appendix I. Site-specific Risk-based Closure Criteria for Birds

COPC	Water SSRBCC (mg/L)				
	Semi-palmated Sandpiper	Long-tailed Duck	Willow Ptarmigan	Peregrine Falcon	Bald Eagle
Chromium	2.90	9.31	8.41	47.7	83.2
Cobalt	8.28	26.6	24.1	137	238
Manganese	195	626	566	3,213	5,598
Molybdenum	3.81	12.2	11.1	62.8	109
Nickel	7.30	23.5	21.2	120	210
Uranium	17.4	56.0	50.6	287	500

COPC	Sediment SSRBCC (mg/kg)	
	Semi-palmated Sandpiper	Long-tailed Duck
Arsenic	0.535 [a]	1.87 [a]
Chromium	3.33 [b]	12.5 [b]
Copper	0.0577 [c]	0.198 [c]
2-Methylnaphthalene	3,797 [d]	15,454 [d]
Acenaphthene	402 [d]	1,636 [d]
Acenaphthylene	413 [d]	1,683 [d]
Naphthalene	3,797 [d]	15,454 [d]
Pyrene	287 [d]	1,169 [d]

COPC	Soil SSRBCC (mg/kg dw)
	Willow Ptarmigan
Aluminum	13,471
Barium	1,038
Chromium	166
Manganese	2,858
Molybdenum	33.1

COPC	Fish Tissue SSRBCC (mg/kg ww)	
	Peregrine Falcon	Bald Eagle
Methylmercury	2.83	0.392

Notes:

SSRBCC = site-specific risk-based closure criteria

COPC = contaminant of potential concern

dw = dry weight

ww = wet weight

[a] *SSRBCC is lower than the CCME interim sediment quality guideline and probable effects level for arsenic (5.9 and 17 mg/L, respectively; CCME 2015). Thus the CCME guideline of 5.9 mg/L is adopted as the SSRBCC* $_{sediment}$ *for semi-palmated sandpiper and long-tailed duck.*

[b] *SSRBCC is lower than the CCME interim sediment quality guideline and probable effects level for chromium (37.3 and 90 mg/L, respectively; CCME 2015). Thus the CCME guideline of 37.3 mg/L is adopted as the SSRBCC* $_{sediment}$ *for semi-palmated sandpiper and long-tailed duck.*

[c] *SSRBCC is lower than the CCME interim sediment quality guideline and probable effects level for copper (35.7 and 197 mg/L, respectively; CCME 2015). Thus the CCME guideline of 35.7 mg/L is adopted as the SSRBCC* $_{sediment}$ *for semi-palmated sandpiper and long-tailed duck.*

[d] *SSRBCC is much higher than the CCME interim sediment quality guideline and probable effects level for the various PAHs (CCME 2015) due to high level of uncertainty in their derivation. Thus the CCME probable effects levels were adopted as the SSRBCC* $_{sediment}$ *for semi-palmated sandpiper and long-tailed duck.*

Appendix J

Site-specific Risk-based Closure Criteria for Humans

Appendix J. Site-specific Risk-based Closure Criteria for Humans

	Soil Ingestion and Contact SSRBCC for Soil (mg/kg dw)	
COPC	Adults	Toddlers
Aluminum	60,216	19,243
Barium	96,279	7,015
Chromium	543	96.6
Manganese	25,766	3,914
Molybdenum	16,700	820

	Food Ingestion SSRBCC for Soil (mg/kg dw)	
COPC	Adults	Toddlers
Aluminum	15,970	13,347
Barium	206 [a]	138 [a]
Chromium	72.6	66.9
Manganese	260	224
Molybdenum	11.3	4.76 [b]

	Water SSRBCC (mg/L)	
COPC	Adults	Toddlers
Antimony	0.0113	0.00662
Arsenic	0.00135 [c]	0.000880 [c]
Chromium	0.00383 [d]	0.00226 [d]
Manganese	0.590	0.301
Mercury	0.00114	0.000670
Nitrate	30.2	17.6
Nitrite	1.89	0.00200 [e]
Selenium	0.0215 [f]	0.0137 [f]
Sulphate	266	669
Uranium	0.00229 [g]	0.00135 [g]

	Fish Tissue SSRBCC (mg/kg ww)		
COPC	Adults	Sensitive Adults	Toddlers
Methylmercury	0.294	0.144	0.0672 [h]

Notes:

SSRBCC = site-specific risk-based closure criteria

COPC = contaminant of potential concern

dw = dry weight

ww = wet weight

[a] *SSRBCC is lower than the CCME soil agricultural and residential guidelines for barium (750 and 500 mg/kg, respectively; CCME 2015). Thus the CCME guideline of 500 mg/kg is adopted as the SSRBCC for humans.*

[b] *SSRBCC is lower than the CCME soil agricultural and residential guidelines for molybdenum (5 mg/kg; CCME 2015). Thus the CCME guideline of 5 mg/kg is adopted for humans.*

[c] *SSRBCC is lower than the Health Canada Drinking Water Quality Guideline for arsenic (0.01 mg/L; Health Canada 2015) but higher than the Diavik benchmark (0.005 mg/L; Golder Associates Ltd. 2014). Thus the Health Canada guideline of 0.01 mg/L is adopted for humans.*

[d] *SSRBCC is lower than the Health Canada Drinking Water Quality Guideline for chromium (0.05 mg/L; Health Canada 2015) but higher than the Diavik benchmark (0.001 mg/L; Golder Associates Ltd. 2014). Thus the Health Canada guideline of 0.05 mg/L is adopted for humans.*

[e] *SSRBCC is lower than the Health Canada Drinking Water Quality Guideline for nitrite (1 mg/L; Health Canada 2015). Thus the Health Canada guideline of 1 mg/L is adopted for humans.*

[f] *SSRBCC is lower than the Health Canada Drinking Water Quality Guideline for selenium (0.05 mg/L; Health Canada 2015) but higher than the Diavik benchmark (0.01 mg/L; Golder Associates Ltd. 2014). Thus the Health Canada guideline of 0.05 mg/L is adopted for humans.*

[g] *SSRBCC is lower than the Health Canada Drinking Water Quality Guideline for uranium (0.02 mg/L; Health Canada 2015) and the Diavik benchmark (0.015 mg/L; Golder Associates Ltd. 2014). Thus the Health Canada guideline of 0.02 mg/L is adopted for humans.*

[h] *SSRBCC is lower than the BC MOE tissue residue guideline for fish/shellfish consumption by humans for high fish consumers (0.1 mg/kg; BC MOE 2015). Thus the BC MOE guideline of 0.1 mg/kg is adopted for humans.*

APPENDIX VI-2

POST-CLOSURE MONITORING AND REPORTING

Appendix VI-2 Post Closure Monitoring and Reporting - North Country Rock Pile (NCRP)

Two types of post-closure monitoring programs are planned: performance monitoring specific to the NCRP and environmental effects monitoring which would include combined effects from all post-closure areas. These are described in Section 1.0 with the type and frequency of reporting described in Section 2.0.

1.0 Performance Monitoring

1.1 Geotechnical

Presently the NCRP is inspected weekly (Annex 1 - NCRP Geotechnical Inspection Form) to identify any stability issues and to identify seepage/runoff. This inspection frequency will continue until the end of commercial operations after which it will reduce to monthly.

Observation wells, collection wells, thermistors and slope inclinometers have been installed in the NCRP as follows (source: Appendix X – NCRP Final Closure Design Report):

Table 4: NCRP Existing Geotechnical Instrumentation

Instrument Type	Instrument ID	Easting (m)	Northing (m)
Observation Well	NCRP-SCW-W1	532918	7152817
Observation Well	PKCN-SCW-3951	533504	7152587
Collection Well	PKCN-SCW-3123	534508	7152241
Observation Well	PKCN-SCW-3154	534490	7152269
Thermistor	NCRP-TN1A	533350	7153091
Thermistor	NCRP-TN1B	533350	7153091
Thermistor	FD1-T	534211	7152777
Thermistor	FD2-T	534208	7152773
Thermistor	FD3-T	534213	7152773
Inclinometer	NCRP-INN1	533350	7153091

Observation wells and thermistors are equipped with data loggers.

Following construction of the NCRP closure cover shallow thermistors will be installed with a target of four in side slopes (two in a south and two in a north slope) and a target of four spread over the top. These are in addition to the thermistors already in place. The objective of these additional thermistors will be to monitor annual thaw depth. Thermistors are expected to be placed to a depth of 15.5m and be constructed with 16 beads. The current plan is for beads to be spaced every 0.5m for the first 10 beads, 1m intervals for beads 11, 12 and 13 and then 2.5m for the remaining 3 beads. Temperature measurements will be taken at least four times per year in April, July, September and November. Results will be reported in each Performance Assessment Report and include the measured annual depth of thaw from each thermistor.

Annually, visual inspection will include an aerial survey for the first 5 years following construction of the cover (see Appendix X - Section 3.6)

1.2 Seepage/Runoff Water Quality

Seepage/runoff water quality monitoring is proposed at the following SNP locations:

SNP Site #	Description
1645-67	Collection Pond 1
1645-68	Collection Pond 2
1645-76	Collection Pond 3
1645-28	Groundwater GW1 between North Rock Pile and North Inlet
1645-30	Groundwater GW2 Northwest of Till Disposal area

Seepage or runoff quality is sampled at a weekly frequency if sufficient volumes are identified during the weekly geotechnical inspections. Water samples will be analyzed for the following (source W2015L2-0001 – SNP 1645-81):

Sampling Parameters:	Total Ammonia, Field Parameters[3], ICP-MS Metal Scan[1](Total), Major Ions[2], pH[4], Total Petroleum Hydrocarbons

Additionally if the estimated flow volume is greater than 10 L/s then a sample will also be collected quarterly and assessed for acute lethality to rainbow trout, *Oncorhynchus mykiss* as per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/13.

SNP 1645-67,68 and 1645-76 are currently located within the collection ponds. Once collection ponds are breached, DDMI proposes to relocate these stations to the outlet channel.

SNP 1645-28 and 1645-30 are currently inactive. DDMI will reactivate them post-closure to either confirm absence of groundwater flow or measure the quality of detected flow.

1.3 Wildlife

DDMI will employ existing monitoring procedures (as updated from time-to-time) to record wildlife use of the NCRP and observations of behavior when animals are present on the NCRP. These procedures include:

ENVR-031-0720 – Caribou Road Surveys
ENVR-032-0721 – Caribou PKC & NCRP Use
ENVR-517-0912 – Caribou Management/Observation
ENVR-531-0812 – Wildlife Monitoring

1.4 Dust

DDMI will use the existing Total Suspended Particulate (TSP) monitoring system and procedures (as updated from time-to-time) combined with visual observations to monitoring dust generated from the NCRP. This monitoring will begin during re-sloping (2017) and continue after the end of commercial production.

1.5 Environmental Effects Monitoring

DDMI implements two environmental effects monitoring programs:

- Aquatic Effects Monitoring Program (AEMP)
- Wildlife Effects Monitoring Program (WEMP)

These are defined programs, updated or revised as warranted, to monitor mine effects on the Lac de Gras aquatic ecosystem and wildlife within a defined study area. These programs are conducted annually with specific scopes varying from year to year. For example the AEMP has an expanded program every three years and a base program annually. Towards the end of commercial operations, DDMI expects to reduce the scope and/or frequency of these programs as the need to implement operational management responses declines. Near-Field AEMP sampling locations will be adjusted to target runoff/seepage rather than the NIWTP effluent discharge. The attached Figure VI-1 shows the proposed relocated near-field AEMP stations renamed near-field closure (NFC). After the end of commercial production DDMI will continue these monitoring programs to monitor responses to the cessation of mining operations. The frequency would be reduced to every three years.

2.0 Reporting

2.1 Reclamation Completion Reporting

Upon completion of construction activities at the end of each calendar year, DDMI and the Engineer of Record will prepare a Construction Record summary report. The report shall include:

- Daily construction reports;
- All testing records including a summary of all test sample locations and test results;
- Photographic documentation of construction works;
- Summary of construction problems and resolutions; and
- Completed construction checklist.

Upon completion of the NCRP closure construction, a single comprehensive NCRP Reclamatione Completion Report will be prepared by the Construction Management team and Engineer of Record for submission to the WLWB as per Part K Item 5.

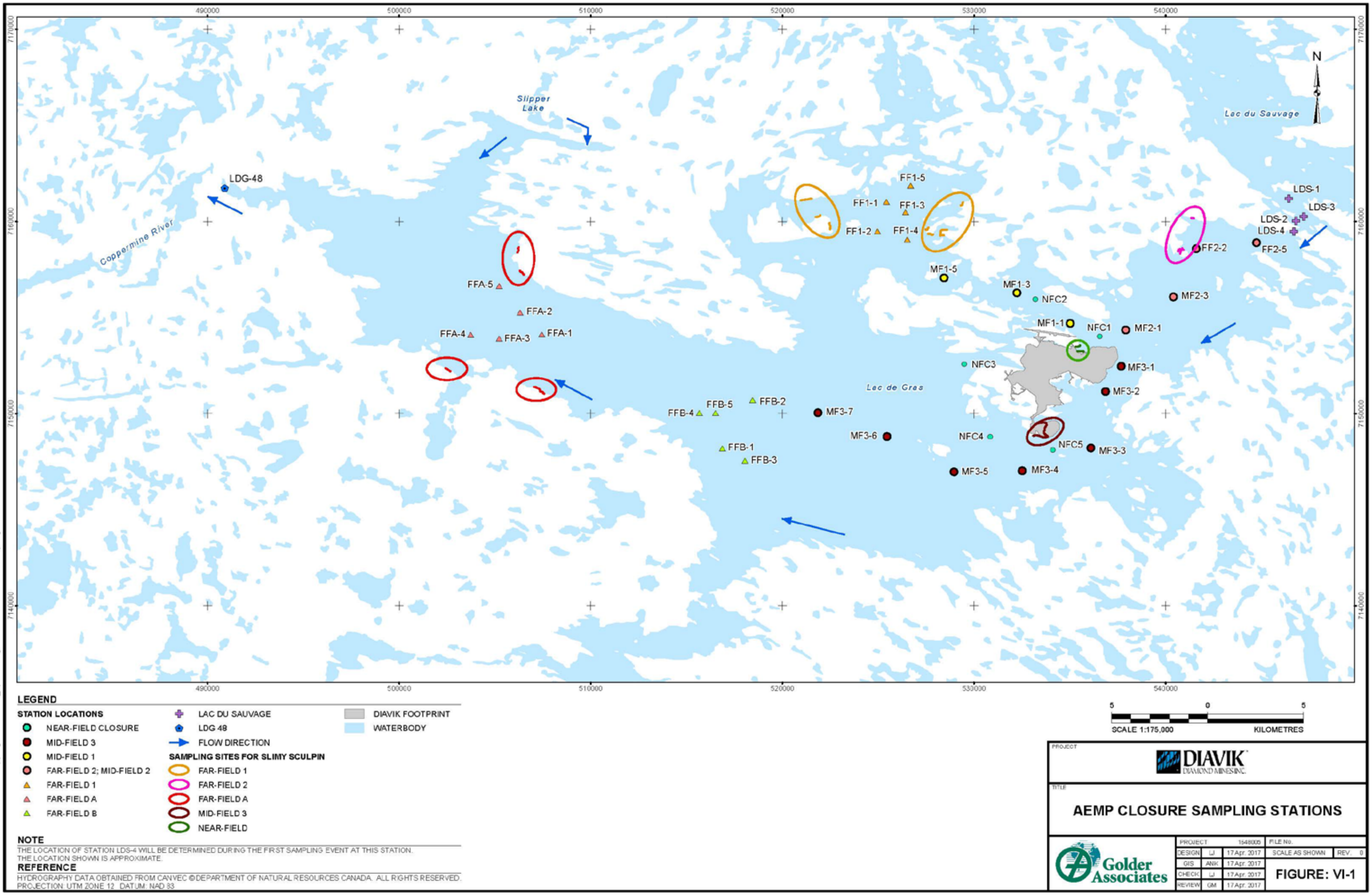
2.2 Performance Assessment Report.

Once sufficient information is available to evaluate the performance of the NCRP cover generally and Closure Objectives and Closure Criteria specifically, DDMI will submit a Performance Assessment Report to the WLWB for approval under Part K Item 6. The Report will be developed in accordance with the Mackenzie Valley Land and Water Board's *Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites within the Northwest Territories*.

3.0 Monitoring and Reporting Schedule

The anticipated monitoring and reporting schedule for the NCRP and site wide effects monitoring is shown below. This schedule is subject to change based on actual construction timeline as well as results from inspections and monitoring programs. The number of years of post-construction monitoring required to adequately assess performance is unknown at this time and will depend upon the results obtained. The monitoring duration will be adaptively managed to be responsive to conditions as they are evaluated. DDMI has assumed 5 year of monitoring from the time the NCRP cover is complete (2023) until there is sufficient information to prepare an assessment report. Professional experience of the Engineer of Record suggest a typical duration would be in the range of 5-10 years, however there are no references that DDMI is aware of to support this view. It should be noted that because the NCRP cover will be placed progressively over a number of years, sections of the constructed cover could have close to 10 years of monitoring information before the Performance Assessment Report is complete.

Activity	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Geotechnical inspections																
Seepage/Run-off monitoring																
Dust Monitoring																
Wildlife Use Monitoring																
Aquatic Effects Monitoring																
Wildlife Effects Monitoring																
Annual CRP Progress Reporting																
Reclamation Completion Report																
Performance Assessment Report																



I:\CLIENTS\DIAVIK\1648005\Mapping\MXD\CRP_update\Fig VI-1 AEMP Closure Sampling Stations.mxd

APPENDIX VII

EXPECTED COST OF CLOSURE AND RECLAMATION

Notes:

This Appendix is printed from: DDMI RECLAIM Estimate 2017 v1.xlms

a) NCRP Reslope volumes updated from 1,501,500 m^3 to 1,532,500 m^3 based on final design.

b) NCRP unit cost for rock cover corrected to WLWB (2014) approved $\$4.20/m^3$

c) PKC Cover unit costs for rock cover corrected to WLWB (2014) approved $\$6.50/m^3$

d) Updated list and area of buidlings to CRP V4 Table 4-5.

e) Added excavation of 2 caribou ramps in A418 pit wall - shoreline

f) added revegetation cost estimate for infrastructure areas, roads-buildings

g) Added costs for cover in Type III rock in CLR (DDMI Letter Oct 16, 2016)

Total	File Name	Description
$128,284,831	WLWB RECLAIM Estimate for DDMI_August 2014.xlsm	WLWB Approved
$129,545,615	WLWB RECLAIM Estimate for DDMI_August 2014 with A21.xlsm	WLWB Approved with addition of A21 open-pit
$124,072,323	DDMI RECLAIM Estimate 2016 V1.xlms	DDMI Proposed: a) NCRP till and rock volumes updated as per Golder (2016) Table 3 b) NCRP unit cost for rock cover set to GNWT recommended $3.30 (Letter to WLWB Feb 17, 2016) c) PKC Cover reduced by $1.10 to align with reduced remine unit costs from GNWT (see NCRP) d) updated A21 - one breach volume corrected to be a causeway excavation e) There has been a net removal of buildings since 2011 that has not been credited in this version f) NCRP Contingency to 10% to refelect level of engineerng detail (AANDC Letter to WLWB Oct 23, 2012)
$123,122,334	DDMI RECLAIM Estimate 2017 V1.xlms	DDMI Proposed: a) NCRP Reslope volumes updated from 1,501,500 m^3 to 1,532,500 m^3 based on final design. b) NCRP unit cost for rock cover corrected to WLWB (2014) approved $4.20/$m^3$ c) PKC Cover unit costs for rock cover corrected to WLWB (2014) approved $6.50/$m^3$ d) Updated list and area of buidlings to CRP V4 Table 4-5. e) Added excavation of 2 caribou ramps in A418 pit wall - shoreline f) added revegetation cost estimate for infrastructure areas, roads-buildings g) Added costs for cover in Type III rock in CLR (DDMI Letter Oct 16, 2016)

SUMMARY OF COSTS

CAPITAL COSTS	COMPONENT NAME	COST	LAND LIABILITY	WATER LIABILITY
OPEN PIT	A514,A418, A21	$2,851,117	$97,322	$2,753,795
UNDERGROUND MINE		$1,402,419	$1,365,476	$36,943
TAILINGS FACILITY		$25,177,261	$43,969	$25,133,292
ROCK PILE	NCRP	$29,643,490	$832,303	$28,811,188
BUILDINGS AND EQUIPMENT		$8,567,896	$7,479,566	$1,088,330
CHEMICALS AND CONTAMINATED SOIL MANAGEMEI		$3,557,553	$1,758,777	$1,798,777
SURFACE AND GROUNDWATER MANAGEMENT		$1,280,539	-	$1,280,539
INTERIM CARE AND MAINTENANCE		$0	-	$0
	SUBTOTAL: Capital Costs	**$72,480,275**	**$11,577,411**	**$60,902,863**
	PERCENT OF SUBTOTAL		**16%**	**84%**

INDIRECT COSTS		COST	LAND LIABILITY	WATER LIABILITY
MOBILIZATION/DEMOBILIZATION		$9,111,200	$1,455,349	$7,655,851
POST-CLOSURE MONITORING AND MAINTENANCE		$19,508,597	$3,116,145	$16,392,452
ENGINEERING	5%	$3,624,014	$578,871	$3,045,143
PROJECT MANAGEMENT	5%	$3,624,014	$578,871	$3,045,143
HEALTH AND SAFETY PLANS/MONITORING & QA/QC	0.5%	$362,401	$57,887	$304,514
BONDING/INSURANCE	0.5%	$362,401	$57,887	$304,514
CONTINGENCY				
- Open Pit	20%	$570,223.37	$91,083	$479,141
- Underground Mine	20%	$280,483.82	$44,802	$235,682
- Tailings	30%	$7,553,178.19	$1,206,483	$6,346,695
- Rock Pile	10%	$2,964,349.00	$473,501	$2,490,848
- Buildings and Equipment	20%	$1,713,579	$273,713	$1,439,866
- Chemicals and Soil Management	20%	$711,510.60	$113,651	$597,860
- Water Management	20%	$256,107.80	$40,909	$215,199
MARKET PRICE FACTOR ADJUSTMENT	0%	$0	$0	$0
	SUBTOTAL: Indirect Costs	**$50,642,059**	**$8,089,152**	**$42,552,907**
TOTAL COSTS		**$123,122,334**	**$19,666,563**	**$103,455,770**

Complete document can be found at:

Open Pit Name: **A514,A418, A21** **Pit # 1**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	% Land	Land Cost	Water Cost
CONTROL ACCESS									
Fence		m	450	FNCH	$203.00	$91,350	100%	$91,350	$0
Signs		each	4.5	#N/A	$37.08	$167	100%	$167	$0
Ditch, mat'l A		m3		#N/A	$0.00	$0		$0	$0
, mat'l B		m3		#N/A	$0.00	$0		$0	$0
Berm		m3		#N/A	$0.00	$0		$0	$0
Block roads		m3	1350	SB1L	$4.30	$5,805	100%	$5,805	$0
Other				#N/A	$0.00	$0		$0	$0
STABILITY STUDY									
Conduct stability and setback study		allow		#N/A	$0.00	$0		$0	$0
STABILIZE SLOPES									
A154									
excavate 4 breaches in dike		m3	48114	SC1H	$9.30	$447,460		$0	$447,460
break concrete guides & wall		m3	1288	SC1H	$9.30	$11,978		$0	$11,978
construct fish habitat		m3		#N/A	$0.00	$0		$0	$0
A418									
excavate 3 breaches in dike		m3	36086	SC1H	$9.30	$335,600		$0	$335,600
break concrete guides & wall		m3	1288	SC1H	$9.30	$11,978		$0	$11,978
construct fish habitat		m3		#N/A	$0.00	$0		$0	$0
excavate 2 shoreline caribou ramps		m3	1500	RC1H	$17.05	$25,575		$0	$25,575
A21									
excavate 3 breaches in dike and 1 causeway		m3	51086	SC1H	$9.30	$475,100		$0	$475,100
break concrete guides & wall		m3	1288	SC1H	$9.30	$11,978		$0	$11,978
construct fish habitat				#N/A	$0.00	$0		$0	$0
COVER/CONTOUR SLOPES									
Place fill, mat'l A		m3		#N/A	$0.00	$0		$0	$0
Place fill, mat'l B		m3		#N/A	$0.00	$0		$0	$0
Rip rap		m3		#N/A	$0.00	$0		$0	$0
Vegetate slopes		ha		#N/A	$0.00	$0		$0	$0
Vegetate pit floor		ha		#N/A	$0.00	$0		$0	$0
Other				#N/A	$0.00	$0		$0	$0
CONSTRUCT DIVERSION DITCHES									
Excavate ditches -soil		m3		#N/A	$0.00	$0		$0	$0
Excavate ditches -rock		m3		#N/A	$0.00	$0		$0	$0
Rip rap in channel base		m3		#N/A	$0.00	$0		$0	$0
CONSTRUCT SPILLWAY									
Excavate channel		m3		#N/A	$0.00	$0		$0	$0
Concrete		m3		#N/A	$0.00	$0		$0	$0
Rip rap		m3		#N/A	$0.00	$0		$0	$0
Other				#N/A	$0.00	$0		$0	$0
RECLAIM QUARRIES									
Contour slopes		m3		#N/A	$0.00	$0		$0	$0
Place overburden		m3		#N/A	$0.00	$0		$0	$0
Vegetate		m3		#N/A	$0.00	$0		$0	$0
FLOOD PIT-Captital									
Remove stationary equipment (sump pumps)		each	4	#N/A	$5,618.00	$22,472		$0	$22,472
Remove dewatering pipeline		m	14385	PSRL	$1.00	$14,385		$0	$14,385
Remove power lines		m	8328	POWRL	$25.50	$212,364		$0	$212,364
Construct diversion ditches		m3		#N/A	$0.00	$0		$0	$0
-Ditch, mat'l A		m3		#N/A	$0.00	$0		$0	$0
-Ditch, mat'l B		m3		#N/A	$0.00	$0		$0	$0
Construct embankment/dam		m3		#N/A	$0.00	$0		$0	$0
siphon installation/operation		each	9	#N/A	$119,925.00	$1,079,325		$0	$1,079,325
silt curtains		each	9	#N/A	$11,731.00	$105,579		$0	$105,579
Remove pump post-closure		each		#N/A	$0.00	$0		$0	$0
Remove pipeline post-closure		m		#N/A	$0.00	$0		$0	$0
FLOOD PIT-Annual Cost									
Operate pumps (power)		m3		#N/A	$0.00	$0		$0	$0
Maintain pump/pipeline		allow		#N/A	$0.00	$0		$0	$0
Labour:fuel management, comissioning/decom		$/h		#N/A	$0.00	$0		$0	$0
Chemical addition, _____ kg/m3 of water		tonne		#N/A	$0.00	$0		$0	$0
Chemicals, purchase and shipping		tonne		#N/A	$0.00	$0		$0	$0
Passive/biological additives		$/ha		#N/A	$0.00	$0		$0	$0
Passive additives purchase and shipping		tonne		#N/A	$0.00	$0		$0	$0
Other				#N/A	$0.00	$0		$0	$0
					Annual pumping costs	$0			
Number of years of pump flooding		years							
					Total pumping costs	$0		$0	$0
					Total	$2,851,117		$97,322	$2,753,795
					% of Total			3%	97%

1 **Underground Mine Name** **UG Mine # *1***

ACTIVITY/MATERIAL	Notes	Unit	Qty	Code	Unit Cost	Cost	Land	Land Cost	Cost
CONTROL ACCESS									
Fence		m	100	FNCH	$203.00	$20,300	100%	$20,300	$0
Signs		each	4	#N/A	$37.08	$148	100%	$148	$0
Block roads		m3		#N/A	$0.00	$0		$0	$0
Berm		m3	300	SB1L	$4.30	$1,290	100%	$1,290	$0
Block adits		m3	320	CLFH	$530.25	$169,680	100%	$169,680	$0
Cap shaft		m3		#N/A	$0.00	$0		$0	$0
Cap raises at A154/A418		m3	72	SRL	$645.00	$46,440	100%	$46,440	$0
Soil cover on raise caps		m3	708	SB1L	$4.30	$3,044	100%	$3,044	$0
Cap raise at A21		m3		#N/A	$0.00	$0		$0	$0
Soil cover on raise cap		m3		#N/A	$0.00	$0		$0	$0
Backfill adit A154		m3	100	SCSS	$18.80	$1,880	100%	$1,880	$0
Contour portal area, A154		m3	2,500	SB1L	$4.30	$10,750	100%	$10,750	$0
Backfill adit A21		m3		#N/A	$0.00	$0		$0	$0
Contour portal area, A21		m3		#N/A	$0.00	$0		$0	$0
Concrete bulkhead, pit portal, A154		allow	1	#N/A	$75,000.00	$75,000	100%	$75,000	$0
Concrete bulkhead, pit portal, A21		allow	0	#N/A	$75,000.00	$0		$0	$0
Backfill open stopes		m3		#N/A	$0.00	$0		$0	$0
Remove decline surface infrastructure		allow	1	#N/A	$1,000,000.00	$1,000,000	100%	$1,000,000	$0
REMOVE HAZARDOUS MATERIALS									
Remove hazardous materials, U/G labor		manhours	1,440	lab-usH	$43.98	$63,331	50%	$31,666	$31,666
Remove/decontam. stationary & elect. equip		manhours	240	lab-usH	$43.98	$10,555	50%	$5,278	$5,278
Remove/decontam. mobile equipment		each		#N/A	$0.00	$0		$0	$0
Remove misc. haz. mat & explosives		kg		#N/A	$0.00	$0		$0	$0
Other				#N/A	$0.00	$0		$0	$0
INSTALL BULKHEADS									
Bulkheads to control water flow		each		#N/A	$0.00	$0		$0	$0
Grout bulkhead		m3		#N/A	$0.00	$0		$0	$0
FLOOD MINE									
Supply/install pump		each		#N/A	$0.00	$0		$0	$0
Supply/install piping system		each		#N/A	$0.00	$0		$0	$0
Operate pumps to flood workings		m3		#N/A	$0.00	$0		$0	$0
Other				#N/A	$0.00	$0		$0	$0
INSTALL GROUNDWATER COLLECTION SYSTEM									
Excavate/install sumps		m2		#N/A	$0.00	$0		$0	$0
Install pumping wells		m3		#N/A	$0.00	$0		$0	$0
Install pumps/pipelines/power supply		LS		#N/A	$0.00	$0		$0	$0
SPECIALIZED ITEMS									
Install water quality monitoring pipes		each		#N/A	$0.00	$0		$0	$0
Install permanent pumping system		each		#N/A	$0.00	$0		$0	$0
Other				#N/A	$0.00	$0		$0	$0
					Total	$1,402,419		$1,365,476	$36,943
					% of Total			97%	3%

1 **Tailings Impoundment Name:** **Pond # 1**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	% Land	Land Cost	Water Cost	
CONTROL ACCESS										
Fence		m	160	FNCH	######	$32,480	100%	$32,480	$0	
Signs		each	8	#N/A	$37.08	$297	100%	$297	$0	
Berm		m3		#N/A	$0.00	$0		$0	$0	
Block roads		m3	1440	SB1L	$4.30	$6,192	100%	$6,192	$0	
Other				#N/A	$0.00	$0		$0	$0	
STABILIZE EMBANKMENT(S)										
Toe buttress, drainage layer		m3		#N/A	$0.00	$0		$0	$0	
Toe buttress, bulk fill		m3		#N/A	$0.00	$0		$0	$0	
Rip rap		m3		#N/A	$0.00	$0		$0	$0	
Vegetate		ha		#N/A	$0.00	$0		$0	$0	
Raise crest		m3		#N/A	$0.00	$0		$0	$0	
Flatten slopes		m3		#N/A	$0.00	$0		$0	$0	
Other				#N/A	$0.00	$0		$0	$0	
COVER TAILINGS										
Coarse PK, doze to slurry sump		m3		#N/A	$0.00	$0		$0	$0	
Coarse PK, slurry pumping		m3		#N/A	$0.00	$0		$0	$0	
Rock for expelled water from N or S dump		m2		#N/A	$0.00	$0		$0	$0	
Rock for expelled water from roads		m2		#N/A	$0.00	$0		$0	$0	
Rock for expelled water from new quarry		m2		#N/A	$0.00	$0		$0	$0	
Soil cover, till		m3		#N/A	$0.00	$0		$0	$0	
Cover rock from N or S dump		m3	2800000	SBSH	$6.50	$18,200,000		$0	$18,200,000	Note #1
geotextile/geogrid over shoreline		m2	592000	GSTS	$9.37	$5,547,040		$0	$5,547,040	
Cover rock from new quarry		m3		#N/A	$0.00	$0		$0	$0	
Remove & treat pond/seepage		m3	1791000	OTPL	$0.35	$626,850		$0	$626,850	
STABILIZE DECANT SYSTEM										
Excavate and replace		m3		#N/A	$0.00	$0		$0	$0	
Plug/backfill with concrete or clay		m3		#N/A	$0.00	$0		$0	$0	
Other				#N/A	$0.00	$0		$0	$0	
REMOVE TAILINGS DISCHARGE										
Cyclones		allow		#N/A	$0.00	$0		$0	$0	
Pipe		m	5000	PSRL	$1.00	$5,000	100%	$5,000	$0	
Remove reclaim barge		allow		#N/A	$0.00	$0		$0	$0	
CONSTRUCT DIVERSION DITCHES										
Excavate ditches -soil		m3		#N/A	$0.00	$0		$0	$0	
Excavate ditches -rock		m3		#N/A	$0.00	$0		$0	$0	
Rip rap in channel base		m3		#N/A	$0.00	$0		$0	$0	
FLOOD TAILINGS										
Doze tailings to final contour		m3		#N/A	$0.00	$0		$0	$0	
Raise crest of dam		m3		#N/A	$0.00	$0		$0	$0	
Other				#N/A	$0.00	$0		$0	$0	
UPGRADE SPILLWAY										
Excavate channel, dam		m3	3240	SC1L	$6.80	$22,032		$0	$22,032	
Excavate channel, tailings	hydraulic mining of tailings	m3	136500	SCSH	$5.00	$682,500		$0	$682,500	
Concrete		m3		#N/A	$0.00	$0		$0	$0	
Rip rap channel to Lac de Gras		m3	6500	RR3L	$7.00	$45,500		$0	$45,500	
Geotextile channel to Lac de Gras		m2	1000	GSTS	$9.37	$9,370		$0	$9,370	
CONSTRUCT SEEPAGE COLLECTION POND										
Excavate seepage collection pond		m3		#N/A	$0.00	$0		$0	$0	
Doze & spread excavated material		m3		#N/A	$0.00	$0		$0	$0	
Vegetate spread material		ha		#N/A	$0.00	$0		$0	$0	
Bedding layer		m3		#N/A	$0.00	$0		$0	$0	
Supply geomembrane		m2		#N/A	$0.00	$0		$0	$0	
Install geomembrane		m2		#N/A	$0.00	$0		$0	$0	
Erosion protection layer		m3		#N/A	$0.00	$0		$0	$0	
INSTALL GROUNDWATER COLLECTION SYSTEM										
Excavate/install sumps		m3		#N/A	$0.00	$0		$0	$0	
Install pumping wells		m3		#N/A	$0.00	$0		$0	$0	
Install pumps/pipelines/power supply		LS		#N/A	$0.00	$0		$0	$0	
SPECIALIZED ITEMS										
Install permanent instrumentation, supply & technican		each		#N/A	$0.00	$0		$0	$0	
Install permanent instrumentation, drilling		each		#N/A	$0.00	$0			$0	
TREAT SEEPAGE - see "Water Management" and "Water Treatment"										
TREAT SUPERNATANT										
Pump water (to pit, U/G)		m3		#N/A	$0.00	$0		$0	$0	
Equipment maintenance and parts		allow		#N/A	$0.00	$0		$0	$0	
Supply reagents		tonne		#N/A	$0.00	$0		$0	$0	
			Annual treatment costs			$0				
Number of years of treatment		years								
			Total treatment costs			$0			$0	
					Total	$25,177,261		$43,969	$25,133,292	
					% of Total			0%	100%	

* for construction of passive treatment system refer to "Water Management"

Note #1 Unit rate corrected to WLWB (2014) approved rate.

1 **Rock Pile Name:** **NCRP**

ACTIVITY/MATERIAL	**Notes**	**Units**	**Quantity**	**Cost Code**	**Unit Cost**	**Cost**	**% Land**	**Land Cost**	**Water Cost**	
STABILIZE SLOPES										
Flatten slopes with dozer, rock pile, north		m3	1532500	DSL	$0.95	$1,455,875	50%	$727,938	$727,938	Note #2
Flatten slopes - Type III in CLR Basin		m3	151000	DSL	$0.95	$143,450	50%	$71,725	$71,725	Oct 13, 2016 letter t o WLWB
Flatten slopes with dozer, till pile		m3		#N/A	$0.00	$0		$0	$0	
Flatten slope with dozer, till pile, south		m3		#N/A	$0.00	$0		$0	$0	
Divert runon, ditch mat'l B		m3		#N/A	$0.00	$0		$0	$0	
Toe buttress, drain mat'l		m3		#N/A	$0.00	$0		$0	$0	
Toe buttress, fill mat'l A		m3		#N/A	$0.00	$0		$0	$0	
Toe buttress, fill mat'l B		m3		#N/A	$0.00	$0		$0	$0	
Other				#N/A	$0.00	$0		$0	$0	
COVER ROCK PILE										
Till on Type III rock areas		m3	2,000,000	SB3L	$5.10	$10,200,000		$0	$10,200,000	Note #1
Type I rock cover		m3	3,980,000	SB3S	$4.20	$16,716,000		$0	$16,716,000	
Till on Type III in CLR Basin		m3	81,150	SB3L	$5.10	$413,865		$0	$413,865	Oct 13, 2016 letter t o WLWB
Type I rock on Type III in CLR Basin		m3	162,300	SB3S	$4.20	$681,660		$0	$681,660	Oct 13, 2016 letter t o WLWB
till on caribou ramps		m3	6400	SB3L	$5.10	$32,640	100%	$32,640	$0	
rock cover from roads etc.		m3		#N/A	$0.00	$0		$0	$0	
Rip rap drainage channel and chute		m3		#N/A	$0.00	$0		$0	$0	
Vegetate		ha	5,980,000	#N/A	$0.00	$0		$0	$0	
Other				#N/A	$0.00	$0		$0	$0	
VERY LOW PERMEABILITY COVER (in addition to above)										
Liner subgrade preparation - compact		m2		#N/A	$0.00	$0		$0	$0	
Supply geomembrane		m2		#N/A	$0.00	$0		$0	$0	
Install geomembrane		m2		#N/A	$0.00	$0		$0	$0	
Protective cover - excavate,haul,spread&compact		m3		#N/A	$0.00	$0		$0	$0	
Vegetate		ha		#N/A	$0.00	$0		$0	$0	
Install infiltration/seepage instrumentation		allow		#N/A	$0.00	$0		$0	$0	
CONSTRUCT DIVERSION DITCHES										
Excavate ditches -soil		m3		#N/A	$0.00	$0		$0	$0	
Excavate ditches -rock		m3		#N/A	$0.00	$0		$0	$0	
Rip rap in channel base		m3		#N/A	$0.00	$0		$0	$0	
CONSTRUCT SEEPAGE COLLECTION POND										
Excavate seepage collection pond		m3		#N/A	$0.00	$0		$0	$0	
Doze & spread excavated material		m3		#N/A	$0.00	$0		$0	$0	
Vegetate spread material		ha		#N/A	$0.00	$0		$0	$0	
Bedding layer		m3		#N/A	$0.00	$0		$0	$0	
Supply geomembrane		m2		#N/A	$0.00	$0		$0	$0	
Install geomembrane		m2		#N/A	$0.00	$0		$0	$0	
Erosion protection layer		m3		#N/A	$0.00	$0		$0	$0	
INSTALL GROUNDWATER COLLECTION SYSTEM										
Excavate/install sumps		m3		#N/A	$0.00	$0		$0	$0	
Install pumping wells		m3		#N/A	$0.00	$0		$0	$0	
Install pumps/pipelines/power supply		allow		#N/A	$0.00	$0		$0	$0	
RELOCATE DUMPS										
Load, haul, dump or doze		m3		#N/A	$0.00	$0		$0	$0	
Add lime		tonne		#N/A	$0.00	$0		$0	$0	
Contour reclaimed area		ha		#N/A	$0.00	$0		$0	$0	
Other				#N/A	$0.00	$0		$0	$0	
SPECIALIZED ITEMS										
Install permanent instrumentation		each		#N/A	$0.00	$0		$0	$0	
Install permanent instrumentation, drilling		each		#N/A	$0.00	$0		$0	$0	
TREAT ROCK PILE SEEPAGE - see "Water Treatment"										
collect and treat seepage		m3	848206	OTPL	$0.35	$296,872		$0	$296,872	
HEAP LEACH SEEPAGE TREATMENT - Cyanide Detox										
Cyanide destruction water treatment pumping		m3		#N/A	$0.00	$0		$0	$0	
Reagents		tonnes		#N/A	$0.00	$0		$0	$0	
Electrician/mechanic to maintain treatment plant		allow		#N/A	$0.00	$0		$0	$0	
Equipment maintenance and parts		allow		#N/A	$0.00	$0		$0	$0	
				Annual treatment costs		$0				
Number of years of treatment		years								
				Total treatment costs		$0			$0	
HEAP LEACH SEEPAGE TREATMENT - ARD/ML**										
Upgrade/modify pumping system - report to WTP		allow		#N/A	$0.00	$0			$0	
					Total	$29,643,490		$832,303	$28,811,188	
					% of Total			3%	97%	

* For construction of passive treatment system refer to "Water Management". ARD/ML seepage treatment becomes post-closure water treatment cost

**Heap leach ARD/ML seepage treatment becomes post-closure water treatment cost

Note #1	Volumes Updated from Final Design (Golder 2016 Table 3) Unit cost corrected to WLWB (2014) approved
Note #2	Volumes updated based on Final Design (Golder 2016)

1 **Chemicals/Soil Area Name:**

Note: The procedures, equipment and packaging for clean up and removal of chemicals or contaminated soils are highly dependent on the nature of the chemicals and their existing state of containment. Government guidelines should be consulted on an individual chemical basis. Any estimate made here should be considered very rough unless specific evaluations have been conducted.

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	% Land	Land Cost	Water Cost
HAZARDOUS MATERIALS INVENTORY									
Contaminated soil investigation ESA		each	1	#N/A	$68,393.00	$68,393	50%	$34,197	$34,197
Contaminated soil drilling and sampling		each	1	#N/A	$277,143.00	$277,143	50%	$138,572	$138,572
LABORATORY CHEMICALS									
load, manifest, ship & disposal fee		pallet	500	#N/A	$1,000.00	$500,000	50%	$250,000	$250,000
PCB hauling		each		#N/A	$0.00	$0		$0	$0
PCB disposal		each		#N/A	$0.00	$0		$0	$0
FUEL									
Tank decontamination		allow	1	#N/A	$223,737.00	$223,737	50%	$111,869	$111,869
Type 2		litre		#N/A	$0.00	$0		$0	$0
Type 3		litre		#N/A	$0.00	$0		$0	$0
WASTE OIL									
Oils/lubricants - burn on site		litre		#N/A	$0.00	$0		$0	$0
Oils/lubricants - ship off-site		litre	650000	ORH	$1.20	$780,000	50%	$390,000	$390,000
Removal glycol		litre	20000	ORH	$1.20	$24,000	50%	$12,000	$12,000
remove batteries		kg	25000	#N/A	$0.50	$12,500	50%	$6,250	$6,250
remove paints		litre	1500	#N/A	$0.27	$405	50%	$203	$203
remove solvents		litre	7500	#N/A	$0.75	$5,625	50%	$2,813	$2,813
Oils/lubricants - disposal fee		litre		#N/A	$0.00	$0		$0	$0
PROCESS OR TREATMENT CHEMICALS									
Sulfuric acid transfer to tanker		litre	80000	PCRH	$2.50	$200,000	50%	$100,000	$100,000
Haul to disposal facility		loads	2	#N/A	$12,000.00	$24,000	50%	$12,000	$12,000
Disposal fee		litre	80000	#N/A	$1.00	$80,000	50%	$40,000	$40,000
Type 4		kg		#N/A	$0.00	$0		$0	$0
EXPLOSIVES									
		allow	1	#N/A	$10,000.00	$10,000	50%	$5,000	$5,000
CONTAMINATED SOILS									
Type 1, light fuel		m3	5000	CSRH	$146.00	$730,000	50%	$365,000	$365,000
Type 2, heavy fuel and oil		m3	2500	CSRH	$146.00	$365,000	50%	$182,500	$182,500
Type 3, metals		m3	250	CSRL	$47.00	$11,750	50%	$5,875	$5,875
HAZARDOUS MAT. TESTING AND ASSESSMENT									
Technician and analyses		each	1	#N/A	$110,000.00	$110,000	50%	$55,000	$55,000
Drilling		each	1	#N/A	$75,000.00	$75,000	50%	$37,500	$37,500
Reporting		each	1	#N/A	$20,000.00	$20,000	50%	$10,000	$10,000
OTHER									
Remove nuclear densometers from mill		each	10	#N/A	$4,000.00	$40,000		$0	$40,000
					Total	$3,557,553		$1,758,777	$1,798,777
					% of Total			49%	51%

1 **Building / Equip Name:** **Bldg / Equip #: 1**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	% Land	Land Cost	Water Cost
DISPOSE MOBILE EQUIPMENT									
Decontaminate, ship off-site		km		#N/A	$0.00	$0		$0	$0
Decontaminate, dispose on-site		each	5000	lab-sH	$49.60	$248,000		$0	$248,000
DISPOSE STATIONARY EQUIPMENT									
Decontaminate, ship off-site		km		#N/A	$0.00	$0		$0	$0
Decontaminate, dispose on-site		each	5000	lab-sH	$49.60	$248,000		$0	$248,000
DISPOSE ORE CONCENTRATION EQUIPMENT									
Decontaminate crushing plant		each		#N/A	$0.00	$0		$0	$0
Decontaminate tanks & plumbing		each		#N/A	$0.00	$0		$0	$0
Remove tanks & plumbing		each		#N/A	$0.00	$0		$0	$0
DISPOSE WATER TREATMENT EQUIPMENT									
Decontaminate tanks & plumb.		each		#N/A	$0.00	$0		$0	$0
Remove tanks & plumbing		each		#N/A	$0.00	$0		$0	$0
Other				#N/A	$0.00	$0		$0	$0
DECONTAMINATE BUILDINGS & TANKS									
site wide allowance		each	1	#N/A	$75,000.00	$75,000	50%	$37,500	$37,500
clean explosives facility		each	1	#N/A	$50,000.00	$50,000	50%	$25,000	$25,000
MOTHBALL BUILDINGS				#N/A	$0.00	$0		$0	$0
Building 1		m2		#N/A	$0.00	$0		$0	$0
Building 2		m2		#N/A	$0.00	$0		$0	$0
Building 3		m2		#N/A	$0.00	$0		$0	$0
Building 4		m2		#N/A	$0.00	$0		$0	$0
Building 5		m2		#N/A	$0.00	$0		$0	$0
Other		m2		#N/A	$0.00	$0		$0	$0
REMOVE BUILDINGS - areas are increased to account for height of biuldings									
1. Processing Plant		m2	8,525	BRS1H	$65.00	$554,125	100%	$554,125	$0
2. Accommodation Complex		m2	17,285	BRS1H	$65.00	$1,123,525	100%	$1,123,525	$0
3. Maintenance Complex		m2	6,560	BRS1H	$65.00	$426,400	100%	$426,400	$0
4. Backfill Plant		m2	2,655	BRS1H	$65.00	$172,575	100%	$172,575	$0
5. Power House 1		m2	2,050	BRS1H	$65.00	$133,250	100%	$133,250	$0
6. Power House 2		m2	2,180	BRS1H	$65.00	$141,700	100%	$141,700	$0
7. Boiler House		m2	540	BRS1H	$65.00	$35,100	100%	$35,100	$0
8. Crusher Building		m2	800	BRS1H	$65.00	$52,000	100%	$52,000	$0
9. Lube Oil Storage		m2	864	BRS1H	$65.00	$56,160	100%	$56,160	$0
10. Batch Plant		m2	646	BRS1H	$65.00	$41,990	100%	$41,990	$0
11. NIWTP Acid Storage		m2	367	BRS1H	$65.00	$23,855	100%	$23,855	$0
12. NIWTP		m2	3,704	BRS1H	$65.00	$240,760	100%	$240,760	$0
13. Tank Farm		m2	8,167	BRS1H	$65.00	$530,855	100%	$530,855	$0
14. SCAP Fab Shop		m2	2,380	BRS1H	$65.00	$154,700	100%	$154,700	$0
15. UG Dry		m2	154	BRS1H	$65.00	$10,010	100%	$10,010	$0
16. ERT Building		m2	336	BRS1H	$65.00	$21,840	100%	$21,840	$0
17. Sewage Treatment Plant		m2	720	BRS1H	$65.00	$46,800	100%	$46,800	$0
18. Emulsion Plant		m2	920	BRS1H	$65.00	$59,800	100%	$59,800	$0
19. Ammonium Nitrate Building		m2	2,850	BRS1H	$65.00	$185,250	100%	$185,250	$0
20. SCAP Warehouses		m2	1,100	BRS1H	$65.00	$71,500	100%	$71,500	$0
21. Potable Water Treatment		m2	81	BRS1H	$65.00	$5,265	100%	$5,265	$0
22. Raw Water Intake		m2	490	BRS1H	$65.00	$31,850	100%	$31,850	$0
23. A21 Offices		m2	570	BRS1H	$65.00	$37,050	100%	$37,050	$0
24. Airport		m2	800	BRS1H	$65.00	$52,000	100%	$52,000	$0
25. Old Site Services		m2	720	BRS1H	$65.00	$46,800	100%	$46,800	$0
26. Enviro Field Lab		m2	200	BRS1H	$65.00	$13,000	100%	$13,000	$0
27. North Inlet Water Intake		m2	102	BRS1H	$65.00	$6,630	100%	$6,630	$0
28. Mine Air Heaters		m2	1,050	BRS1H	$65.00	$68,250	100%	$68,250	$0
29. Windfarm		m2	95	BRS1H	$65.00	$6,175	100%	$6,175	$0
30. Incinerator		m2	455	BRS1H	$65.00	$29,575	100%	$29,575	$0
31. Communications		m2	72	BRS1H	$65.00	$4,680	100%	$4,680	$0
32. Core Storage Area		m2	670	BRS1H	$65.00	$43,550	100%	$43,550	$0
BREAK BASEMENT SLABS									
Buildings - all		m2	4500	BRCL	$40.00	$180,000	100%	$180,000	$0
Building 2		m2		#N/A	$0.00	$0		$0	$0
Building 3		m2		#N/A	$0.00	$0		$0	$0
Building 4		m2		#N/A	$0.00	$0		$0	$0
Building 5		m2		#N/A	$0.00	$0		$0	$0
Vegetate building footprint		ha	68	VB	$13,000.00	$885,404	100%	$885,404	$0
REMOVE BURIED TANKS									
Tank 1, decontaminate		m3		#N/A	$0.00	$0		$0	$0
, excavate & dispose		m3		#N/A	$0.00	$0		$0	$0
Tank 2, decontaminate		m3		#N/A	$0.00	$0		$0	$0
, excavate & dispose		m3		#N/A	$0.00	$0		$0	$0
Other				#N/A	$0.00	$0		$0	$0
LANDFILL FOR DEMOLITION WASTE									
Place rock cover		m3	187500	SB3S	$4.20	$787,500	50%	$393,750	$393,750
Vegetate		ha		#N/A	$0.00	$0		$0	$0
Landfill disposal fee		tonne		#N/A	$0.00	$0		$0	$0
GRADE AND CONTOUR									
Grade mill area		m2	30750	SB3S	$4.20	$129,150	50%	$64,575	$64,575
Place rock cover		m3	34050	SB3S	$4.20	$143,010	50%	$71,505	$71,505
Rip rap on ditches		m3		#N/A	$0.00	$0		$0	$0
Vegetate		ha		#N/A	$0.00	$0		$0	$0
Other				#N/A	$0.00	$0		$0	$0
RECLAIM ROADS									
Haul roads, A 154 & A418 lease		ha	3.71	SCFYL	$4,300.00	$15,953	100%	$15,953	$0
Service roads, A154 & A418 lease		ha	1.6	SCFYL	$4,300.00	$6,880	100%	$6,880	$0
Haul roads, A21 lease		ha	0	SCFYL	$4,300.00	$0	100%	$0	$0
Service roads, A21 lease		ha	1.65	SCFYL	$4,300.00	$7,095	100%	$7,095	$0
Haul roads, PKC & dumps lease		ha	10.13	SCFYL	$4,300.00	$43,559	100%	$43,559	$0
Service roads, PKC & dumps lease		ha	23.2	SCFYL	$4,300.00	$99,760	100%	$99,760	$0
Haul roads, infrastructure lease		ha	14.85	SCFYL	$4,300.00	$63,855	100%	$63,855	$0
Service roads, infrastructure lease		ha	5.4	SCFYL	$4,300.00	$23,220	100%	$23,220	$0
Haul roads, airstrip lease		ha	0	SCFYL	$4,300.00	$0	100%	$0	$0
Service roads, airstrip lease		ha	2.9	SCFYL	$4,300.00	$12,470	100%	$12,470	$0
Vegetate roads		ha	63	VB	$13,000.00	$824,720	100%	$824,720	$0
SPECIALIZED ITEMS									
Reclaim airstrip		ha	11	SCFYL	$4,300.00	$47,300	100%	$47,300	$0
Yellowknife landfill disposal fee		allow	1	#N/A	$250,000.00	$250,000	100%	$250,000	$0
					Total	$8,567,896		$7,479,566	$1,088,330
					% of Total			87%	13%

1 **Capital Expenditures and Short Term Water Treatment identified in 'Instructions' worksheet**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost
STABILIZE EMBANKMENT						
Toe buttress, drain mat'l		m3		#N/A	$0.00	$0
, fill mat'l A		m3		#N/A	$0.00	$0
, fill mat'l B		m3		#N/A	$0.00	$0
Rip rap		m3		#N/A	$0.00	$0
Vegetate		ha		#N/A	$0.00	$0
Raise crest		m3		#N/A	$0.00	$0
UPGRADE SPILLWAY IN NORTH INLET BERM						
Excavate channel		m3	680	SC1L	$6.80	$4,624
Place rip rap		m3	190	RR3L	$7.00	$1,330
STABILIZE SEDIMENT CONTAINMENT PONDS						
Place soil cover		m3		#N/A	$0.00	$0
Place geotextile		m2		#N/A	$0.00	$0
Vegetate		ha		#N/A	$0.00	$0
BREACH EMBANKMENT						
Remove fill		m3		#N/A	$0.00	$0
COLLECTION PONDS						
Breach 4 dams		m3	2200	SB1L	$4.30	$9,460
place geotextile, 4 by 15,000 m2		m2	60000	#N/A	$10.00	$600,000
place rock over geotextile		m3	60000	SBSH	$6.50	$390,000
BREACH DITCHES						
Excavate		m3	7875	SB1L	$4.30	$33,863
Backfill/recontour		m3	2625	SC1H	$9.30	$24,413
Vegetate		ha		#N/A	$0.00	$0
REMOVE PIPELINES						
Remove pipes		m		#N/A	$0.00	$0
Concrete plug deep pipes		m3		#N/A	$0.00	$0
Install pumps/pipelines/power supply		LS		#N/A	$0.00	$0
NORTH INLET EAST DIKE						
Excavate/construct spillway		m3	4500	SC1H	$9.30	$41,850
Excavate & backfill		m3		#N/A	$0.00	$0
COLLECT DRAINAGE FOR TREATMENT						
Excavate collection ditches		m3		#N/A	$0.00	$0
Rip rap ditches		m3		#N/A	$0.00	$0
Pipes		m		#N/A	$0.00	$0
Pumps		each		#N/A	$0.00	$0
Collect'n pond, exc. mat'l A		m3		#N/A	$0.00	$0
, exc. mat'l B		m3		#N/A	$0.00	$0
Collect'n pond, fill mat'l A		m3		#N/A	$0.00	$0
, fill mat'l B		m3		#N/A	$0.00	$0
Collect'n pond, liner		m2		#N/A	$0.00	$0
COLLECT DRAINAGE FOR TREATMENT						
Remove and treat north inlet water		m3	500000	OTPL	$0.35	$175,000
SHORT TERM WATER TREATMENT*						
Annual water treatment cost, from "Water Treatment"						$0
					Total	$1,280,539

1 Post-Closure Monitoring & Maintenance:

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost
MONITORING & INSPECTIONS						
Annual geotechnical inspection		each	7	RPTH	$20,000.00	$140,000
Survey inspection		each	7	#N/A	$50,000.00	$350,000
Performance monitoring (water, dust, wildlife, etc.)		each	10	#N/A	$250,000.00	$2,500,000
Reporting		each	10	#N/A	$100,000.00	$1,000,000
person, labour, equipment, logistics, etc		each	1	#N/A	$6,237,680.00	$6,237,680
INTERIM CARE AND MAINTENANCE						
annual C&M		yrs	3	#N/A	$2,223,639.00	$6,670,917
fish consumption advisory signage		allow	1	#N/A	$10,000	$10,000
POST-CLOSURE EFFECTS MONITORING AND COMMUNITY ENGAGEMNT						
Aquatic Effects Monitoring and Reporting		yrs	3	#N/A	$250,000	$750,000
Wildlife Effects Monitoring and Reporting		yrs	3	#N/A	$50,000	$150,000
Traditional Knowledge Monitoring and Review (at site)		yrs	10	#N/A	$120,000	$1,200,000
Environmental Monitoring Advisory Board	Unique to Diavik Environmental Agreemen	yrs		#N/A		$0
Community Engagement (at communities)		yrs	10	#N/A	$50,000	$500,000
Subtotal, Annual post-closure costs						$19,508,597
Discount rate for calculation of net present value of post-closure cost, %				0.00%		
Number of years of post-closure activity					years	
Present Value of payment stream						$19,508,597

*Regulatory costs - annual reporting, management plans, progress reports etc.
Include water treatment cost from "Water Treatment" worksheet if treatment is considered long term, such as ARD/ML.

ANNUAL INTERIM CARE & MAINTENANCE

	No.	hrs/year	Rate	Annual Cost	
Site supervisor	1	3650	$61.20	$223,380	
laborers	3	3650	$38.76	$141,474	
equipment operators	2	3650	$56.10	$204,765	
mechanic	1	3650	$61.20	$223,380	
electrician	1	3650	$70.00	$255,500	
envir. coodinator	1	3650	$61.20	$223,380	
				$1,271,879	total staff
Fuel, power & heat	L/hr	mon/yr	fuel		
	50	3	108000		
	40	7	201600		
	25	2	36000		
Fuel, mobile equipment	15	12	129600		
			475200	total fuel	
air charter	flights/yr		cost/flight		
	52		4500	234000	
camp costs	108	m-mont	1320	142560	
misc. supplies, allowance				50000	
reagents				50000	
		Total annual C&M		$2,223,639	

1 Mobilization/Demobilization:

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	
MOBILIZE HEAVY EQUIPMENT							
Excavators -2		km	4800	MHERH	10.25	$49,200	
Dump trucks - 15		km	120000	MHERH	10.25	$1,230,000	
Dozers - 4		km	16000	MHERH	10.25	$164,000	
Demolition shears - 2		km	9600	MHERH	10.25	$98,400	
Crane - 2		km	1600	MHERH	10.25	$16,400	
Loader - 2		km	4800	MHERH	10.25	$49,200	
Compactor		km		MHERH	10.25	$0	
Service vehicles - 10		km	16000	MHERH	10.25	$164,000	
MOBILIZE MISC. EQUIPMENT							
Pump shipping		each		#N/A	0	$0	
Pipe shipping		m		#N/A	0	$0	
Minor tools and equipment		allow	1	#N/A	500000	$500,000	
Truck tires		allow	1	#N/A	500000	$500,000	
Other				#N/A	0	$0	
MOBILIZE CAMP							
Reclamation activities		allow	1	#N/A	150000	$150,000	
Long term reclamation activities (eg pump flooding)		allow		#N/A	0	$0	
MOBILIZE WORKERS							
Rotations over reclamation period		manhours	26000	#N/A	45	$1,170,000	
Reclamation activities - transport		each		#N/A	0	$0	
Reclamation activities - travel time		manhours		#N/A	0	$0	
Long term reclamation activities (eg pump flooding) - transport		each		#N/A	0	$0	
Long term reclamation activities (eg pump flooding) - travel time		each		#N/A	0	$0	
Monitoring Airfare		each		#N/A	0	$0	
WORKER ACCOMODATIONS							
Reclamation activities 20800 mandays		mandays	20800	ACCML	100	$2,080,000	
Long term reclamation activities (eg pump flooding)		manmonths		#N/A	0	$0	
MOBILIZE FUEL							
Fuel freight - reclamation activities		litre		#N/A	0	$0	
Fuel freight - long term reclamation activities		litre	7000000	FCMH	0.42	$2,940,000	
Fuel freight accomodations		litre		#N/A	0	$0	
WINTER ROAD							
Construction and operation - 400km	once for C&M, twice for contractor mob/dem	km		WRCH	11500	$0	tabled pending A21 pit development plans
Limited winter use		km		#N/A	0	$0	
Winter road tarriff		km		#N/A	0	$0	
DEMOBILIZE HEAVY EQUIPMENT							
Excavators		km		#N/A	0	$0	
Dump trucks		km		#N/A	0	$0	
Dozers		km		#N/A	0	$0	
Demolition shears		km		#N/A	0	$0	
Crane		km		#N/A	0	$0	
Loader		km		#N/A	0	$0	
Compactor		each		#N/A	0	$0	
Light duty vehicles		km		#N/A	0	$0	
Other		km		#N/A	0	$0	
DEMOBILIZE CAMP							
		allow		#N/A	0	$0	
DEMOBILIZE WORKERS							
crew travel time		mandays		#N/A	0	$0	
crew transportation		each		#N/A	0	$0	
WINTER ROAD							
Construction and operation		km		#N/A	0	$0	
Limited winter use		km		#N/A	0	$0	
Winter road tarriff		km		#N/A	0	$0	
					Total	**$9,111,200**	

Equipment Mobilization	# of machines	loads/machine	round trip km	total road mileage
excavator	2	3	800	4800
dump trucks	15	10	800	120000
dozers	4	5	800	16000
demolition shears	2	6	800	9600
front end loader	2	3	800	4800
cranes	2	1	800	1600
service vehicles	10	2	800	16000

Unit Cost Table (for refining unit costs see "Estimator" worksheet)

Filter by unit

ITEM	Detail	COST CODE	UNITS	LOW $	HIGH $	SPECIFIED $	COMMENTS
Accomodation							
		ACCM	manday	100.00	175.00		
Buildings - Decontaminate							
	Asbestos	BDA	m2	25.60	51.20		Low: removal of asbestos siding & flooring; High: removal of insulated pipes
Buildings - Remove							Unit costs are based on 3m high, single storey building. Scale areas accord
	Wood	BRW	m2	27.50	41.00		
	Concrete	BRC	m2	40.00	65.00	6.00	Specified: puncture concrete foundation slabs
	Steel - teardown	BRS1	m2	45.00	65.00		
	Steel - for salvage	BRS2	m2	67.00	100.00		
Concrete work							
	Small pour	CSF	m3	426.50	639.75		Low: YK; High=1.5xLow
	Large pour	CLF	m3	353.50	530.25	2,130.00	Specified: concrete crown pillar
Contaminated Soils							
	ESA Phase 1	CS1	each	7500.00			Low: small, "clean" site
	ESA Phase 1	CS2	each	50000.00			Low: small, "clean" site
	Remediate on site	CSR	m3	47.00	146.00		
Dozing							
	doze rock piles	DR	m3	1.05	2.40		Low cost: doze crest off dump
	doze overburden/soil piles	DS	m3	0.95	3.80		High cost: push up to 300 m
Excavate Rock; Low Spec's and QA/QC							
	drill/blast/load/short haul	RB1	m3	11.40	17.05		Low:quarry operations for bulk fill
	drill/blast/load/long haul	RB2	m3	12.05	17.80		
	RB1 + spread and compact	RB3	m3	12.05	17.80		
	RB2 + spread and compact	RB4	m3	12.50	30.75		
	Specified activity	RBS	m3				
Excavate Rock; High Spec's and QA/QC							(e.g. ditch/spillway excavation)
	drill/blast/load/short haul	RC1	m3	12.05	17.80		Low:foundation excavation;High:spillway excavation
	drill/blast/load/long haul	RC2	m3	12.70	18.40		
	RC1 + spread and compact	RC3	m3	12.70	18.40		e,g, cover construction
	RC2 + spread and compact	RC4	m3	13.50	19.20		e,g, cover construction
	Specified activity	RCS	m3			175.00	Specified-drift excavation
Excavate Rip Rap							
	drill/blast/load/short haul/place	RR1	m3	13.50	17.75		High: quarry & place rip rap in channel
	drill/blast/load/long haul/place	RR2	m3	14.20	20.65		
	source is waste dump/short haul	RR3	m3	7.00			cost includes sorting
	source is waste dump/long haul	RR4	m3	7.60			
	Specified activity	RRS	m3				
Excavate Soil; Low Spec's and QA/QC							
	clear & grub	SBC	m2	3.40	5.00		
	excavate/load/short haul	SB1	m3	4.30	5.90		
	excavate/load/long haul	SB2	m3	4.60	7.30		
	SB1 + spread and compact	SB3	m3	5.10	8.90	4.20	Low: non-engineered; High:engineered; specified 2011 $3.96 adjusted for ir
	SB2 + spread and compact	SB4	m3	5.50	11.00		Low: non-engineered; High:engineered
	Specified activity	SBS	m3	3.20	6.50		Low: rehandle waste rock dump by dozing; High:rehandle waste rock by hau
	Tailings	SBT	m3	1.35	3.70	15.50	High:contour surface - wet or frozen; Specified:haul/place wet infill
Excavate Soil, High Spec's and QA/QC							
	excavate/load/short haul	SC1	m3	6.80	9.30		
	excavate/load/long haul	SC2	m3	7.10	11.75		
	SC1 + spread and compact	SC3	m3	8.90	14.20		Low: non-engineered; High:engineered
	SC2 + spread and compact	SC4	m3	9.30	23.20		Low: non-engineered; High:engineered (e.g. complex covers, low volume da
	Specified activity	SCS	m3		5.00	18.80	High:hydraulic mining; Specified:Backfill adit with waste rock
Fence							
		FNC	m	13.55	203.00		
Fuel and Electricity							
	Fuel cost - gas	FCG	litre	1.05	1.40		
	Fuel cost - diesel	FCD	litre	0.99	1.39		
	Fuel mobilization	FCM	litre	0.22	0.42		High: winter road usage
	Electricity	FCE	kW-h	0.17	0.19	0.49	Low and High:Yellowknife; Specified:diesel generator
Geo-Synthetics							
	geotextile	GST	m2	3.44		9.37	Supply and install
	geogrid	GSG	m2	5.75			
	liner, HDPE	GSHDPE	m2	7.95			Supply and install; large quantity
	liner, ES3	GSES3	m2	20.20			FOB Yellowknife
	geosynthetic installation	GSI	m2	3.16	14.00		Low:geotextile; High:ES3 or HDPE

Unit Cost Table (for refining unit costs see "Estimator" worksheet)

	Filter by unit					
bentonite soil ammendment	GSBA	tonne	308.30	348.50		FOB Edmonton, add shipping & mixing
Grouting (/m3 of rock grouted)						
	grout	m3	236.55	286.75		High: cement, FOB Yellowknife
Labour & Equipment Rates						
Site manager	sman	$/hr	125.00	152.00		
Supervisor	super	$/hr	52.00	91.84		
Registered engineer	eng	$/hr	95.00	220.00		
Environmental coordinator	envco	$/hr	74.16	130.00		
Evironmental technologist	envtech	$/hr	36.00			
Electrician	elec	$/hr	74.00	95.00		
Journeyman - various	journey	$/hr	44.00	71.79		
Labour - skilled	lab-s	$/hr	41.00	49.60		
Labour - unskilled	lab-us	$/hr	31.00	43.98		
Equipment operator	oper	$/hr	41.00	65.00		
Heavy duty mechanic	mech	$/hr	49.00	72.85		
Water treatment plant operator	oper-wt	$/hr	41.00	59.86		
Security / first aid	safety	$/hr	36.00	66.97		
Administative staff	admin	$/hr	38.00	57.89		
Equipment rates include operator and fuel						
Loader - 4 cu.yd (3.06m3)	load-s	$/hr	175.00			
Loader - 7 cu.yd (5.35m3)	load-l	$/hr	315.00			
Excavator - 26.76-30.84 tonnes	exc-s	$/hr	190.00			
Excavator - 68.95+tonnes	exc-l	$/hr	420.00			
Grader	grad	$/hr	190.00			
Dump truck off hwy 30-50 tonnes	truck-s	$/hr	225.00			
Dump truck off hwy 55-75 tonnes	truck-l	$/hr	300.00			
dozer, small	dozers	$/hr	205.00	260.00		
dozer, large	dozerl	$/hr	490.00	565.00		
smooth drum compactor	comp	$/hr	155.00			
scooptram, 6 yd3 bucket	scoop	$/hr	170.00			
flat bed truck with hiab	hiab	$/hr	155.00			
fuel truck	ftruck	$/hr	150.00			
water truck	wtruck	$/hr	58.00	150.00		
Mobilize Heavy Equipment						
Road access	MHER	kmtonne	3.40	10.25		
Air access	MHEA	kmtonne	12.00			cargo rate>500lb
Mobilize Camp						
Road access	MCR	each	50000.00			refurbish existing camp
Mobilize Workers						
flight	MW	each	4500.00	9100.00		Low:e.g. 8 passenger; High: Dash 7
Oil Removal						
oil removal	OR	litre	0.43	1.20		Low:waste oil heater; High: ship offsite
PCB Removal						
Remove from site	PCBR	litre	40.20	46.90		Low: shipping, handling & disposal from Yellowknife
Pipes, small (<6in dia.)						
remove/dispose on site	PSR	m	1.00	24.00		Low: remove/dispose on site; High: remove/re-use
supply	PSS	m	6.10	11.10		Low:supply; High:supply and ship
install	PSI	m	25.00			
Pipes, large (>6in dia.)						
remove/dispose on site	PLR	m	22.00	72.00		Low: remove/dispose on site; High: remove/re-use
supply	PLS	m	129.00	143.00		Low:supply; High:supply and ship
install	PLI	m	50.00			
Power Lines						
remove/dispose on site	POWR	m	25.50			
Process Chemicals						
Remove from site	PCR	kg	0.45	2.50		Low: shipping, handling & disposal from Yellowknife
Pumps						
Pump capital cost	PC	each	195000.00			
Pump shipping	PS	each	2500.00			
Pump operating cost	POC	m3	0.12			pump operating costs should be calculated based on pump capacity, fuel cc
Pump maintenance	PM	allow	25000.00			
Pump sand BackFill						
	PBF	m3	85.00	300.00		
Scarify - road/mine site						
	SCFY	ha	4300	6030	2150	
Shaft, Raise & Portal Closures						

Unit Cost Table (for refining unit costs see "Estimator" worksheet)

Filter by unit

Shaft & Raises	SR	m2	645.00	2132.00		Low:pre-cast concrete slabs, little site prep. Area=shaft+>1m all around
Portals	POR	m3	18.80	250.00	1200.00	Low:unit cost code SCS;High:excavate & backfill collapsed portal;Spec: inst
Site Inspection Report						
	RPT	each	10000.00	20000.00		
SpillWay - Clear						
	SW	each	3000.00	7000.00		
Survey/Instrumentation						
	SI	each	1800.00	3600.00		2 person crew
Treatment Plant - Construct						
Small (< 1000 m3/d)	TPS	lump sum	9000000	15000000		
Large (> 1000 m3/d)	TPL	lump sum	15000000	46000000		
Constructed Wetland	CWTS	ha	200000	300000		
Treatment Plant - Operate						
	OTP	m3	0.35	2.00		
Treatment Chemicals						
ferric sulphate	ferric	kg	1.19			
ferrous sulphate	ferrous	kg	1.32			
lime	lime	kg	0.56			
hydrogen peroxide, 35%	hperox	kg	1.50			
Sodium Metabisulfate	Nametab	kg	1.18			
Caustic soda, 50%	caustic	kg	0.74			
Sulfuric acid, 93%	sulfuric	kg	0.31			
flocculant	flocc	kg	6.00			
copper sulphate	copper	kg				
shipping	shipping	kg	0.20			
Vegetation						
Hydroseed, Flat	VHF	ha	4000.00			
Hydroseed, Sloped	VHS	ha	4500.00			
Veg. blanket/erosion mat	VB	ha	13000.00			
Tree planting	VT	ha	2600.00	6000.00		
Wetland species	VW	ha			47.72	Specified= /m3, Wetland Growth Media Substrate mixed and installed (sanc
Water Sampling/Analysis/Reporting						
	WS	each	7000.00	10000.00		
Winter Road						
Construction	WRC	km	2000.00	11500.00		
Usage	WRU	kmtonne	0.29			