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20 April 2017

Re: Closure and Reclamation Plan Version 4.0

Diavik Diamond Mines (2012) Inc. (DDMI) is pleased to submit Closure and Reclamation Plan (CRP) Version 4.0 for review and approval under W2015L2-0001 Part K Item 3.

We note three items for the Board:

1. Appendix XII-1: Section 10 of the Annual Closure and Reclamation Plan Progress Reports compiles a list of items to be addressed in the next iteration of the CRP. Appendix XII-1 of CRP V4 provides a conformance summary against the most recently approved Annual Closure and Reclamation Plan Progress Report (2015).

2. Final Closure Plan – Waste Rock and Storage Area (WRSA) – North Country Rock Pile (NCRP) – Version 1.1: While this document is a part of the site closure plan, it was submitted separately to the Board on April 18, 2017. We appreciate separate submission may cause some confusion and, where possible, we have limited the content of CRP V4 to references to the WRSA-NCRP Final Closure Plan.

3. The Waste Rock Storage Area for the A21 open-pit mining operation (South Country Rock Pile – SCRP) is not included in the scope of CRP V4 as the development designs are still pending submission to the Board for approval. DDMI anticipates providing the Board with a CRP for the WRSA-SCRP as part of a future Closure and Reclamation Progress Report. All other aspects of the A21 development have been included.

DDMI has significantly advance closure planning for the Diavik mine site from the Interim Closure and Reclamation Plan (ICRP) Version 3.2. The Reclamation Research Plans are nearing completion and closure designs for the open-pits, underground, dikes, infrastructure and North Inlet are adequate to advance to final design. Work is also underway to evaluate the technical feasibility of changes to enhance operations and closure of the Processed Kimberlite Containment Facility and an overview of closure considerations for such potential changes are discussed in CRP V4. Lastly, as noted above (2), the Final Closure Plan for the WRSA-NCRP forms a part of CRP V4 and has been submitted separately for Board approval, with plans to begin progressive reclamation of the Waste Rock Storage Area-North Country Rock Pile in 2017.

DDMI would like to highlight the important work of the Traditional Knowledge Panel. We have been very pleased with the interactions, contributions and recommendations that the Panel has provided to this closure plan. We encourage the Board to review their reports that are included in Appendix IX-1.

DDMI looks forward to the review from all Parties in addition to the Board and Board Staff.

Regards,

Gord Macdonald

cc Anneli Jokela (WLWB)
Ryan Fequet (WLWB)
Patty Ewaschuk (WLWB)

Closure and Reclamation Plan – Version 4.0

Diavik Diamond Mines (2012) Inc.

April 2017

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ATTACHMENTS

TABLES

1 Executive Summary

This Closure and Reclamation Plan (CRP) update (Version 4.0) has been prepared as per the requirements of Diavik Diamond Mines (2012) Inc.'s (DDMI) Class "A" Water License WL2015L2-0001 and directives from the Wek'èezhìı Land and Water Board. The Interim Closure and Reclamation Plan (ICRP) currently approved under the Water License is Version 3.2 – August 2011.

Closure planning began with the original mine design work in 1996 to 1998 and continues to be refined based on new information. Many of the important design decisions related to closure occurred during the original mine design. This update documents the most recent changes but also provides a summary description of how the closure plan for each area has evolved. A comprehensive set of closure objectives have been developed to guide the closure planning. Initial criteria have also been proposed to describe how each objective might be evaluated.

Closure planning is an ongoing activity and the purpose of this document is to provide for general review and comment, but also regulatory acceptance of the current state of the plan and intentions for the future.

The A418, A154 and A21 open pit, underground and dike areas will be flooded at closure and the areas rejoined with Lac de Gras by excavating small sections of the dikes. Fish habitat enhancements, constructed during the mine operations in the pit shelf area, will provide additional habitat for the fish of Lac de Gras. Options for the North Inlet closure have been identified, however current hydrocarbon contamination in the sediments is limiting these options. A revised closure concept for the Processed Kimberlite Containment (PKC) facility has been approved, however additional alternatives are being considered. A final closure design has been completed for the North Country Rock Pile – Waste Rock Storage Area. This final design is currently under regulatory and public review. DDMI is considering starting construction of a thermal cover on the waste rock in 2017 as a progressive mitigation measure to manage runoff/seepage water quality.

On land, the waste rock pile and the PKC area will remain as a significant landscape feature post-closure. The area will be physically and geochemically stable and safe for people and wildlife, but visually will remain as a large rock-covered hill. Travel routes will be established to provide safe access and movement for people and wildlife.

Buildings, equipment, power lines, pipeline, fuel tanks and other infrastructure will not be visible post-closure. Where possible buildings, equipment and materials will be salvaged for resale/reuse preferably in the north and where not possible material will be made available for recycling. Inert material with no resale/reuse/recycle value will be disposed of on-site.

The plant site, roads, airstrip and laydown areas will be contoured, original drainage channels restored, and surfaces scarified and targeted for re-vegetation. Travel routes for people and wildlife will be established and linked with those constructed for other areas.

Like the 2011 ICRP, this is an interim plan. Closure planning is an ongoing activity and this document is effectively a progress report towards the Final Closure Plan, required in 2020.

2 Introduction

The Diavik Diamond Mine (Mine) is an unincorporated joint venture between Rio Tinto (60 percent [%]) and Dominion Diamond Diavik Limited Partnership (40%) with Rio Tinto being the operating manager. Diavik Diamond Mines (2012) Inc. (DDMI) is a wholly owned subsidiary of Rio Tinto plc of London, England. DDMI has been appointed Manager and is the corporate entity responsible for conducting Project activities.

The Diavik Diamond Mine is located on East Island, a 17 square kilometre (km^2) island in Lac de Gras, Northwest Territories (NWT), approximately 300 kilometres (km) northeast of Yellowknife (64 degrees [^{o}] 31 minutes ['] North, 110^o 20' West) (Figure 2-1). The area is remote, and major freight must be trucked over a seasonal winter road from Yellowknife. Worker access is by aircraft to the Mine's private airstrip.

The Diavik Diamond Mine involves mining of four diamond-bearing kimberlite pipes. The pipes, designated as A154North (A154N), A154South (A154S), A418 and A21, are located directly off shore of East Island (Figure 2-2). All mining, diamond recovery, support activities and infrastructure will be limited to East Island.

The Community of Wekweètì lies about 187 km to the west-southwest of the mine site. Lutsel K'e is 230 km to the south, Bathurst Inlet is about 275 km to the northeast, and the Lupin mine site is about 125 km to the north. The Ekati Mine is located roughly 25 km to the north (Figure 2-1).

2.1 Purpose and Scope of the Closure and Reclamation Plan

DDMI is committed to sustainable development, fully embracing our share in that joint responsibility with all legitimate interested parties. DDMI contributes to sustainable development by seeking to maximize the resources we mine, by pursuing opportunities to enhance environmental, social and economic benefits, and by reducing adverse effects that may result from our undertakings.

Mine closure has been integral to mine design and operations. DDMI recognizes that the land and water in the mine area is being borrowed, for the purpose of diamond mining, for a relatively short period of time. DDMI will operate and close the mine site responsibly, leaving behind a positive community and environmental legacy.

Planning for permanent closure is an active and iterative process. The intent of the process is to develop a final plan for permanent closure. The process began in the mine design phase and continues through to closure implementation. It enables the plan to evolve as new information becomes available. However, timely closure plan decisions must also be made throughout the planning process. Some of these decisions are significant, are made early in the planning process and can affect the final closure plan. For example the decision on a location for the waste rock piles or the Processed Kimberlite Containment (PKC) is made during the mine design phase and has implications for the final closure plan. Other decisions, for example a final cover material, can be made later in the mine life and can change. Closure planning ensures that information is collected, reviews completed and decisions made as appropriate for a successful implementation.

Closure and Reclamation Plans (CRP) are documents prepared during the life of the mine that describe the current state of closure planning. The CRP are interim plans that build from an *Initial* Closure and Reclamation Plan and ultimately become the *Final* Closure and Reclamation Plan. The expectation is that each iteration of the CRP will be a step toward the Final Plan.

The Wek'èezhìı Land and Water Board (WLWB) asked that CRP V4.0 address a number of specific items that are listed in Appendix XII.

This document remains however as an *Interim* plan. With the exception of the North Country Rock Pile – Waste Rock Storage Area (NCRP-WRSA) this Plan does not include detailed engineering designs for preferred closure options. Rather, it includes design concepts and options. DDMI's intent with this document is to:

- describe the current closure plan and future direction of the closure planning process for consideration by communities, regulators, advisory board and government;
- satisfy the requirements of the Water License and Land Lease; and
- obtain feedback regarding the priority areas for advancement of the closure plan before the final CRP.

A note to readers: in this document the term "closure" is specifically intended to mean both "closure and reclamation". The single term closure has been used simply for convenience.

2.2 Closure and Reclamation Plan Goals

DDMI's overall goal for the operation and closure of the mine site, as stated in *Diavik's Sustainable Development Policy* is:

> To operate and close the Diavik Mine responsibly, leaving behind a positive community and environmental legacy.

Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories (MVLWB 2013) provide three main areas of focus regarding closure and reclamation goals:

- *Physical Stability* – Any mine component that would remain after closure should be constructed or modified at closure to be physically stable such that it does not erode, subside or move from its intended location under natural extreme events or disruptive forces to which it might be subject after closure. Mine site reclamation will not be successful into the long term unless all physical structures are designed such that they do not pose a hazard to humans, wildlife, or environment health and safety.
- *Chemical Stability* – Any mine component, including wastes, that remains after mine closure should be chemically stable; chemical constituents released from the mine components should not endanger public, wildlife, or environmental health and safety,

should not result in the inability to achieve the water quality objectives in the receiving environment, and should not adversely affect soil or air quality into the long term.

- *Future Use and Aesthetics* – The site should be compatible with the surrounding lands once reclamation activities have been completed. The selection of reclamation objectives at a project site should consider:
    - naturally occurring bio-physical conditions, including any physical hazards of the area (pre- and post-development);
    - characteristics of the surrounding landscape pre- and post-development;
    - level of ecological productivity and diversity prior to mine development and intended level of ecological productivity and diversity for post-mine closure;
    - local community values and culturally significant attributes of the land;
    - level and scale of environmental impact; and
    - land use of surrounding areas, including the proximity to protected areas, prior to mine development and expected end land use activities for each area on site for humans and wildlife.

Closure goals, specific to the Diavik Mine site, have been developed through a process involving DDMI, reviewers and WLWB staff and are listed in Table 2-1. Selected options for site closure should be consistent with the stated closure goals. The goals have been designed to be reasonably attainable and specific enough to develop closure objectives.

Table 2-1 Closure Goals – Diavik Mine Site

Goals
1. Land and water that is physically and chemically stable and safe for people, wildlife and aquatic life.
2. Land and water that allows for traditional use.
3. Final landscape guided by traditional knowledge.
4. Final landscape guided by pre-development conditions.
5. Final landscape that is neutral to wildlife – being neither a significant attractant nor significant deterrent relative to pre-development conditions.
6. Maximize northern business opportunities during operations and closure.
7. Develop northern capacities during operations and closure for the benefit of the north, post-closure.
8. Final site conditions that do not require a continuous presence of Mine Staff.

2.3 Closure and Reclamation Planning Team

Closure planning at Diavik is conducted by a multi-discipline, interdepartmental team that has been formally organized as a committee. The committee was established April 9, 2003, three months after production began. The committee's original focus was communicating closure plans and rationale to the operations departments, with the understanding that closure would remain a focus and that operations needed to be fully aware of the current plans. The committee also sought input on ways to improve these plans for both closure success and for operations. Participation on the committee was originally limited to operations and environment departments, and the focus was waste rock segregation and deposition plans for the PKC.

By October 2004 the committee had expanded to include company-wide representation including community affairs, human resources and finance. Currently the committee composition and areas of focus are as follows:

- *Principal Advisor, Sustainable Development* – planning, coordination, internal and external communication, documentation, review and water-related environmental aspects.
- *Vice President, Finance* – financial approval planning, governance
- *Human Resources Business Partner* – human resources and work force planning.
- *A21 Construction Manager* – general earthworks including construction design, operations planning, engineering investigations, and closure costs estimating.
- *Senior Engineer, Geotechnical* – geotechnical oversight, inspection and assurance.
- *Manager, Communities and External Relations* – community engagement, Traditional Knowledge, socio-economics, business and community opportunities.
- *Superintendent, Environment* – monitoring, Traditional Knowledge, wildlife access, hazardous materials, landfill, vegetation research, permits, licenses and communication with Inspector.
- *Principal Advisor, Strategic Planning* – mine planning, closure costs and finance.
- *Senior Advisor, Risk and Compliance* – asset retirement obligations

Each of the participants on the committee has access to or directly manages additional DDMI staff, expert consultants, researchers and external advisors to assist as required in closure-related activities. External teams include but are not limited to:

- University of Alberta (vegetation, fish habitat, thermal).
- University of Waterloo (geochemistry, oxygen transport, microbiology).
- University of British Columbia (hydrology, water transport).
- Golder Associates Ltd. (Golder) (closure planning, geotechnical, mine and engineering design/investigation, deposition, fish habitat, wildlife, environmental assessment, monitoring, closure cost estimates).
- AMEC Earth and Environmental Ltd. (AMEC; geotechnical, engineering design/investigations).

- Rio Tinto Health Safety and Environment (closure planning, communication).
- Diavik Geotechnical Review Board (geotechnical).

The committee is responsible to the Vice President of Finance.

2.4 Community Engagement

Community engagement in closure planning was initiated through general discussions about the Project in June 1995, when only a limited amount of information was available about the size of the kimberlite pipes or the assortment of infrastructure and additional engineering structures required for a future mine. The Project Concepts that formed the basis of these initial discussions with communities are shown in Figure 5-7. Diavik was made aware of several views from the communities:

- land and water are significant to the people of the north;
- potential employment and business opportunities created by the Diavik Mine are important to the people of the north;
- concern for compensation from use of the land and water;
- DDMI needs to consult regularly with communities that are potentially affected;
- people are concerned about placing mining material in Lac de Gras, particularly waste;
- people of the north associate mining with chemicals and contamination of water and animals; and
- minimizing the footprint of the proposed mine site would also minimize the environmental effects.

In June 1997, a workshop was held at an exploration camp at the Diavik Mine site to present and discuss a Project Description that had been developed with input from communities. Key design principles that were identified at the workshop and incorporated into the Project Description included:

- consolidate the mine site and locate all components on the East Island;
- locate the PKC within the central depression on the East Island and not in Lac de Gras between the two islands;
- manage water discharged to Lac de Gras; and
- consider aspects of closure in the design of the mine and associated facilities.

Community engagement then proceeded to the Environmental Assessment (EA) and Water Licensing phases. Engagement activities associated with the EA are documented in Canada (1999) and in DDMI (1999a) where closure planning continued to be discussed, including the *Initial Abandonment and Restoration Plan* (DDMI 1999b).

As the Mine developed, community engagement was focused on employment, training and environmental monitoring. DDMI regularly engaged with communities through the Environmental Monitoring Advisory Board (EMAB) and the Diavik Technical Committee (DTC) of the Mackenzie Valley Land and Water Board (MVLWB). The DTC was involved in the review and recommendation for approval of the *Interim Abandonment and Restoration Plan* (DDMI 2001a). Although there were opportunities for community engagement through the DTC and EMAB, communities provided minimal additional closure input beyond what had been provided from 1995 to 1998.

Closure-specific community engagement was initiated in 2009 to support the development of ICRP V3.2. An on-site workshop with communities in August 2009 assisted with identifying community preferences for wildlife movement at closure. This was followed by a series of community meetings to confirm areas of focus for future closure engagement, as well as to identify concerns to be addressed in the ICRP, or through closure research and further community engagement.

A Traditional Knowledge (TK) Panel (TK Panel or 'the Panel') was formed under the EMAB for the Diavik Diamond Mine in 2011 and administration of the Panel then transferred to Diavik during the summer of 2013. Membership for the TK Panel is comprised of male and female Elders and youth that are selected by their community organization based on their experience, and familiarity and/or interest in the land around the Lac de Gras region. DDMI views the Panel as a body to facilitate appropriate and meaningful accommodation of TK in the planning and review of mine closure options. Similarly, the Panel identifies themselves as a 'standing body' to strengthen the role of Aboriginal TK holders in closure planning. Information and recommendations shared by the Panel are reviewed at the end of each day and each session to ensure accuracy and determine what is appropriate to share publically in the report. Reports generated from each Panel session are then shared with respective community organizations, EMAB and through the WLWB process (annual CRP Progress Reports). These reports are included in this document as Appendix IX-1 and the Panel recommendations are provided in Appendix IX-2.

Specific community engagement related to this update of the CRP is outlined in Appendix IX-3. Some of the initiatives and outcomes from 2012 through to 2016 are summarized below and seek to address the key topics identified in the Traditional Knowledge and Community Participation Research Plan (ICRP V3.2 - Appendix VIII-1).

DDMI developed an Engagement Plan (Version 1) that was approved in January 2015. This plan was developed to guide engagement activities between DDMI and each of the 5 Participation Agreement (PA) community organizations. The Engagement Plan identifies key contacts within each PA organization, engagement triggers (including Closure and Reclamation planning) and the suggested primary method(s) and purpose of engagement. It is then intended that community leadership will identify the appropriate contact(s) to work cooperatively with DDMI in developing a suitable process and content for engagement on closure, and that these would be specific to each Aboriginal organization.

DDMI submitted Version 2 of the Engagement Plan to the WLWB in November 2016. DDMI met with leadership from each of the five PA organizations in 2016 to discuss the overall approach for the plan and provided a copy of the Engagement Plan V2 prior to submission to the WLWB. This Plan ultimately replaces the Engagement Protocols that were referenced in ICRP V3.2 and allows flexibility to address the needs of individual community organizations while meeting the WLWB's requirements. Version 2 of the Engagement Plan has yet to be approved.

The WLWB issued a directive for DDMI to engage communities on the issue of on-site burial of buildings, machinery and equipment at closure. DDMI held community meetings in 2011 and 2012 to explain the results of the Golder Associates Ltd. analysis relating to on-site versus off-site disposal, and clearly indicated DDMI's preference for material disposal. General support was received for on-site disposal of buildings and was subsequently approved by the WLWB.

To facilitate discussions with communities on closure planning from 2011 through to 2015, DDMI primarily utilized existing processes and mechanisms to facilitate discussions with each PA organizations. These included discussions with: community members during open house meetings in the communities, PA Implementation/Steering Committees or working groups, community and DDMI leadership, Aboriginal and Northern businesses, Lands and Environment department staff, Elders committees and school children. A list of meetings conducted relating to closure have been identified and documented in Appendix IX-3. DDMI views these meetings as opportunities for community members to remain informed and to provide comment, but suggests that more specific closure engagement requires a smaller group.

As noted above, DDMI assumed administration of TK Panel in 2013. Panel members and representatives from the community organizations that assist with coordinating TK Panel meetings have shown commitment to maintaining consistent membership and building the knowledge and trust required for this Panel to work effectively. As a result, the recommendations and guidance received from the Panel has been meaningful and detailed, and addresses the majority of Research Objectives identified in DDMI's Traditional Knowledge and Community Participation Research Plan (ICRP V3.2 - Appendix VIII-1). Specific closure discussions that were initiated with the Panel under EMAB or DDMI include: operational caribou monitoring (2012, Appendix IX-1.1), renewing the landscape (NCRP-WRSA) at closure (2012, Appendix IX-1.2), reclamation & landscape (NCRP-WRSA) history (2012 and 2013, Appendices IX-1.3 and IX-1.4), PKC closure options (2013, Appendices IX-1.5), re-vegetation plans (2014, Appendices IX-1.6), fish and water quality monitoring after closure (2015, Appendices IX-1.7) and caribou and wildlife monitoring after closure (2016, Appendices IX-1.8). Full copies of the reports generated from each session are included as Appendix IX-1 and a complete list of the 156 recommendations made by the Panel to date are included as Appendix IX-2. These reports, recommendations and summaries have also been shared as part of DDMI's Annual CRP Progress Reports.

DDMI appreciates the Panel's level of understanding that is clearly reflected in the recommendations put forth by the Panel. However, both DDMI and Panel members recognize that Panel members do not necessarily represent the views and opinions of their community leadership, which implies that the Panel process does not supersede the need for further engagement with community organizations. DDMI is working with community organizations to identify and establish an appropriate process for reviewing and verifying the information shared with, and recommendations provided by the TK Panel within each organization.

The results of TK Panel discussions, particularly the two most recent sessions relating to post-closure monitoring, will require discussion with communities to refine and develop more detailed monitoring programs for water, wildlife and fish. The Traditional Knowledge and Community Participation Research Plan addresses this need. Many Panel and community members support the continued use of the Aquatic Effects Monitoring Program (AEMP) TK

Study design to assess the water quality and fish health in Lac de Gras. DDMI coordinated community working groups to re-design this program in 2011 and 2012 and community members have demonstrated increasing interest and ownership of the program over the years. Identification and evaluation of community-based monitoring programs such as this will require an evaluation of their applicability and association with scientific monitoring programs, as well as any necessary modifications required to address closure monitoring needs. This will be a key priority for DDMI over the next few years.

During DDMI's work with the TK Panel, both parties identified the need for a model that clearly depicted the post-closure landscape and would assist community members to visualize the site at closure. A 3-dimensional, interactive electronic model was developed and shared with the Panel and communities during closure engagement sessions in 2016. The model allows the user to toggle between what the mine looks like today, and what it would look like at closure. While the interactive model cannot effectively be shared as a part of this plan, representative screen shots depicting key elements of closure design have been included in Appendix IX-4 to help illustrate some of the concepts discussed.

DDMI met with community representatives from each of the five PA groups at the mine site or in communities to review the Closure Plan during the latter half of 2016. As per DDMI's Engagement Plan, Diavik staff initiated engagement with community leadership and took their direction on how best to proceed with engagement for their respective organization. Appendix IX-3 reflects this process and outlines the face-to-face community meetings conducted either at the mine site or in communities. Discussions largely focused on closure design plans, including the NCRP-WRSA closure design, as well as the recommendations and mitigation options for various aspects of the CRP previously identified by the TK Panel and DDMI. For 2016, an Engagement Record that aligns with the Engagement Log template in the MVLWB *Engagement Guidelines for Applicants and Holders of Water Licenses and Land Use Permits* (2014) is provided and documents the date/time, trigger, attendees, location/ engagement type, summary of issues/recommendations raised, DDMI's response and materials provided at each meeting. A generic copy of the presentation that DDMI shared to assist with discussions is included as Appendix IX-4.

DDMI endeavours to employ effective communication techniques that are relevant across the various levels of each of the five PA organizations, and meet the needs of individual community groups. DDMI expects that the level of interest and frequency of engagement activities relating to closure will continue to increase with all parties – Aboriginal, territorial and federal governments, local community members and regulatory authorities – as Diavik nears the end of its mine life.

2.5 Closure Plan Requirements

2.5.1 Guidelines and Regulations

This CRP follows applicable regulatory guidelines, the principles of which are described in:

- MVLWB and Aboriginal Affairs and Northern Development (AANDC) *Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories* (MVLWB 2013)*;*
- Indian and Northern Affairs Canada (INAC) *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007); and

- INAC *Mine Site Reclamation Policy for the Northwest Territories* (INAC 2002).

This CRP is also subject to several Federal and Territorial Acts and Regulations which are listed in Table 2-2.

Table 2-2 Relevant Federal and Territorial Acts and Regulations

Federal Acts and Regulations	Territorial Acts and Regulations
Arctic Waters Pollution Prevention Act and Regulations	*Commissioner's Lands Act* and Regulations
Canadian Environmental Assessment Act and Regulations	*Environmental Protection Act* and Regulations
Canadian Environmental Protection Act and Regulations	*Environmental Rights Act* and Regulations
Fisheries Act and Regulations	*Mine Health and Safety Act* and Regulations
Mackenzie Valley Resource Management Act and Regulations	*Science Act* and Regulations
Navigable Water Protection Act and Regulations	
Northwest Territories Waters Act and Regulations	
Territorial Lands Act and Regulations	
Transportation of Dangerous Goods Act and Regulations	

The overall approach to closure and reclamation planning for the Diavik Diamond Mine conforms to both corporate and established international guidelines for mine closure. Selected aspects of closure and reclamation planning completed for other mining operations in the NWT have been reviewed in the development of this plan.

2.5.2 Permits and Authorizations

The Diavik Diamond Mine received ministerial approval under the *Canadian Environmental Assessment Act* on November 1999 based on a Comprehensive Study Report (Canada 1999). On March 3, 2000, DDMI signed an Environmental Agreement with parties including the Federal Government, the Government of the Northwest Territories, and First Nations.

2.5.2.1 Comprehensive Study Report Conclusions

Initial plans for closure were considered in the Environmental Assessment for the Project as documented in DDMI (1998a) and Canada (1999). These initial plans for closure are summarized in Section 5. Canada (1999) provided conclusions, relevant to closure, that DDMI understood to be for consideration in the regulatory phase (Land Leases, Water License, Fisheries Authorization). These conclusions included:

- p. 111 – "The RAs [Regulatory Authorities] conclude that there will be no significant adverse environmental effects provided that the mine is properly decommissioned. Diavik must prepare a comprehensive Abandonment and Restoration (A&R) Plan, and have it reviewed and approved by regulatory authorities."

- p. 111 – “The approved A&R Plan will not allow burial of buildings, machinery and equipment on the mine site. It will include an estimate of implementation costs at various stages in the life of the mine.”
- p. 111,151 - “Should this project be allowed to proceed, Diavik must provide to the regulatory authorities adequate financial security for assuring that the A&R Plan will be fully implemented, independent of the corporation’s financial status when the mine is closed.”
- p. 111 – “The A&R Plan must be submitted within two years from the time of regulatory approvals should the Project be allowed to proceed. The A&R plan will address the time frame associated with the commencement of long-term closure procedures, advancement of rehabilitation procedures and identification of indigenous plant species to be used for re-vegetation.”
- p. 111 – “The follow-up program to be specified in the environmental agreement or land lease will also require Diavik to refine reclamation techniques in consultation with other developers that are best suited to the local climate and geology.”
- p. 141 – “Permafrost will aggrade into the saturated pond sediments of the PKC after mine abandonment, under the current proposal. Permafrost aggradation and the consequential build-up of pore water pressure ahead of the freezing front will enhance horizontal and vertical movement of metal-contaminated pore fluids, especially if there is no residual pond following abandonment. Permafrost may then rupture and contaminated PKC pore waters could be outside the confines of the PKC. The RAs concluded that the potential environmental effects from pore water release of contaminants to the environment can be mitigated through proper engineering design that would be detailed at the regulatory stage. Diavik must also develop appropriate closure and contingency plans for inclusion in its Abandonment and Reclamation Plan.”
- p. 145 – “These surface water collection systems will accumulate sediments and leachate from the country rock piles, plant site and road ditches, and Diavik must develop an Abandonment and Restoration Plan that fully addresses restoration of the collection system.”
- p. 151 – “The RAs concur with Diavik’s commitment to isolate the North Inlet from Lac de Gras with an impermeable barrier and to treat the North Inlet water before discharge to Lac de Gras. The RAs conclude that there will be no significant adverse environmental effects provided that the mine is properly decommissioned.”
- p. 151 – “Since no closure plan has been proposed for the North Inlet, Diavik must prepare a comprehensive Abandonment and Restoration (A&R) Plan, have it reviewed and approved by the regulatory authorities.”
- p. 167 – “At post closure, metal concentrations in fish flesh in some of the East Island lakes are predicted to exceed consumption guidelines. The RAs agree that Diavik should monitor metal concentrations post-closure and agree with KIA’s recommendation that a plan be developed to warn people fishing these lakes (e.g., posting signs), if the predictions are correct.”
- p. 169 – “The responsible authorities (RAs) concur with Environment Canada’s recommendations and direct Diavik to further consider the effects of climate warming on

the long-term integrity of frozen structures at the regulatory stage should the Project be allowed to proceed. Geotechnical monitoring must continue for the life of the Project to ensure the integrity of the frozen dam structures for the abandonment and restoration."

Where follow-up programs with environmental aspects are not within the jurisdiction of a specific permit, license or authorization, Canada (1999) determined that it would be included in an environmental agreement. On March 8, 2000 an Environmental Agreement was established. Article XV – Security and Enforcement – of the Environmental Agreement specifies the terms and conditions regarding financial securities held by the INAC Minister for the performance by DDMI of its reclamation and abandonment obligations under the Water License, Land Lease and any other obligations for which the INAC Minister is responsible. All other environmental aspects of closure are specifically included in the terms and conditions of the regulatory instruments listed in Table 2-3 and described below.

On March 31, 2000, the Federal Government issued DDMI 30-year land leases for the mine site (all expire March 29, 2030) under the *Territorial Lands Act*. In August 2000, a Class "A" Water Licence (successfully renewed in 2007 and again in 2015) was granted under the *Mackenzie Valley Resource Management Act*, various fisheries authorizations were granted under the *Fisheries Act*, and a Navigable Waters Permit (expires August 2030) was issued under the *Navigable Water Protection Act*. Energy, Mines, and Resources Canada issued an Explosives Permit (renewed annually with no expiry) in December 1999.

A summary of all potential permits required and existing authorizations held by jurisdiction for closure are listed in Table 2-3.

Table 2-3 List of Permits and Authorizations

List of Existing Permits, Authorizations and Agreements	Responsible Authority
Water Licence W2015L2-0001	Wek'èezhìı Land and Water Board
Fisheries Authorization	Fisheries and Oceans Canada
Navigable Waters Permit	Transportation Canada
Explosives Permit	Natural Resources Canada
Land Leases	Government of the Northwest Territories

2.5.2.2 Water Licence Requirements

The water license for the Diavik Diamond Mine (Class "A" Water Licence W2015L2-0001) sets out several conditions with respect to DDMI's right to alter, divert or otherwise use water for the purpose of mining. Specifically, Part K: Conditions Applying to Closure and Reclamation specifies that DDMI shall implement the CRP as approved by the Board and endeavour to carry out Progressive Reclamation as soon as is reasonably practical. Updates to this CRP shall be in accordance with directives from the Board and *Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories* (MVLWB 2013).

The plan is to include specific closure and reclamation objectives, and an evaluation of alternatives for the closure of each mine component.

In addition to the Closure and Reclamation Plan, Part K of the Water License specifies that:

- DDMI shall submit an annual Closure and Reclamation Plan Progress Report;
- DDMI shall submit a Final Closure and Reclamation Plan by October 2020 or a minimum of 24 months prior to the end of commercial operations, whichever occurs first;
- DDMI shall submit a Reclamation Completion Report; and
- DDMI shall submit a Performance Assessment Report.

2.5.2.3 Fisheries and Oceans Canada Authorization Requirements

The Diavik Diamond Mine is subject to the Authorization for Works or Undertakings Affecting Fish Habitat File No SC98001 ("Fisheries Authorization") issued by Fisheries and Oceans Canada (DFO 2000). The Fisheries Authorization outlines reporting requirements and approvals, offsetting requirements for the Harmful Alteration, Disruption or Destruction (HADD) of fish habitat, and requirements for compensation plans. DDMI must also produce monitoring plans to determine the effectiveness of all fish habitat enhancement and development efforts.

The Fisheries Authorization also stipulates that DDMI must meet the following specific requirements prior to final closure and reclamation of the enclosure dikes and open pits:

- DDMI shall provide updated estimates of pit water quality for each dike area a minimum of three months before habitat compensation works within each dike area is expected to begin;
- DDMI shall demonstrate that water quality will be acceptable to DFO before any dike is breached;
- if water quality within the dike area is unacceptable, DDMI shall submit a revised Compensation Plan (within six months of the unacceptable water quality results) for habitat compensation within the A21 area of Lac de Gras before implementing compensation efforts within the dike;
- upon demonstration of acceptable water quality, DDMI shall begin the Compensation Plan for each of the dike areas, provided that the locations and sizes of dike breaches are as specified within the Navigable Waters Permit (DFO Canadian Coast Guard 2000);
- DDMI shall ensure that habitat features within the dike areas upon completion of mining in each open pit (including depth, substrate type, size and configuration), are modelled after those features found in other productive areas of the lake, as well as incorporating traditional knowledge where applicable;
- DDMI shall submit a report on the habitat compensation efforts (a final calculation of actual habitat losses and habitat gains expressed as habitat units for each of the dikes) including any follow-up monitoring within one year of breaching of each dike; and

- DDMI shall maintain all habitat compensation as required, and monitor, verify and report on the effectiveness of the compensation efforts that will be outlined in Compensation and Monitoring Plans as approved by DFO.

2.5.2.4 Land Lease Requirements

The Diavik Diamond Mine operates under a set of five Land Leases covering the mine footprint area on the East Island. Conditions specified within the Land Lease relevant to closure include:

- Submission of a plan of restoration within 2 years of commencement of the lease with the objective of restoring the land as near as possible to its original state, including the removal of all buildings and structures, or such alternative objectives as may be approved by the Minister.
- The plan of restoration should be based on new information and technology as well as regulatory requirements so that the Project will be abandoned incrementally, in a manner consistent with sustainable development.
- Undertake ongoing restoration during the term of the lease in accordance with the approved plan of restoration.
- Requirements for security deposits.
- Dispose of all combustible garbage and debris by burning in an incinerator and all non-combustible garbage and debris by removal to an authorized dump site. Do not deposit any waste materials in any body of water or the bed or banks thereof which will in the opinion of the Minister impair the quality of the waters or the natural environment.

2.5.2.5 Navigable Waters Permit Requirements

In accordance with the Navigable Waters Permit (DFO Canadian Coast Guard 2000), DDMI must meet the following requirements before final closure and reclamation of the enclosure dikes and open pits:

- all internal fish habitat reefs shall be placed a minimum 2 metres (m) depth from lower water; and
- dike breaches shall be 30 m width and minimum 2 m depth from low water.

2.5.2.6 Explosives Permit Requirements

In accordance with Explosives Permit requirements, DDMI must remove all explosives and ammonia nitrate off site before final closure and reclamation.

3 Project Environment

3.1 Atmospheric Environment

3.1.1 Climate

The Mine has been collecting meteorological data since 1994. In 2003, a second weather station was installed to aid in collecting evaporation data and supplement weather data. The meteorological stations measure the following:

- wind speed;
- wind-direction;
- precipitation;
- ambient air temperature;
- incoming solar radiation; and
- relative humidity.

Manual precipitation stations were also used to measure rain, snow and evaporation. Summary information for temperature, precipitation and wind conditions at the mine site is presented below based on data collected at the Mine from 1997 to 2016. Months for which data coverage was low, or where data were not available, were excluded from the summary. In addition, available information from baseline studies and the EA are provided below.

3.1.1.1 Temperature

The Canadian Arctic is characterized by long, cold winters and short, cool summers. Based on data collected from 1997 to 2016, January is typically the coldest month of the year in the region of Lac de Gras, with a mean daily air temperature of -2.0 degrees Celsius (°C) to -32.9°C (Figure 3-1). The minimum daily air temperature recorded during the period was -44.0°C in January 2005 (Figure 3-2). These cold temperatures result in slow development of soils and the presence of permafrost, where soils and bedrock remain frozen year-round (DDMI 1998b). July is typically the warmest month, with mean daily air temperature of approximately 10.1°C to 15.7°C. The maximum hourly air temperature recorded was 27.6°C in July 2014 (Figure 3-3). Figures 3-1 to 3-3 show the maximum and minimum range of temperatures for each of the mean, minimum, and maximum daily air temperatures, respectively, as well as the average of each category.

Annual average, minimum and maximum seasonal temperatures are presented in Table 3-1. The annual average temperature in the Lac de Gras area ranged from -6.3°C to -11.9°C from 1999 to 2010, and 2013 to 2015, for which full years of data were available (Table 3-2).

Lac de Gras has two seasons: ice-cover (typically, January to June and November, December) and open-water (typically July to October). During the open-water season, average daily temperatures ranged from -4.1°C to 6.9°C (Table 3-1) Average temperatures during ice-cover conditions ranged from -19.9°C to -12.7°C (Table 3-1).

Table 3-1 Mean, Minimum and Maximum Seasonal Recorded Temperatures (°C) at the Meteorological Stations from 1999 and 2015, Open-water and Ice-cover Seasons

Season and Summary Statistic	Lowest	Average	Highest
Open-water Season			
Mean Seasonal Temperature	4.1	5.3	6.9
Minimum Seasonal Temperature	-24.7	-20.1	-12.7
Maximum Seasonal Temperature	22.2	25.3	27.6
Ice-cover Season			
Mean Seasonal Temperature	-19.9	-16.1	-12.7
Minimum Seasonal Temperature	-44.3	-41.2	-36.6
Maximum Seasonal Temperature	18.3	23.2	27.2

Note: All values are based on hourly averages.

Table 3-2 Annual Average, Minimum and Maximum Temperatures (°C) Recorded at the Meteorological Stations from 1997 to 2016

Season and Summary Statistic	Lowest	Average	Highest
Mean Annual Temperature	-11.9	-8.9	-6.3
Minimum Annual Temperature	-44.3	-41.2	-36.6
Maximum Annual Temperature	24.2	25.9	27.6

Note: All values are based on hourly averages.

3.1.1.2 Precipitation

Consistent rainfall data has been collected at the mine site since 1997. Precipitation may occur as rainfall generally from May to October, with mean monthly rainfall peaking in August. Rainfall in the Arctic region usually occurs as prolonged, low-intensity events. Precipitation can occur as snow year-round. Average annual rainfall recorded from 1999 to 2010, and from 2013 to 2015, for which full years of data were available, was 135.0 millimetres (mm). A summary of monthly rainfall is presented in Figure 3-4. Precipitation normals from Yellowknife are included for comparison. Rainfall patterns are similar at the Mine, though average rainfall is lower than at Yellowknife. In shoulder seasons, this may be due to more precipitation coming as snowfall, as the Mine has an average temperature less than that of Yellowknife. Yellowknife climate stations have an annual total precipitation normal of 288.6 mm (Environment Canada 2016).

3.1.1.3 Wind

Southeast winds occurred most frequently at the mine site (9.5% of the time) over the last ten years of monitoring (2007 to 2016) and the strongest winds also came most frequently from the southeast. The average wind speed recorded was 18.8 kilometres per hour (km/hr) and the average wind speed from the southeast was 19.6 km/hr. A wind rose for the Diavik Mine meteorological station wind data from 2007 to 2016 is presented in Figure 3-5.

3.1.2 Air Quality

Diavik's location is considered a remote site where ambient air quality concentrations are primarily the result of emissions from distant anthropogenic sources and natural sources. Remote sites located on the tundra normally have good air quality, especially for the primary air contaminants such as particulate, carbon dioxide, carbon monoxide, sulphur dioxide and nitrogen dioxide.

Based on a limited number of measurements of suspended particulate matter recorded from 1994 to 1997, the ambient concentrations were low (less than 10 micrograms per cubic metre [$\mu g/m^3$]) or a small fraction of Environment Canada's 120 $\mu g/m^3$ objective (Environment Canada 1997) for a 24-hour average.

Annual monitoring of dust deposition has occurred since 2002 as part of the AEMP for the Mine. Two methods are used to monitor dustfall: snow core surveys and dust collection gauges. The snow surveys are conducted in the spring and integrate dustfall over the winter. The 10 dustfall gauges, plus gauges from two reference stations are recovered on a quarterly basis and integrate dustfall over each quarter year.

In general, dust fall gauges nearest to the Mine property boundary record the highest deposition rates; however, results are variable and have changed over time in response to changes in the mining methods. Dustfall gauges within the Diavik zone of influence (ZOI) were pooled and stratified by year according to the following periods based on mining activities at Diavik:

- 2002 to 2005 (open pit Mine construction and mining);
- 2006 to 2009 (open pit mining and underground Mine construction); and
- 2010 to 2016 (underground mining).

Figure 3-6 plots the temporal evolution of average dust deposition rates for the dust gauges within the Diavik ZOI compared to observations from the reference stations.

There is no ambient air quality standard or guideline related to dust deposition rates for the NWT. The Alberta ambient air quality guidelines include an aesthetic target for dust deposition of 645 milligrams per square decimetre per year ($mg/dm^2/y$) for "Residential and Recreation Areas" and a target of 1,924 $mg/dm^2/y$ for "Commercial and Industrial Areas" (AEP 2016). Dust deposition rates were consistently below the Alberta Commercial and Industrial Area guideline from 2002 to 2016, and have been below the Alberta Residential and Recreation Area guideline since initiation of underground mining in 2010 (Figure 3-6).

3.2 Physical Environment

3.2.1 Overview

The Diavik Diamond Mine is located at Lac de Gras, about 300 km northeast of Yellowknife in the NWT (64º 31' North, 110º 20' West). The mine site is located approximately 100 km north of the treeline at the headwaters of the Coppermine River. The Coppermine River flows north to the Arctic Ocean east of Kugluktuk and is 520 km long with a drainage area of approximately 50,800 km^2.

The Lac de Gras area is characteristic of the northwestern Canadian Shield physiographic region, with rolling hills and relief limited to approximately 50 m in elevation. The terrain in this area has been formed as a result of multiple glaciation periods, with the most recent being the Late Wisconsin period. The landscape consists of relatively diffuse watersheds with numerous lakes interspersed among boulder fields, eskers and bedrock outcrops.
Lac de Gras is within the continuous permafrost zone. Harsh physiographic conditions have resulted in little soil development and low-growing vegetation cover.

3.2.1.1 Topography and Relative Relief

The Regional Study Area (RSA) defined in the EA for the Mine (DDMI 1998b) is part of the Slave Geological Province, which is located in the north-western portion of the Canadian Shield and within the continuous permafrost zone. Major elements of the landscape were shaped in pre-Quaternary times (before 1.64 million years ago); however, many details of the terrain are products of Quaternary glaciation (Fulton 1989).

The growth and decay of the Laurentide ice sheet of the Wisconsin ice age (about 9,500 years ago), have had the most significant effect on the terrain of this region (Fulton 1989), with eskers, boulder fields, and large exposed bedrock outcrops being major landscape features. The glacial deposits have been and continue to be modified by geomorphological processes, especially those associated with the annual freeze-thaw of the active layer of permafrost. Hence, the present landscape results from the interaction between the bedrock geology of the area, historical glacial activity and current geomorphological processes.

The terrain on East Island is characterized by steep-sided bedrock ridges, undulating to strongly rolling slopes consisting of glacial till, ridged eskers and level to depressional glaciolacustrine and organic deposits. The topographical relief is low to moderate, with elevations ranging from 415 metres above sea level (masl) at the shoreline of Lac de Gras to 445 masl inland. Most of the terrain features are controlled by shallow bedrock and boulders, which are present on all portions of the island.

3.2.1.2 Watershed and Lake Characteristics

The Lac de Gras watershed is located close to the southern boundary of the Low Arctic region, north of the tree line, in the central barren-ground tundra of the NWT (Figure 3-7). It has a drainage area of 3,559 km^2 (DDMI 1998c; Golder 1997a). The landscape of the watershed consists of relatively diffuse water flows and numerous lakes interspersed among boulder fields, eskers, and bedrock outcrops (DDMI 1998d).

Lac de Gras is a large lake with a surface area of 572 km^2, which is about 14% of the total watershed area (Figure 3-7; Golder 1997a). The lake is approximately 60.5 km long and up to 16.5 km wide (DDMI 1998c). Lac de Gras has approximately 470 km of lake shoreline and 267 km of island shoreline (DDMI 1998d). Lac du Sauvage (120 km^2 surface area) provides the main inflow to Lac de Gras, although small tributary streams also contribute directly. Over 200 small tributary streams, many of which are ephemeral (i.e., flow intermittently, usually during snowmelt), discharge directly into Lac de Gras (see Section 3.2.7 for more details on local hydrology).

In terms of the presence and frequency of wetlands in the watershed, sedge wetland occupies 2% (46 hectares [ha]) of the Local Study Area (LSA) and 3% (13,406 ha) of the RSA, as defined in the EA for the Mine (DDMI 1998b). The riparian tall shrub type is the least widely distributed cover class. It occurs in less than 1% of either study area, covering approximately 5 ha within the LSA, and 7 ha within the RSA (DDMI 1998b).

Several rock types that have different groundwater flow characteristics are present at the mine site. Permafrost consists of soil or rock that is continuously below 0°C for two or more years (DDMI 1998a). The thickness of permafrost decreases towards Lac de Gras and is absent beneath the lake itself. Permafrost underlies all of the small lakes on East Island, and prevents shallow groundwater from flowing from these small lakes into Lac de Gras.

The estimated concentration of total dissolved solids (TDS) in groundwater increases exponentially with depth (DDMI 1998a). The increase in TDS concentration with depth is similar to that observed at other mines in the Canadian Shield, including mines in the Yellowknife area. The general groundwater chemistry is typical of water that has a long residence time in association with granitic rock (DDMI 1998a).

3.2.1.3 Littoral Zone Description

The shoreline of Lac de Gras is rugged and interspersed with numerous bays and inlets. In most areas, shorelines are delineated by a sharp drop-off into deeper waters. This drop-off occurs at varying distances from the water’s edge, ranging from zero to 30 m, but most often approximately 3 to 5 m from the waterline (DDMI 1998c).

In the sheltered bays of Lac de Gras, shoreline substrates typically consist of a mixture of sand and silt. Beaches occur infrequently along the shorelines and are usually present in association with eskers (DDMI 1998c).

In open-water areas of Lac de Gras, the shoreline substrates along the islands consist mainly of boulder with a variety of secondary substrates, including cobble, sand and silt. Boulder substrate typically extends away from the shoreline into the open-water area, and is abruptly replaced with silt (DDMI 1998c).

Almost no rooted aquatic plants grow along the shoreline of Lac de Gras and little to no overhanging cover from shoreline vegetation exists, as tundra is present up to the lake margin. Dense willows can be found at the base of inlet streams (DDMI 1998c).

The EA for the Mine (DDMI 1998a) predicted that construction of the Mine would remove, alter and create sections of shoreline within Lac de Gras. Construction of the dikes required for mining of the four kimberlite pipes was estimated to physically alter approximately 10.5 km of existing shoreline of Lac de Gras that adjoins East Island and small offshore islands (DDMI 1998d). It was also predicted that approximately 4.6 km of shoreline of the North Inlet (NI) would be affected by water level fluctuations and altered nutrient regime due in part to Mine discharge to this diked-off area (DDMI 1998d). Dike and dam construction were predicted to create approximately 7.9 km of new rocky shoreline along dikes and dams by the year 2020. Construction of the NI, and A154, A418 and A21 dikes have been completed according to the original plans considered in the EA.

3.2.2 Surficial Geology

Soil development on East Island is restricted to pockets within bedrock and till blankets, and in depressions and rock crevices where organic matter has accumulated. Maximum soil depths are typically less than 0.5 m thick, and up to 2.0 m thick where organic matter has accumulated (Figures 3-8a and 3-8b).

Glacial till is the dominant surficial material on East Island and overlies most of the bedrock. Glaciofluvial deposits are in the form of eskers and kames, and are most common on the north end of the island. Glaciolacustrine deposits occur mainly in lowland areas, while organic deposits typically overlie glaciolacustrine deposits near the lake shoreline. Shallow organic deposits less than 1 m thick typically have large stones exposed at the surface.

All of the soils that have developed on East Island are Cryosols, which have been influenced by varying degrees of cryoturbation. Cryoturbation refers to the mixing of materials from various horizons of the soil down to the bedrock due to freezing and thawing. There are also numerous solifluction lobes on East Island. These lobes typically occur on slopes ranging from 10 to 25%, although they may occur on slopes as shallow as 2%.

Superficial lakebed sediments are underlain by a layer of organic-rich lake bottom sediments, which overly bouldery glacial till. The lake bottom sediments primarily consist of organic silts and clays and vary in thickness from 5 to 8 m. The underlying till may reach a thickness of between 20 m and 30 m.

3.2.3 Bedrock Geology

The Lac de Gras RSA is located in the central part of the Slave Geological Province of the Precambrian Shield. This province is 190,000 km^2 and lies in the middle of the NWT, bordered to the south by Great Slave Lake and to the north by the Coronation Gulf (Goodwin 1991) (Figures 3-9 and 3-10). One-third of the Slave Province is underlain by metasedimentary rocks of Archean age (dated at 3.96 billion years old) (EMPR 1995). The remainder is primarily underlain by intrusive igneous rock of granitic composition (dated at 2.3 to 2.6 billion years old) (Douglas 1970).

The surface expression of East Island is controlled by bedrock, with bedrock outcropping occurring over about 40% of the surface of the island. The bedrock geology of the island is dominated by granitic rock, with volcanic rocks such as diabase present in small proportions.

The Diavik diamond deposits occur in kimberlite pipes intruding in the granitoid country rock located under Lac de Gras adjacent to East Island. Material within the kimberlite pipes comprises three broad classes: hypabyssal kimberlite, volcanic and epiclastic kimberlite, and xenoliths. Volumetrically, the kimberlite pipes are dominated by volcaniclastic and epiclastic material, often with a significant xenolithic component. The hypabyssal phases are volumetrically less significant, occurring as feeders to the pipes at deeper levels and as contact intrusions along the pipe margins.

3.2.4 Geological Hazards and Seismicity

The mine site is situated in a region of low seismicity, as characterized by the following:

- acceleration related seismic zone (Z_a) = 0;
- velocity related seismic zone (Z_v) = 1; and
- zonal velocity ratio (v) = 0.05.

3.2.5 Permafrost Conditions

The mine site is located just north of the diffuse boundary between the widespread discontinuous and continuous permafrost, which generally coincides with the northern extent of trees (Heginbottom 1989; Johnston 1981).

Based on deep thermistor installation measurements, the permafrost has been confirmed to a depth of 150 m in the Lac de Gras area based on deep thermistor installation measurements; however, temperature projections from these thermistor installations also suggest that the permafrost may extend up to a depth of 240 m. The seasonal active layer in the vicinity of the mine site is about 1.5 to 2.0 m deep in till deposits, 2.0 to 3.0 m deep in well-drained granular deposits (eskers) and about 5 m in bedrock. The active layer is less than 1 m in depth in poorly drained areas including bogs with thicker vegetation cover.

The depth of the permafrost decreases towards Lac de Gras, and permafrost is absent beneath the lake itself. Other smaller lakes and very small islands in the region may also be underlain by unfrozen materials referred to as “taliks”.

3.2.6 Hydrogeology

The relatively low amount of precipitation (less than 400 mm in Lac de Gras area) in the Arctic restricts the amount of water available to recharge aquifers. Permafrost in Arctic terrain can act to reduce the movement of groundwater. Aquitards may be continuously present in ground that is frozen year-round (Prowse and Ommanney 1990).

Groundwater at the mine site is contained within surface and lakebed sediments and fractures contained within the country rock and kimberlite pipes. Groundwater at the mine site appears to have essentially no regional groundwater flow. This is likely the result of the combined effects of 1) the presence of Lac de Gras, which acts as a boundary for water movement; 2) the low topographic relief; and 3) the presence of permafrost beneath the islands and the mainland.

The hydraulic conductivity of the lakebed sediments is approximately 1 x 10-5 metres per second (m/s). The hydraulic conductivity of the competent country rock is approximately 5 x 10-8 m/s. Weathered and fractured zones of the country rock are considerably more permeable, with hydraulic conductivities of approximately 1 x 10-5 m/s and 1 x 10-6 m/s, respectively. The kimberlite pipes are more permeable than the competent country rock, with an estimated hydraulic conductivity of 1 x 10-6 m/s.

The hydraulic conductivity of the permafrost zone is very low (essentially zero). The hydraulic conductivity of the surface sediments has not been characterized, but is expected to vary in accordance with local lithology. Groundwater flow occurs in warmer seasons through the thin (0.5 to 1.5 m thick) active layer near surface, but these flows are considered relatively small.

3.2.7 Hydrology

3.2.7.1 Inflow, Evaporation, Precipitation and Outflow

The hydrology of Arctic regions is strongly affected by low precipitation and permafrost. Most of the precipitation accumulates during winter as snow, which melts and runs off rapidly in early June. With its large surface area, Lac de Gras provides a large inflow storage and results in fairly steady outflows. Based on the baseline report (DDMI 1998c), average derived basin inflow to Lac de Gras was about 19 cubic metres per second (m^3/s) and the mean monthly inflows to Lac de Gras ranged from about 3 m^3/s in March to about 57 m^3/s in July. The average lake outflow was estimated to be 20.7 m^3/s. Mean monthly lake outflow peaked in September (29.6 m^3/s) and reached its lowest value in May (14.8 m^3/s) (DDMI 1998a).

Mean annual precipitation onto Lac de Gras was about 373 mm (Golder 1997a).
This compares with an estimated mean annual lake evaporation of 275 mm, which mostly occurs from mid-June to mid-October. The mean annual net precipitation (total precipitation minus lake evaporation) on the lake was about 98 mm and represented a direct inflow onto the lake surface at an average rate of about 2 m^3/s (DDMI 1998c).

3.2.7.2 Lake Volume and Flushing Rate

The lake has an estimated volume of 6.7 billion cubic metres (m^3) of water and an estimated lake outflow of 20.7 m^3/s (DDMI 1998c). The flushing rate of Lac de Gras is estimated to be 0.09 times per year and the residence time is estimated to be 11.6 years (DDMI 1998d).

3.2.7.3 Major Inflows and Other Tributary Streams to Lac de Gras

Lac du Sauvage (120 km^2 surface area) provides the main inflow to Lac de Gras through a narrow channel located to the northeast of the lake. Over 200 small tributary streams also discharge directly to Lac de Gras. The majority of these small tributary streams are ephemeral and only flow during snowmelt (Figure 3-11). Small streams fed by small basins without significant lake storage and with drainage areas of less than 1,500 km^2 are likely to have no flows for extended durations in winter (Golder 1997a). Mean monthly inflows to Lac de Gras range from about 3 m^3/s in March to about 57 m^3/s in July. Daily lake inflow exceeds 9 m^3/s about 50% of the time.

Water discharges into the Coppermine River on the northwest side of Lac de Gras and flows north to the Arctic Ocean east of Kugluktuk (DDMI 1998d). The Coppermine River is 520 km long and has a drainage area of 50,800 km^2 (DDMI 1998c).

3.2.7.4 Bathymetry

The average water depth in Lac de Gras is approximately 12 m and the maximum depth is about 56 m (Golder 1997b). Detailed bathymetry for Lac de Gras is presented in Figures 3-12 and 3-13.

3.2.7.5 Lake Currents

Modelling was conducted in association with the 1998 baseline report and the EA to determine the circulation characteristics of Lac de Gras for baseline conditions and over the life of the Mine (DDMI 1998c,d). A two-dimensional flow model (RMA-2) was used to predict the potential effects of the dikes on lake circulation in areas near East Island and away from the Mine. Simulated lake circulation patterns for construction, operations, and after closure conditions were compared with baseline conditions to quantify potential changes. Aspects of the lake circulation modelling relevant to fish habitat included current and direction.

Three dike configurations, at three snapshots in time, were used to represent the effects of the dikes on lake circulation conditions during construction, operations, and after closure. Two modelling approaches were used for each configuration to simulate lake circulation conditions in Lac de Gras: steady-state and dynamic (Golder 1997b).

Steady-state simulations were conducted to describe the lake circulation conditions under average wind and inflow conditions. Nine simulations were carried out for each configuration:

- eight simulations for the average wind speeds in eight different directions (northwest, north, northeast, east, southeast, south, southwest, west) during the open-water season; and
- one simulation for the ice-cover season.

Dynamic simulations were conducted at daily intervals to characterize the varying lake circulation conditions under representative median (1988) and extreme (1982) wind seasons. The period of simulation was the open-water season, from June 15 to October 15. The dynamic simulation results were analyzed to derive statistics for varying daily lake current velocities and water levels at various locations on the lake. Daily wind, inflow and outflow series for 1982 and 1988 derived for Lac de Gras were used as input for the dynamic simulations (Golder 1997b).

Results of the modelling for the baseline period indicated that there is a distinct flow circulation pattern around East Island in summer (DDMI 1998c; Figure 3-14). This circulation is mainly caused by the long wave generation distance west to east across Lac de Gras and the location of East Island. The circulation can be clockwise or counter-clockwise depending on the wind direction. Current velocities were generally estimated to be higher near the shore in shallower water than those further removed from the shore in deeper water (DDMI 1998c). Lake circulation in winter is estimated to be relatively weak, because the ice-cover prevents contact between the water and the wind.

No adverse effect on lake circulation patterns was anticipated in the EA either regionally in Lac de Gras or locally near the dikes, resulting from construction of the dikes (DDMI 1998d). The maximum current velocity predicted regionally for Lac de Gras was not sufficient to move silt particles during any phase of the Mine. The maximum current velocity in areas near the dikes during operations was predicted to be sufficient to remove silt particles from fish habitat, but not larger substrate particles. The slight increase in lake currents predicted adjacent the dikes would potentially be beneficial to fish and fish habitat. For example, removal of silt particles from fish habitat by lake currents assists in maintaining clean, high quality spawning shoals (DDMI 1998d).

3.3 Chemical Environment

3.3.1 Soil Composition

Soils in the RSA are of the Cryosolic order. Cryosolic soils are formed in both mineral and organic parent material under the influence of seasonal freeze-thaw cycles and are characterized by disrupted, mixed or broken horizons. Cryosolic soils form where permafrost occurs within 1 to 2 m of the ground surface.

All of the soils that have developed on East Island are Cryosols, which have been influenced by varying degrees of cryoturbation. There are also numerous solifluction lobes on East Island. These lobes typically occur on slopes ranging from 10 to 25%, although they may occur on slopes as shallow as 2%.

Detailed mapping of terrain and soils in the LSA was conducted in the summer of 1996 (Golder 1997c). A detailed inventory and classification of soils and surficial deposits of East Island were conducted by investigating 47 representative stations. Terrain characteristics were recorded at each station and soil types were classified and photos were taken. Surficial materials were also classified with respect to their potential use for reclamation. Site-specific information was used to aid in air photo interpretation and subsequent mapping of terrain in the study area at a 1:10,000 scale.

Determining the suitability of the soil materials for reclamation was a key objective of the soils inventory. The information collected will help identify the potential of these soils for reclamation. At each of the 47 inspection stations, soils were characterized by the depth of each horizon, colour, texture, structure, consistency and percent rock content. A reclamation rating was given for texture, consistence and percent rock content. In addition, landscape characteristics such as topography, slope, surface stoniness, drainage and parent material were also recorded. Organic materials, glaciolacustrine materials, frost boil materials and soliflucted materials are the most suitable for reclamation. Maps of these areas are included in Golder 1997c.

3.3.2 Groundwater Quality

The composition and quality of groundwater in the vicinity of the mine site is described in the integrated baseline report (Blowes and Logsdon 1997; DDMI 1998c). The groundwater at the mine site is a slightly alkaline (pH near 8), moderate TDS (generally less than 500 milligrams per litre [mg/L]), Na-Mg-Ca – HCO_3-(Cl) water. This general chemistry is consistent with waters with long residence times in a granitic terrain. The stable isotope geochemistry indicates that the groundwater recharged under a cold climate. The stable isotope and tritium signatures of groundwater are distinct from water in Lac de Gras. Concentrations of metals in the groundwater are low to very low and radionuclide concentrations are close to detection limits in all samples.

A general trend of increasing concentration of most constituents in groundwater with depth is evident. A plot of TDS relative to depth for samples collected at the Diavik Mine site, the Lupin Mine and data presented in Frape and Fritz (1987) for numerous mines in the Canadian Shield including in the Yellowknife area is provided in Figure 3-15. Profile 1 of Figure 3-15 is an interpretation made by Blowes and Logsdon (1997) of the Frape and Fritz (1987) data. The interpretation takes into account that some of the samples are considered to be diluted by shallower fresh groundwater, which has flowed towards the Mine during the years of operation before sampling. Considering the Diavik-specific data and the data collected from the Lupin Mine, which is geographically closer than many of the Frape and Fritz (1987) sample locations, profile 2 seems a much more likely profile for the Diavik Mine site. The distinctly different water chemistry of groundwater and Lac de Gras water (DDMI 1998c) is consistent with the interpretation that there is very little recharge or discharge of groundwater to or from Lac de Gras under baseline conditions.

3.3.3 Acid Rock Drainage/Metal Leaching Potential

3.3.3.1 Overview of Acid Rock Drainage/Metal Leaching Potential

Poor quality drainage may develop when sulphide minerals that may be contained in mining waste rock oxidize and weather when exposed to the atmosphere. If sulphide minerals are present in sufficient quantities, sulphide mineral oxidation can release acidity, sulphate and dissolved metals to water draining from waste materials. This type of drainage is commonly referred to as Acid Rock Drainage (ARD) and Metal Leaching (MLch).

Prior to Mine development, a comprehensive baseline geochemistry program conducted static and kinetic tests of Diavik ore and country rock to characterize the acid-generating potential (Blowes and Logsdon 1997). Mineralogical data and test results included the following:

- the biotite-muscovite granites (including pegmatite granites) contain only trace sulphides and are considered non acid-generating with very low potential to leach metals during weathering;
- the biotite schist contains locally disseminated sulphide minerals at low, but sufficient quantities to be considered potentially acid-generating (PAG);
- the granite and biotite schist contain little carbonate, providing little neutralization potential;
- the diabase dikes contain trace sulphides, but are considered insignificant because of their very limited spatial extent;
- the siltstone/mudstone portion of the kimberlite, comprising approximately 1 to 5% of the kimberlite, contains fine-grained sulphides that can contribute to ARD/MLch during subaerial weathering;
- the volcanogenic portion of the kimberlite (greater than 95% of the kimberlite material) contains low sulphide concentrations with an excess of carbonate; and
- the carbonates in the volcanogenic portion act to neutralize acidity derived from oxidation of the sulphides in the siltstone/mudstone portion.

The average acid-base accounting measurements conducted during the baseline study (Blowes and Logsdon 1997) are summarized in Table 3-3. The granite and diabase were determined to have non-acid-generating potential. The biotite schist has more variable geochemical properties compared to the granite and diabase dikes. Most biotite schist samples ranged from non-acid generating to uncertain acid generating potential, with some samples in the PAG zone. Most kimberlite samples (volcanogenic and mudstone portions not segregated) were non-acid generating with few samples plotting in the uncertain to PAG zone.

Table 3-3 Average Acid-Base Accounting Measurements from the Baseline Study

Lithology	Average Sulphur Concentration (wt% S)	Average Neutralization Potential (NP) (kg $CaCO_3$/tonne)	Average Maximum Potential Acidity (MPA) (kg $CaCO_3$/tonne)	Average Net Neutralization Potential (NP-MPA) (kg $CaCO_3$/tonne)
Granite	0.02	8.1	0.6	7.6
Diabase	0.06	16.6	1.7	14.9
Biotite schist	0.16	9.2	4.3	4.8
Kimberlite	0.21	316	5.8	310
Kimberlitic mudstone	0.73	248	21.3	227
Processed kimberlite	0.60	196	14.8	181
Processed mudstone	1.80	128	50.7	77.3

Source: Blowes and Logsdon 1997.
wt% S = percent by weight of sulphur; kg $CaCO_3$/tonne = kilograms of calcium carbonate per tonne.

3.3.3.2 DDMI Waste Rock Type Classifications

Waste rock classifications based on total sulphur content were developed to segregate PAG waste rock, which contains biotite schist, from non acid-generating granites (Table 3-4). The classification criteria were based on results from the baseline geochemistry study and are described in greater detail in Blowes and Logsdon (1997) and DDMI (2011a).

Table 3-4 Waste Rock Type Classification Criteria

Waste Rock Classification	Criteria (total sulphur in wt%)	Description
Type I	<0.04 wt% S	• Predominantly granites • Considered non acid-generating ("clean") waste rock suitable for construction material
Type II	<0.04 wt% S to 0.08 wt% S	• Granites with little biotite schist • Considered intermediate or mixed rock with low acid-generating potential
Type III	>0.08 wt% S	• Granites containing some amount of biotite schist • Considered potentially acid-generating

wt% = percent by weight; S = sulphur; <= less than.

3.3.4 Surface Water Quality

3.3.4.1 Baseline Water Quality

Water quality samples were collected annually from 1994 to 2000 to determine the baseline water quality characteristics of Lac de Gras. Approximately 50 stations were sampled, with most being located in the area immediately surrounding East Island (Figure 3-16). Water samples were collected during two sampling seasons: ice-cover (typically April/May) and open-water (typically August/September).

The analytical capabilities of laboratories to measure low-level metal and nutrient concentrations have improved appreciably since the baseline data were collected. Additionally, standardization of sampling protocols has also improved. As a consequence, the quality of the data collected today (Section 3.3.4.2) is better than it was during the baseline period.

Water samples were collected at mid-depth or as depth-integrated samples (0 to 10 m) and submitted to accredited laboratories for analyses that included:

- general parameters (conductivity, pH, total alkalinity, total organic carbon [TOC], total suspended solids [TSS]);
- major ions (calcium, chloride, magnesium, potassium, sodium, sulphate);
- nutrients (ammonia, nitrate-nitrite, total Kjeldahl nitrogen [TKN], total phosphorus [TP]); and
- total metals.

A summary of water quality programs completed from 1994 to 2000 is provided in Table 3-5. The locations of baseline water quality stations within Lac de Gras are shown in Figure 3-16.

A detailed summary of baseline water quality at various stations in Lac de Gras is presented in the *2011 to 2013 Aquatic Effects Monitoring Re-evaluation Report Version 3.2* (Golder 2016a); results are also detailed in DDMI 1998c.

Table 3-5 Summary of Baseline Water Quality Monitoring

Year	Stations	Reference
1994	LDG1 to LDG9	Acres and Bryant (1995, 1996)
1995	LDG1 to LDG25	Acres and Bryant (1995, 1996)
1996	WQ01 to WQ14	Golder (1997d,e,f)
1997	WQ01 to WQ14	Golder (1998a)
1998	WQ01 to WQ14	DDMI unpublished data
1999	WQ01 to WQ14	DDMI unpublished data
2000	LDG40 to LDG48	DDMI unpublished data

DDMI = Diavik Diamond Mines (2012) Inc.

The water quality of Lac de Gras is typical of many Arctic lakes. Baseline water quality conditions in Lac de Gras were characterized by low conductivity and low concentrations of hardness, TSS, TDS and associated major ions. The lake was mildly acidic, with a pH range of 6.3 to 6.8, based on data from 2000. Many of the metals were near or below detection limits used at the time with the exception of aluminum, which occurred naturally at levels above the detection limit (DDMI 1998d).

Baseline water quality data suggested that Lac de Gras is an ultra-oligotrophic lake because of its low phosphorus concentrations, low primary productivity, and very high water clarity (DDMI 1998d). This classification was based primarily on the TP value of 5 micrograms per litre (µg/L) as the upper boundary of ultra-oligotrophic conditions, which was developed during the EA process, based on the scientific literature. The range of TP in oligotrophic lakes can be considered to be from 4.9 µg/L to 13.3 µg/L (Ryding and Rast 1998), though some classifications consider lakes with TP concentrations less than 4 µg/L to be in the ultra-oligotrophic category (CCME 2004).

More recent data accumulated from reference areas through the AEMP indicate that the normal range of TP concentrations in Lac de Gras is 2.0 to 5.3 µg/L during the open-water period, and 2.0 to 5.0 µg/L during the ice-cover period (as provided in the AEMP Reference Conditions Report Version 1.1 [Golder 2015a]). These ranges indicate that TP concentrations in Lac de Gras are occasionally above 5 µg/L under background conditions, indicating that Lac de Gras appears to fall in the upper range of ultra-oligotrophic status, with TP concentrations occasionally in the oligotrophic range.

3.3.4.1.1 Lac de Gras in a Regional Context

This section compares analyte concentrations in Lac de Gras water to those in nearby lakes and to lakes sampled in the Arctic region, to provide regional context for water quality in Lac de Gras. The comparisons were completed at three different levels:

- Water quality data were compared between Lac de Gras and Lac du Sauvage for winter, summer and fall 1996. Lac de Gras data were obtained from the intensive study area as defined in the EA (DDMI 1998c). Data for Lac du Sauvage came from the baseline program for the Diavik Mine.
- Water quality data collected from Lac de Gras in 1995 and 1996 were compared to data in lakes sampled by BHP Billiton (BHPB) and to four additional lakes, which included Courageous Lake, Matthews Lake, Contwoyto Lake, and Unnamed Lake. These four lakes are collectively referred to as the "nearby lakes". Water quality results for the BHPB lakes came from the aquatic monitoring program for the Ekati Mine (BHP Diamonds Inc. 1995). No information was available on the sampling methods or the detection limits used for the BHPB monitoring. The BHPB stations were sampled in 1994 and were compared to baseline Lac de Gras data from 1996 (DDMI 1998c). The nearby lakes were studied by Environment Canada before 1978. No information was available regarding methods, detection limits, and time of sampling. Water quality data for the nearby lakes were compared to 1995 and 1996 baseline data for Lac de Gras (DDMI 1998c).
- Water quality data from Lac de Gras in 2000 were compared to data from various lakes sampled in the Arctic region from 1982 and 2000. The water quality data for this comparison were extracted from government reports and scientific journals. Data collected from scientific journals included information on methods and sampling periods. Limited information was available on detection limits. Although lakes were sampled from 1982 and 1991, detection levels appeared to be similar or lower than detection limits used for Lac de Gras from 1995 to 1996 based on the range of reported values. Data from scientific journals were compared to 1996 and 2000 baseline data for Lac de Gras.

Sampling years with data collected using similar detection limits were compared wherever possible.

3.3.4.1.2 Lac de Gras and Lac du Sauvage

Water samples were collected from Lac de Gras and Lac du Sauvage as part of the baseline program for the Mine (Figure 3-16). Information on methods can be found in the original baseline report (DDMI 1998c).

In 1995 and 1996, general parameters measured at the various sample stations in Lac de Gras and Lac du Sauvage did not vary substantially among stations or between the two years. Concentrations were low, although some parameters such as conductivity and TSS were slightly higher during winter. Conductivity in Lac de Gras and Lac du Sauvage were similar and ranged from 11.5 microSiemens per centimetre (μS/cm) to 17.8 μS/cm. Median pH measurements in Lac de Gras and Lac du Sauvage were similar in 1996, ranging from 6.0 to 6.2.

In 1996, major ion concentrations were similar between Lac de Gras and Lac du Sauvage. Concentrations of calcium, magnesium, sodium and potassium were generally higher in winter samples compared to samples from other seasons. Higher concentrations of these ions during winter were likely a reflection of freeze out, also known as cryoconcentration (Welch and Legault 1986).

Nutrient concentrations measured in 1996 were low in both lakes. Nitrite + nitrate concentrations were above detection limits only during winter and were greater in Lac du Sauvage (median of 0.047 mg/L) than in Lac de Gras (median of 0.026 mg/L). Nitrite and nitrate were analyzed individually only for winter samples. Stations in Lac de Gras with higher median nitrate concentrations included WQ3 (0.058 mg/L) and WQ13 (0.064 mg/L), which are located between the East and West Islands (Figure 3-16). Nitrite concentrations were typically below the detection limit. Total Kjeldahl nitrogen concentrations ranged from 0.09 to 0.40 mg/L in Lac du Sauvage and from 0.06 to 0.29 mg/L in Lac de Gras.

In 1996, TP and orthophosphate concentrations in Lac de Gras and Lac du Sauvage were below the detection limit of 0.003 mg/L. The low concentrations of TP in Lac de Gras are consistent with the lake's oligotrophic status.

Total metal concentrations were similar and low in Lac de Gras and Lac du Sauvage. Aluminum, arsenic, barium, chromium, copper, lithium, manganese, nickel, silicon, strontium, sulphur and zinc were the most commonly measured metals at concentrations greater than the detection limit in Lac de Gras in 1996. Detectable metals in Lac du Sauvage in 1996 were aluminum, barium, copper, lithium, manganese, nickel, silicon, strontium, sulphur and zinc. With the exception of arsenic and chromium, all metals measured above the detection limit in Lac du Sauvage in 1996 were also detected in Lac de Gras in 1996. No clear seasonal trends were found in the concentrations of these metals in Lac de Gras or Lac du Sauvage in 1996.

3.3.4.1.3 Nearby Lakes and BHPB Stations

Water quality in several lakes close to Lac de Gras was assessed in 1975 and 1976 by Moore (1978a,b). Courageous Lake, Matthews Lake, Unnamed Lake, Contwoyto Lake and nine other lakes located near Contwoyto Lake were sampled during this study.

Courageous Lake, Unnamed Lake and Matthews Lake are located less than 100 km southwest of Lac de Gras (Figure 3-17) and are smaller in size than Lac de Gras. Courageous Lake is 40 km long and has a maximum width of 7 km (Moore 1978a); Unnamed Lake is 3 km long and has a maximum width of 0.8 km; and Matthew Lake is 8 km long and has a maximum width of 2 km. By comparison, Lac de Gras is approximately 61 km long and has a maximum width of 17 km. No information was available on depth of these lakes (Moore 1978a). Water quality samples were collected in these lakes in July, August and September of 1976 (Moore 1978a). Other lakes in the Lac de Gras area were sampled as part of the Ekati Mine's aquatic monitoring program (BHP Diamonds Inc. 1995).

Contwoyto Lake is located approximately 100 km northeast of Lac de Gras (Figure 3-18). The lake has a surface area of approximately 950 km^2 (Moore 1978b), which is greater than that of Lac de Gras (572 km^2). Nine lakes surrounding Contwoyto Lake were also included in the study. Surface areas of these lakes ranged from 0.05 to 10.4 km^2. Collectively, these 10 lakes are referred to as the “Contwoyto Lake system”. Contwoyto Lake has a maximum depth of 30 m, whereas the maximum depth of the other nine lakes ranged from 2 to 10 m (Moore 1978b). Water samples were collected from the 10 lakes in July 1975 (Moore 1978b).

Overall, concentrations of general parameters in Lac de Gras were similar to concentrations reported in the nearby lakes and at the BHPB stations. Levels of conductivity measured in Courageous Lake (10 to 12 µS/cm), and Matthews Lake and Unnamed Lake (both 18 to 20 µS/cm) were similar to those measured in Lac de Gras (7.9 to 12.3 µS/cm). Conductivity in the Contwoyto Lake system (5.8 µS/cm) was lower than in Lac de Gras. The average conductivity at the Ekati Mine stations ranged from 8 to 17 µS/cm (BHP Diamonds Inc. 1995).

Hardness ranged from 4.3 to 5.6 mg/L (as $CaCO_3$) in Lac de Gras, whereas Contwoyto Lake and Courageous Lake had hardness values below 5.0 mg/L. Matthew Lake and Unnamed Lake had the highest hardness values at 13.6 mg/L and 9.6 mg/L respectively.

Median pH values in Lac de Gras ranged from 6.55 to 6.60 in 1995 and from 6.06 to 6.16 in 1996. Similar values for pH were found in the lakes sampled at the Ekati Mine site and ranged from 6.3 to 6.7, which is characteristic of waters flowing over the Precambrian Shield of the Lac de Gras area (BHP Diamonds Inc. 1995).

Total alkalinity was lowest in Contwoyto Lake (less than 1 mg/L as $CaCO_3$) and highest in Lac de Gras (5.2 to 6.6 mg/L in 1995). Turbidity values were similar among all the lakes and equal or below 2.2 nephelometric turbidity units (NTU).

Concentrations of nitrate + nitrite in the nearby lakes (except Contwoyto Lake) were less than or equal to 0.01 mg/L (Moore 1978a). These values were within the range of concentrations found in Lac de Gras in 1996 (less than 0.003 to 0.028 mg/L). The average concentrations of nitrogen parameters in the lakes at the Ekati Mine site were similar to concentrations found in Lac de Gras (Table 3-6) (BHP Diamonds Inc. 1995). Concentrations of TP for the lakes at the Ekati Mine site (0.0049 to 0.0127 mg/L) were in the upper range or greater than concentrations observed in Lac de Gras (<0.003 to 0.007 mg/L in 1995, <0.003 mg/L in 1996).

Dissolved metal concentrations were usually below or close to detection limits in Lac de Gras and nearby lakes. A few exceptions included arsenic (0.009 mg/L) and zinc (0.1 mg/L) in Matthews Lake; and zinc in Lac de Gras 1996 (0.0044 mg/L), Courageous Lake (0.016 mg/L) and Unnamed Lake (0.022 mg/L).

Table 3-6 Median Concentrations of Water Quality Parameters in Lac de Gras (1995 to 1996), Nearby Lakes (1975 to 1976) and BHPB Stations (1994)

Variable	Units	Lac de Gras		BHPB Sites	Courageous Lake	Matthews Lake	Contwoyto Lake[b]	Unnamed Lake[c]
		1995[a]	1996[a]					
Conventional Parameters								
Conductivity, lab	µS/cm	7.9 to 12.3	11.7 to 12.1	8 to 17	10 to 12	18 to 20	5.8	18 to 20
Hardness (as $CaCO_3$)	mg/L	-	4.3 to 5.6	-	4.2	13.6	<5.0	9.6
pH, lab	pH unit	6.55 to 6.63	6.06 to 6.16	6.3 to 6.7	-	-	-	-
Total alkalinity (as $CaCO_3$)	mg/L	5.2 to 6.6	4.8 to 5.9	-	3.7	6.2	<1	3.7
Turbidity	NTU	-	0.1 to 0.7	-	2	2.2	1.5	1.7
Nutrients								
Ammonia	mg-N/L	<0.01	<0.01 to 0.05	0.006 to 0.02	-	-	-	-
Nitrite	mg-N/L	<0.2	<0.003 to 0.004	0.0017 to 0.0023	-	-	-	-
Nitrate	mg-N/L	<0.003	0.014 to 0.064	0.0053 to 0.1740	-	-	-	-
Nitrite + nitrate	mg-N/L	-	<0.003 to 0.028	-	<0.01	0.01	-	<0.01
Total phosphorus	mg-P/L	<0.003 to 0.007	<0.003	0.0049 to 0.0127	-	-	<0.005 to 0.010	-

Table 3-6 Median Concentrations of Water Quality Parameters in Lac de Gras (1995 to 1996), Nearby Lakes (1975 to 1976) and BHPB Stations (1994) (continued)

Variable	Units	Lac de Gras		BHPB Sites	Courageous Lake	Matthews Lake	Contwoyto Lake[b]	Unnamed Lake[c]
		1995[a]	1996[a]					
Dissolved Metals								
Arsenic	mg/L	-	0.0002	-	<0.0005	0.009	-	0.0006
Cadmium	mg/L	-	<0.0002	-	<0.001	<0.001	-	<0.001
Cobalt	mg/L	-	0.0003	-	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	-	0.001	-	<0.001	0.002	<0.002	0.004
Iron	mg/L	-	<0.005	-	<0.005	<0.005	<0.05	0.010
Lead	mg/L	-	<0.0002	-	<0.005	<0.005	<0.005	<0.005
Manganese	mg/L	-	0.0014	-	<0.01	<0.01	<0.01	<0.01
Nickel	mg/L	-	0.0009	-	<0.005	<0.005	<0.005	<0.005
Zinc	mg/L	-	0.0044	-	0.016	0.1	<0.001	0.022

Source: DDMI 1998c.

a) Ranges were based on the median concentrations calculated for the Lac de Gras intensive area sites as defined in the EA (1995 = LDG1 to LDG8, LDG10 to LDG19, LDG 21 to LDG25; 1996 = WQ2 to WQ9, WQ13) (DDMI 1998c; Figure D6-2). Median concentrations at each site were based on concentrations measured during the winter, summer and fall of either 1995 or 1996.

b) Concentrations at Contwoyto Lake are arithmetic means that take into account concentrations of parameters in Contwoyto Lake as well as concentrations in nine smaller lakes surrounding Contwoyto Lake.

c) Values are means not medians.

NTU = nephelometric turbidity unit; mg/L = milligrams per litre; µS/cm = microSiemens per centimetre; <= less than; - = sample was not collected or analyzed during that period.

3.3.4.1.4 Arctic Lakes

Lac de Gras data collected in 1996 and 2000 were compared to water quality data published in the scientific literature for Arctic Lakes (Pienitz et al. 1997a,b; Ruhland et al. 2003; Shortreed and Stockner 1986). These data were collected from June to September 1982 (Shortreed and Stockner 1986), in July 1990 (Pienitz et al. 1997b), in July 1991 (Pienitz et al. 1997a), and in August 1996 (Ruhland et al. 2003).

Pienitz et al. (1997a) studied 24 lakes in the Yellowknife area. The lakes are located in the Slave Geologic Province, where Lac de Gras is located. Ruhland et al. (2003) sampled 56 lakes in the same area. The two other datasets (Pienitz et al. 1997b; Shortreed and Stockner 1986) came from studies completed in the Yukon and in the NWT close to Inuvik.

The vegetation cover in the drainage areas of the various lakes investigated in the scientific literature included boreal forest, forest-tundra, Arctic tundra and alpine tundra. When possible, data from lakes located in the Arctic tundra vegetation zone were isolated to minimize the effect of vegetation cover on water quality.

Concentrations of nitrogen parameters (e.g., nitrite, nitrate, TKN) and silica (reactive) were available from some studies (Pienitz et al. 1997a,b; Shortreed and Stockner 1986). However, the concentrations were determined from filtered samples (i.e., only the dissolved fraction was measured) and consequently could not be compared to the Lac de Gras results.

Surface areas and depths of Lac de Gras and the lakes used in the comparison are presented in Table 3-7. The other lakes were smaller and usually shallower than Lac de Gras.

Table 3-7 Arctic Lakes Surface Area in Maximum Depth

Source	Surface Area (km^2)	Maximum Depth (m)
Lac de Gras	572	56
Yellowknife 1991 (Pienitz et al. 1997a)	0.53 to 5.02	2.5 to 25
NWT-Nunavut 1996 (Ruhland et al. 2003)	0.009 to 0.366	0.5 to 19.0
Yukon 1982-1983 (Shortreed and Stockner 1986)	1.6 to 90	2.5 to 93[a]
Yukon and NWT 1990 (Pienitz et al. 1997b)	0.011 to 12.62	1.2 to 49

a) Mean depths.
km^2 = square kilometres; m = metres; NWT = Northwest Territories

Water quality of Lac de Gras was similar to other lakes in the Arctic region, with low conductivity and low concentrations of major ions. The median conductivity of the water in Lac de Gras was 11.5 µS/cm and 13.5 µS/cm in 1996 and 2000, respectively. Similar conductivity values were reported in lakes sampled in the Yellowknife area by Pienitz et al. (1997a) and the NWT-Nunavut area by Ruhland et al. (2003), where median conductivity was 8 µS/cm and 10.8 µS/cm respectively. Lakes sampled in 1990 in the Yukon-NWT area by Pienitz et al. (1997b) had higher conductivity (median of 128.5 µS/cm); however, conductivity was strongly influenced by proximity to the ocean. Lakes sampled from the Arctic tundra in 1990 by Pienitz et al. (1997b) were very close to the ocean compared to Lac de Gras.

Lac de Gras was mildly acidic, with median pH values of 6.1 and 6.6 in 1996 and 2000, respectively. In general, pH values were variable Arctic lakes, ranging from 5.9 to 9.3 (Pienitz et al. 1997a,b; Shortreed and Stockner 1986; Ruhland et al. 2003). When data from the literature were limited to lakes in the same vegetation zone as Lac de Gras, pH values were still variable, although median values were slightly higher.

Concentrations of major ions were very low in Lac de Gras and in lakes sampled within the Yellowknife and NWT-Nunavut areas by Pienitz et al. (1997a) and Ruhland et al. (2003), respectively. Lakes from these areas had low median concentrations of calcium, potassium, chloride and sodium, with concentrations all below 1 mg/L. Sulphate concentrations in Lac de Gras were similar to those in lakes sampled in the Yellowknife area by Pienitz et al. (1997a), having median concentrations of 1 mg/L and 0.9 mg/L, respectively. Major ion concentrations reported for Yukon and NWT area lakes by Pienitz et al. (1997b) were higher than those recorded in Lac de Gras, and in Yellowknife or NWT-Nunavut area lakes assessed by Pienitz et al. (1997a) and Ruhland et al. (2003), respectively. Chloride and sodium concentrations were strongly related to proximity to the ocean (Pienitz et al. 1997b). The greater concentrations of other major ions are likely related to differences in geological and edaphic (i.e., soil-related) conditions (Pienitz et al. 1997b).

Total Kjeldahl nitrogen concentrations were lowest in Lac de Gras (medians of 0.08 mg/L in 1996 and 2000) and slightly higher in lakes in the Yellowknife and NWT-Nunavut areas assessed by Pienitz et al. (1997a) and Ruhland et al. (2003), respectively (medians of 0.123 mg/L in 1991 and 0.1455 mg/L in 1996). In comparison, the median TKN concentration in the Yukon and NWT area lakes assessed by Pienitz et al. (1997b) was 3.95 mg/L.

Concentrations of TP were low in all lakes. Median concentrations ranged from less than 0.003 mg/L in Lac de Gras to 0.012 mg/L in the Yukon and NWT area lakes sampled by Pienitz et al. (1997b). According to Pienitz et al. (1997b), the higher TP concentrations could be related to particular geological and edaphic conditions. All other lakes sampled were considered oligotrophic.

Median concentrations of aluminum and barium were similar between Lac de Gras and lakes sampled in the Yellowknife area by Pienitz et al. (1997a). Median concentrations of total iron in Lac de Gras (less than 0.01 to 0.019 mg/L) were below the median concentration of lakes sampled in the Yellowknife area (0.0272 mg/L; Pienitz et al. 1997a) and an order of magnitude lower than the median concentration of lakes sampled by Pienitz et al. (1997b) in the Yukon-NWT area (0.101 mg/L). Similarly, total lead and lithium concentrations were below detection limits in Lac de Gras, but were higher in lakes assessed by Ruhland et al. (2003) in the NWT-Nunavut area. The median concentration of total manganese was at or below 0.002 mg/L in Lac de Gras in 1996 and 2000 and in the Yellowknife area lakes assessed by Pienitz et al. (1997a). The median concentrations of total manganese in the NWT-Nunavut area lakes sampled by Pienitz et al. (1997a) and the Yukon-NWT area lakes sampled by Pienitz et al. (1997b) were 2.55 mg/L and 0.014 mg/L respectively. Finally, total strontium concentrations were greater in Lac de Gras (medians of 0.005 mg/L and approximately 0.006 mg/L in 1996 and 2000, respectively) than in the NWT-Nunavut area (0.001 mg/L) lakes sampled by Pienitz et al. (1997a).

3.3.4.2 Recent Monitoring of Water Quality

3.3.4.2.1 Effluent and Water Chemistry

Water quality samples are collected as part of the AEMP to assess effects of the Mine on the water quality of Lac de Gras (Golder 2014a). Monitoring of water quality in Lac de Gras under the AEMP has occurred annually from 2001 to 2016. Water quality samples are analyzed for conventional parameters, major ions, nutrients and total and dissolved metals. Field measurements of conductivity, dissolved oxygen (DO), water temperature and pH are also collected during the AEMP field surveys. Sampling occurs 1) in the near-field area of Lac de Gras, which is located close to the point of effluent discharge; 2) in three mid-field areas (i.e., transects extending away from the near-field area) in the main body of Lac de Gras; and 3) in three far-field areas in Lac de Gras.

The 2016 AEMP represents the most recent analysis of effluent and water chemistry data for the Lac de Gras environment. The 2016 AEMP Annual Report (Golder 2017) was submitted to the WLWB on March 31, 2016, as required by the Water Licence. Results for the AEMP water quality component are summarized as follows.

Analysis of field-measured water quality data collected in 2016 indicate that that conductivity and pH values were greater in the near-field area of Lac de Gras compared to mid-field and far-field sampling areas, reflecting the greater concentration of Mine effluent near the diffusers (Golder 2017). No Mine-related spatial trends were detected in the concentrations of DO measured at AEMP stations or in water temperature.

A total of 15 water quality variables analyzed in 2016 had near-field area concentrations that were greater than reference conditions used to detect an early warning indication of Mine-related effects (TDS, turbidity, calcium, chloride, sodium, sulphate, nitrate, aluminum, copper, lead, manganese, molybdenum, silicon, strontium and uranium). Statistically significant differences were detected between the near-field and far-field sampling areas for most variables, and most had spatial patterns of decreasing concentration with distance from the Mine-effluent diffusers (Golder 2017). Concentrations of these variables and all other variables analyzed in 2016 remain well below AEMP Effects Benchmark values for the protection of aquatic life and drinking water (Golder 2014a).

The most recent temporal analysis of trends in water quality variables in Lac de Gras was undertaken as part of the 2011 to 2013 Aquatic Effects Re-evaluation Report Version 3.2 (Golder 2015b). The data presented in that report indicate that concentrations of most of the 16 aforementioned water quality variables have been increasing gradually over time throughout Lac de Gras. The analysis also indicated that a small amount of effluent had reached the far-field areas in Lac de Gras, which were previously considered reference areas. As a result, the AEMP now relies primarily on approved reference conditions established for Lac de Gras (Golder 2015a) to compare with conditions in exposed areas of the lake, combined with gradient analysis.

Finally, results of the effluent chemistry screening completed as part of the AEMP in 2016 indicate that regulated effluent parameters are consistently below effluent quality criteria (EQC) defined in the Water Licence. In addition, effluent toxicity testing completed in 2016 indicated that the Mine effluent is generally non-toxic (Golder 2017).

3.3.4.2.2 Indicators of Eutrophication

Diavik has been monitoring indicators of eutrophication in Lac de Gras as a component of the AEMP since 2007. Eutrophication indicators consist of nutrients (phosphorus, nitrogen) chlorophyll a (the green pigment in algae) and zooplankton biomass. Nutrients are a key component of the AEMP, because one of the predicted effects of the discharge of effluent was an increase in productivity in Lac de Gras. This is evident in the growth of the algae, which is evaluated by measuring chlorophyll a concentration in lake water.

Analysis of the 2016 eutrophication indicators data indicated that the Mine is having a nutrient enrichment effect in Lac de Gras (Golder 2017). Statistically greater concentrations of chlorophyll a, TP, total nitrogen (TN) and zooplankton biomass were observed in the near-field area relative to the far-field areas. Concentrations of TP and TN were greatest during the ice-cover season.

During both the ice-cover and open-water seasons, approximately 6.5% of Lac de Gras was considered affected by increased TP concentrations, as indicated by elevated concentrations in the NF and MF3 areas (Golder 2017). For zooplankton biomass, 0.5% of Lac de Gras was considered affected during the open-water season. The area of the lake showing effects on TN was larger. Concentrations of TN exceeded the normal range in 84.7% of the lake, which is greater than the affected area calculated for this variable in previous years. Finally, the concentration of chlorophyll a exceeded the normal range for Lac de Gras over an area representing 43.7% of the lake.

A comparison of the spatial extent of effects on indicators of eutrophication over the last ten years of monitoring is provided in Table 3-8.

Table 3-8 Spatial Extent of Effects on Concentrations of Total Phosphorus, Total Nitrogen and Chlorophyll a, and on Zooplankton Biomass, 2007 to 2016

Year	Total Phosphorus		Total Nitrogen		Chlorophyll a		Zooplankton Biomass (ash-free dry mass)	
	Area[(a)] (km^2)	Lake Area[(b)] (%)	Area[(a)] (km^2)	Lake Area[(b)] (%)	Area[(a)] (km^2)	Lake Area[(b)] (%)	Area[(a)] (km^2)	Lake Area[(b)] (%)
2007	29.4	5.1	-[(d)]	-[(d)]	89	15.5	-[(d)]	-[(d)]
2008	112[(c)]	19.6	84.8	14.8	77.1	13.5	-[(e)]	-[(e)]
2009	53.5[(c)]	9.3	180	31.5	121	21.0	0	0
2010	23.8[(c)]	4.2	132[(c)]	23.1	88.5	15.5	52.3	9.1
2011	9.2[(c)]	1.6	213[(c)]	37.2	89.3	15.6	129	22.5
2012	3.6[(c)]	0.6	118	20.7	17.0	3.0	76.7	13.4
2013	80.6[(c)]	14.1	183[(c)]	31.9	129	22.6	355	62.1
2014	3.5[(c)]	0.6	≥229.6[(c)]	≥40.1[(f)]	≥242.8	≥42.4[(f)]	-[(g)]	-[(g)]
2015	<3.5[(h)]	<0.6[(h)]	≥242.8[(c)]	≥42.4[(f)]	59.0	10.3	<3.5[(h)]	<0.6[(h)]
2016	37.1	6.5	484.9	≥84.7[(i)]	250.4	43.7	2.9	0.5

a) Lake area reported is the greater of the area affected during the open-water or ice-cover season.
b) The lake area affected represents the percentage (%) of lake area experiencing levels greater than the normal range, and was calculated relative to the total surface area of Lac de Gras (573 km^2).
c) Lake area reported is for the ice-cover season.
d) Data not available due to field subsampling errors.
e) Data not available due to differences in sample collection procedures.
f) Percent lake area affected could not be estimated, because the far-field areas were not sampled.
g) Data not available due to the loss of the zooplankton samples.
h) The mean of the near-field area stations was within the normal range. Since only one or two near-field stations exceeded the normal range, the affected area was assumed to be less than the total area of the near-field area (0.6% of lake area).
i) Due to an uncertain effect boundary at the end of the MF3-FFB-FFA transect, the extent of effects could have been greater than the area presented.
% = percent; km^2 = square kilometres; <= less than; ≥ = greater than or equal to; - = not determined.

3.3.5 Sediment Quality

3.3.5.1 Baseline Sediment Quality

A description of baseline sediment quality in Lac de Gras was based on the following data sources:

- baseline programs initiated by DDMI, including the lake sediment quality baseline program conducted in 1996 and 1997 and the A154 and A418 dike baseline monitoring program conducted in 2000;
- sediment quality information collected as part of the 2001 AEMP (DDMI 2002), which occurred prior to initiation of Mine effluent discharge;

- a survey of sediments in the A154 dike area (EBA 2004a);
- a drilling program completed in March 2004 along the proposed alignment of the A418 dike (EBA 2004b);
- a survey of baseline sediment quality in the A21 dike area (DDMI 2008a); and,
- a study of lake sediments in the Coppermine River basin completed in summer 2000 (Peramaki and Stone 2005).

3.3.5.1.1 Sediment Quality in the Vicinity of the A154, A418 and A21 Dikes

3.3.5.1.1.1 Sediment in the A154 Dike Area

The dewatering of the A154 pit exposed an area of lakebed that previously could only be explored by drilling and sampling from the ice (EBA 2004a). An opportunity existed to gain knowledge from excavations in the drained lakebed. The investigation occurred in September, 2003. Results of the survey indicated that the matrix component of the glacial tills comprised relatively well-graded fine to coarse sands with 10% to 30% fines. These matrix soils supported varying gravel, cobble, and boulders and they typically showed no evidence of segregation at the bedrock contact. Particle size analyses showed that fines consisted of a very low proportion of clay size particulates and that much of the silt was quite coarse. All of the glacial tills observed contained principally subangular clasts.

The till and glaciofluvial units were capped by beach sands or low to non-plastic silts, which slump or deform easily with water. Boulder content was variable in the till, ranging from 10% to 20% by volume, with no trend of higher or lower boulder contents in any particular till unit. Boulders that were 1 m and larger in diameter were relatively few in number, whereas cobbles and small-diameter boulders (up to 300 mm diameter) were pervasive.

3.3.5.1.1.2 Sediment in the A418 Dike Area

Lakebed sediment was investigated in the area of the A418 dike before its construction. The investigation occurred in September, 2003. The sediment comprised poorly graded, grey or brown grey silt with a trace of sand to silty sand. Sandy silt was the most typical material. Particle size analyses indicated that the lakebed sediment comprised 76% to 88% silt, 5% to 15% sand, 5% to 7% clay, and 0% to 1% gravel (EBA 2004b). Most of the material recovered during drilling was wet, soft, sensitive, dilative (i.e., expands when wet), and low plastic (i.e., does not take much water to make the material slump or deform without an applied load).

The thicker deposits of lakebed sediment were generally found in the deeper sections of the lake or within depressions of the underlying glaciofluvial or granular till deposit. The organic content of the samples selected for testing ranged between 0.6% and 1.3% by weight. The upper surface of the lakebed sediment generally consisted of very soft to soft material (EBA 2004b).

3.3.5.1.1.3 Sediment in the A21 Dike Area

Sediment quality data were collected in the area of the A21 dike before construction, during the A21 dike baseline study, which occurred in August 2007 (DDMI 2008a). Sediments were collected along three transects near the A21 dike location. A reference transect was also sampled in a reference area (referred to as the “control area”), which was established during the A154 and A418 dike monitoring studies.

Bottom sediments in the vicinity of the A21 dike were typically dominated by silt and sand. The organic carbon content of sediments was low, ranging from 0.6% to 3.5%. Concentrations of sediment quality parameters were similar among stations with exception of elevated arsenic concentrations in the control area and along one of the three transects near the A21 dike. Cadmium and nickel concentrations were also elevated along the same transect near the A21 dike.

3.3.5.1.2 Sediment Quality in Lac de Gras

Sediment quality information collected by DDMI during the baseline period (1996 to 1999) and as part of the 2001 AEMP (DDMI 2002) were used to establish baseline sediment quality conditions in Lac de Gras. Samples were collected at locations in the near-field, mid-field and far-field areas of Lac de Gras. The sampling stations are presented in Figure 3-19.

3.3.5.1.3 Sediment Physical Characteristics

Sediment samples collected during the sediment baseline program were generally dominated by sand, with sand content varying from 44.6% to 71.3% (Table 3-9). Near-field and mid-field stations were similar in sand and silt content. Silt was the second most abundant grain size in near-field and mid-field samples, representing 33.4% to 43.3% of the samples, respectively (Table 3-9). Far-field stations were dominated by sand. Total organic carbon concentrations were low, ranging from 1.1% to 4.0% (Table 3-9).

Table 3-9 Sediment Physical Characteristics at Stations Sampled during the Sediment Quality Baseline Program

Year	Station	Depth (m)	Sand (wt%)	Silt (wt%)	Clay (wt%)	Clay/Silt (wt%)	TOC (wt%)
Near-field Area							
1996	N7-1	17.0	56.5	33.5	10.0	-	2.7
	N7-2	15.1	56.6	35.4	7.9	-	3.5
	N7-3	21.6	44.7	43.3	12.0	-	1.1
Mid-field Area							
1996	F14-1	19.2	44.6	33.4	21.9	-	1.8
	F14-2	20.0	46.6	39.4	13.9	-	3.0
	F14-3	22.5	44.6	39.5	15.9	-	2.6

Table 3-9 Sediment Physical Characteristics at Stations Sampled during the Sediment Quality Baseline Program (continued)

Year	Station	Depth (m)	Sand (wt%)	Silt (wt%)	Clay (wt%)	Clay/Silt (wt%)	TOC (wt%)
Far-field Area							
1997	WQ14-1	17.0	71.3	-	-	27.5	4.0
	WQ14-2	17.0	65.3	-	-	32.2	3.1
	WQ14-3	17.0	71.3	-	-	27.5	3.4

TOC = total organic carbon; m = metre; wt% = percent by weight; - = no data.

3.3.5.1.4 Sediment Chemistry

Bottom sediment chemistry in Lac de Gras is typical of sediment chemistry in other lakes in the Slave Geological Province (Puznicki 1996 in DDMI 2001b). Metal concentrations were generally similar among the near-field, mid-field and far-field stations (Table 3-10). Arsenic concentrations were greater in the near-field area (median of 49.8 milligrams per kilogram [mg/kg]) compared to the far-field area (median of 19.5 mg/kg) based on data from 1997 and 2000 (Table 3-10). Cadmium concentrations were lower in the near-field and mid-field areas (medians of 0.10 mg/kg and 0.17 mg/kg, respectively) compared to the far-field area (0.30 mg/kg). Nickel concentrations were greater in the far-field area (median of 56.4 mg/kg) than in the near-field and mid-field areas (medians of 33.15 mg/kg and 26.7 mg/kg, respectively). The concentration of TKN increased from the near-field area (median of 758.9 mg/kg) to the mid-field area (median of 1,363 mg/kg) (Table 3-10).

A study by Peramaki and Stone (2005) assessed concentrations of metals in sediment in four lakes from the Coppermine basin in summer of 2000, which included Lac de Gras. Sediment cores were collected at 15 locations in Lac de Gras. Cores were sectioned at 1 centimetre (cm) intervals in the top 10 cm and a 2 cm intervals below 10 cm. Each core fraction was dated using 210Pb and analyzed for total arsenic, copper, mercury and lead.

Data presented by Peramaki and Stone (2005) indicate that lake sediment represents a good indicator of the state of the Coppermine basin and can be used to evaluate historic trends of metal deposition. However, use of lake sediment as an environmental indicator has low sensitivity to change and coarse temporal resolution, due to low sedimentation rates in northern environments (Peramaki and Stone 2005). Concentrations of arsenic and copper in sediments were slightly higher at Lac de Gras compared to the other study lakes with mean concentrations of 264.9 mg/kg and 105.3 mg/kg, respectively for Lac de Gras (Peramaki and Stone 2005). Arsenic concentrations in Lac de Gras sediments increased at approximately the 5 cm layer (Figure 3-20). Concentrations of lead and copper were elevated compared to historic background levels, suggesting long-range atmospheric deposition (Peramaki and Stone 2005).

Table 3-10 Sediment Chemistry at Stations Sampled during the Sediment Quality Baseline Program

Analyte	Units (dry wt.)	Statistic	Near-field	Mid-field	Far-field
Aluminum	mg/kg	Median	14,600	13,900	13,400
		75 Percentile	16,425	16,850	16,600
		25 Percentile	12,400	11,800	12,250
		N	42	18	11
Arsenic	mg/kg	Median	49.8	32.5	19.5
		75 Percentile	140.5	71.58	26.55
		25 Percentile	17.15	16.6	14.7
		N	42	18	11
Cadmium	mg/kg	Median	0.1	0.17	0.3
		75 Percentile	0.18	0.23	0.47
		25 Percentile	0.1	0.09	0.17
		N	42	18	11
Chromium	mg/kg	Median	53.4	61.5	55.7
		75 Percentile	58.73	75.9	89.5
		25 Percentile	46.8	52.8	45.95
		N	42	18	11
Copper	mg/kg	Median	42.05	43.9	45.1
		75 Percentile	48.43	52.55	64.9
		25 Percentile	28.85	36.7	33.35
		N	42	18	11
Lead	mg/kg	Median	4.29	4.23	3.42
		75 Percentile	5.28	6.78	6.58
		25 Percentile	3.65	4.03	2.71
		N	42	18	11
Nickel	mg/kg	Median	33.15	26.7	56.4
		75 Percentile	42.38	59.95	73.8
		25 Percentile	22.13	19.9	52.55
		N	42	18	11

Table 3 10 Sediment Chemistry at Stations Sampled during the Sediment Quality Baseline Program

Analyte	Units (dry wt.)	Statistic	Near-field	Mid-field	Far-field
Zinc	mg/kg	Median	68	73.35	74.6
		75 Percentile	73.48	81.3	82
		25 Percentile	56.35	64.8	69.55
		N	42	18	11
Total phosphorus	mg/kg	Median	900	1,095	833
		75 Percentile	1,375	1,187.5	947.5
		25 Percentile	597.5	763	615
		N	12	18	11
Total Kjeldahl nitrogen	mg/kg	Median	758.9	1,363	-
		75 Percentile	931	1,615	-
		25 Percentile	358.9	1,175	-
		N	9	9	0
Total organic carbon	%	Median	1.31	1.76	1.68
		75 Percentile	2.33	2.01	3.27
		25 Percentile	0.85	1.38	1.6
		N	36	18	11

Source: DDMI 2001b.

mg/kg = milligrams per kilogram; % = percent; N = sample size; - = not collected.

3.3.5.2 Recent Monitoring of Sediment Quality

Sediment samples are collected as part of the AEMP to assess effects of the Mine on sediment quality in Lac de Gras and to provide supporting environmental information to help interpret findings from the AEMP benthic invertebrate survey. Monitoring of sediment quality under the AEMP has occurred annually from 2001 to 2010 and every third year thereafter (i.e., in 2013 and 2016). Sediment quality samples are analyzed for particle size (sand, silt, clay), TOC, nutrients (TN and phosphorus) and total metals.

Results of the 2016 AEMP sediment quality analysis indicate that nine variables (nitrogen, bismuth, lead, molybdenum, potassium, sodium, strontium, tin and uranium) had mean concentrations that were statistically greater in the near-field area compared to the far-field areas (Golder 2017). Of these nine variables, bismuth, lead and uranium had near-field area mean concentrations that were greater than the normal range for Lac de Gras.

Results of dike monitoring studies at the mine site have reported similar elevations of bismuth, lead and uranium in the vicinity of the A154 and A418 dikes. Sediment results indicated that effluent discharge is the most likely source of these metals in the exposure area, although other factors, such as dike construction and seepage from the dike may have also contributed to the observed pattern.

Compared to sediment quality guidelines and information in the primary literature, concentrations of bismuth, lead, and uranium encountered in exposure area sediments are considered unlikely to pose a toxicological risk to biota. Benthic invertebrates collected in Lac de Gras do not demonstrate toxicological effects as a result of exposure to constituents in sediment (Section 3.4.3).

Concentrations of several nutrients and metals in sediments in Lac de Gras were above sediment quality guidelines; however, variables that exceeded guidelines did so throughout the lake, and they reflected patterns in TOC content of bottom sediments and had no clear spatial trends related to the Mine.

3.4 Biological Environment

3.4.1 Overall Ecosystem

The Project area is located within the Southern Arctic Ecozone, as defined by Environment Canada and Agriculture Canada (Ecological Stratification Working Group [ESWG] 1995) (Figure 3-21). An ecozone is an area at the earth’s surface that is representative of large and very generalized ecological units characterized by various abiotic (climate, geology, soil) and biotic (plants, animals) factors. There are 15 terrestrial ecozones in Canada.

Hudson Bay splits the Southern Arctic Ecozone into east and west portions, with over 80% of the land area in the western portion. It covers northern mainland Canada from the Richardson Mountains in the Yukon to Ungava Bay in northern Quebec. It has the most extensive vegetation cover and greatest diversity of species of the three arctic ecozones identified by the ESWG.

Each ecozone is subdivided into ecoregions, which are characterized by distinctive regional ecological factors, including physiography, climate, soil, vegetation, water and wildlife (ESWG 1995). There are 217 terrestrial ecoregions in Canada. Lac de Gras and the Diavik Mine site are within the Takijuq Lake Upland Ecoregion of the Southern Arctic Ecozone.

Within the ecoregions are Ecodistricts, which are characterized by distinctive assemblages of relief, geology, landforms, soils, vegetation, water and fauna. There are 1,030 terrestrial Ecodistricts in Canada (ESWG 1995). The Diavik Mine falls within Ecodistrict 168 of the Takijuq Lake Upland Ecoregion.

3.4.2 Vegetation and Wildlife Habitat

The mine site is located in the tundra biome of the central Canadian Arctic, in an area described as the Low Arctic. This is the transitional zone between taiga and upper arctic tundra. The short growing season and cool soil and subsoil temperatures have limited soil development, which have in turn limited the establishment of productive or diverse plant communities. Plant community types vary between dwarf tree/shrub wetlands and wet sedge meadows, to drier, raised hummock grassland associations, and non-vascular (moss-lichen) plant communities associated with rock outcrops.

The heath tundra plant community is the dominant plant community present in the Lac de Gras area and represents the climax vegetation stage in the tundra biome. It covers most of the dry upland area at Lac de Gras. Sedge meadows less than 20 m in diameter are also very common in the Lac de Gras area. These communities develop on nearly level slopes or in shallow depressions in areas where water accumulates on silty or organic soil. Sedge meadows occur throughout the heath tundra, among boulder associations, in depressions in bedrock outcrops, or where water collects on organic soil.

All exposed boulders in the area that are not flooded by water are about 80% covered with lichens, while lichen coverage on exposed bedrock ranges from 5% on smooth rock that is highly exposed to the wind to 80% on protected faces. Crests of many of the islands and peninsulas are covered with an additional association called lichen veneer. This occurs mostly on gravelly surfaces where the snow layer is very thin in winter and where exposure creates an extremely harsh microclimate.

Shoreline vegetation cover varies depending on the soil or bedrock material present in the area, water depth and slope of shoreline. Most of the shoreline of Lac de Gras is covered by boulders and little emergent or submergent vegetation is present. Similarly, cobble to gravel shorelines do not support much vegetation since wave action and unstable substrates make it difficult for plants to survive. Silt and sand shorelines that occur in sheltered areas with gradual slopes support emergent vegetation such as sedges. Riparian shoreline shrub communities are found along the shorelines of islands or peninsulas extending out into Lac de Gras and sporadically along all shorelines of Lac de Gras. Shoreline shrub communities consist of dwarf birches and willows growing in slumped areas near the water's edge. Other less common vegetation communities associated with Lac de Gras shorelines are grass ridges, sedge meadows and heath tundra.

Specific vegetation communities on East Island include esker complexes, heath tundra, sedge associations, riparian associations, boulder associations and lichen veneer. Island riparian associations contain dwarf birches and willow, but do not contain alder and spruce, which are present on the mainland. As well, the understorey is slightly less diverse than on the mainland, likely due to the slightly harsher climate. In the immediate vicinity of the mine site, heath tundra is the most common association, followed by sedge meadows, boulder associations, esker complexes, bedrock associations, riparian associations, and lichen veneer.

No rare plant species were reported in the literature for past collections in the Lac de Gras area, as summarized in McJannet et al. (1995). In addition, no rare plant species were found at any of the sites examined during the baseline study.

Vegetation and habitat availability for wildlife were anticipated to be reduced directly by disturbance from the Mine footprint. In the Environmental Effects Report (EER), direct disturbance to vegetation from the Mine footprint was predicted to be 11.6 km^2 (DDMI 1998d). Currently, the expected area of the Mine footprint is 12.7 km^2, which is due to a change in shape and spatial extent of the mine site.

3.4.3 Aquatic Biota and Habitat

Lac de Gras is classified as oligotrophic based on nutrient levels in lake water (Section 3.3.4.1). Generally, Lac de Gras supports marginal growth of aquatic plants (DDMI 1998c). The main areas where aquatic plants can be found include a small, isolated area between the East and West Islands and the unique, riverine habitat present between Lac de Gras and Lac du Sauvage, referred to as the Narrows.

Most of the energy required by aquatic organisms in the lake comes from algal production. Phytoplankton growth is highly seasonal and is dependent on light availability, nutrient levels and grazing by zooplankton. In the spring, algae begin to multiply under the ice and typically undergo dramatic changes in standing stock through the short Arctic summer. Phytoplankton production is essentially zero during the winter, when the light level under the thick ice cover of Arctic lakes is too low to support algal growth.

The phytoplankton community in Lac de Gras is typical of other oligotrophic lakes at northern latitudes. The species of algae present are largely motile, nanoplanktonic (i.e., very small) forms. The community is dominated by relatively few taxa, compared to more southern waterbodies, and typically includes members of the families Chrysophyceae (golden-brown algae) and Chlorophyceae (green algae) and the Cyanobacteria (blue-green algae) (DDMI 1998c).

Lac de Gras supports a zooplankton community that is typical of northern lakes in that it is dominated by several key species. Members of the phylum Rotifera (rotifers) are dominant in terms of abundance, but account for a small proportion of total zooplankton biomass. The crustacean suborder Cladocera and class Copepoda are present at lower abundances, but account for most of the zooplankton biomass.

Plankton has been included as a monitoring component under the AEMP since 2002 (Golder 2014a). Samples are collected annually to determine if the Mine discharge to Lac de Gras has resulted in changes in phytoplankton and zooplankton communities. Increased concentrations of nutrients (Section 3.3.4.2) are linked to increased primary production, which may also lead to a change in plankton community composition (Golder 2014a).

The 2016 AEMP represents the most recent analysis of the plankton community data in Lac de Gras (Golder 2017). The phytoplankton community in Lac de Gras continues to exhibit a Mine-related nutrient enrichment effect, which has been observed since 2007. Analysis of the 2016 zooplankton data suggests that zooplankton biomass in the near-field area of Lac de Gras is lower compared to the far-field areas of Lac de Gras. In addition, zooplankton community composition differed between the near-field and far-field areas.

Benthic invertebrates are small animals such as insect larvae, worms, clams and crustaceans that live on the bottom of lakes. These organisms feed on a variety of materials, including algae growing on rocks, decaying algae and zooplankton that sink to the bottom, and other benthic invertebrates. Benthic invertebrate abundance can vary considerably among seasons. The abundance of these organisms is controlled by several factors such as food availability, feeding by fish and life cycle processes. The dominant members of this group in Arctic lakes are typically chironomid midge larvae, which emerge from the lake as winged adults once their larval life stage is complete (DDMI 1998c).

The benthic community of Lac de Gras is characterized by low density and few species. This reflects low nutrient levels and water temperature, a short season of primary production and the lack of a well-developed littoral zone, and low TOC content of bottom sediments. Invertebrate density varies considerably among different areas of the lake, suggesting a patchy distribution on the lake bottom. The benthic community is dominated by chironomid midge larvae, which are represented largely by a few common genera, including *Procladius, Micropsectra, and Heterotrissocladius,* and small larvae in the subfamily Orthocladiinae, which could not be identified to a lower level. Other common invertebrates include nematode worms, small clams in the family Pisidiidae, oligochaete worms, ostracods and aquatic mites (DDMI 1998c).

Benthic invertebrate monitoring is conducted every three years in Lac de Gras as part of the AEMP. The objective of the AEMP benthic invertebrate survey is to determine whether the benthic invertebrate community of Lac de Gras is affected by effluent discharged from the Mine.

The 2016 AEMP benthic invertebrate survey results suggest that the benthic invertebrate community in Lac de Gras is exhibiting a Mine-related nutrient enrichment effect (Golder 2017). This assessment is based on an observed increase in total invertebrate density and the densities of two common taxa (*Procladius* and *Micropsectra*) in the near-field area compared to the far-field areas. As well, the percentage of chironomid midge larvae was greater in the near-field area compared to the far-field areas. These findings are consistent with the results of previous benthic invertebrate surveys in Lac de Gras and were first encountered in 2008. Results of the most recent temporal analysis of trends for benthic invertebrates (Golder 2016a) do not suggest any consistent changes are occurring within the Lac de Gras community over time.

3.4.4 Fish and Fish Habitat

The fish community in Lac de Gras consists of eight species, which are present in variable abundance. These species include Lake Trout (*Salvelinus namaycush*), Cisco (*Coregonus artedii*), Round Whitefish (*Prosopium cylindraceum*), Arctic Grayling (*Thymallus arcticus*), Burbot (*Lota lota*), Slimy Sculpin (*Cottus cognatus*), Longnose Sucker (*Catostomus catostomus*) and Northern Pike (*Esox lucius*). The community in general is stable and slow growing and is characteristic of the cold, nutrient-poor status of Lac de Gras. Despite the low productivity of the lake, the biomass of fish is high (DDMI 1998c). This is due largely to the long life of the species present. The presence of a substantial fish community under nutrient-poor conditions is representative of the incremental accumulation of low annual production over many years (DDMI 2007).

Shorelines of Lac de Gras are covered by boulders which make the shorelines vary from unsuitable to moderately suitable for fish spawning, nursery/rearing, and foraging activities. The bottom of Lac de Gras is uneven and shallow shoals (1 to 10 m deep) are prevalent throughout open areas of the lake. Shoals in Lac de Gras provide fair to good quality spawning habitat for Lake Trout and Cisco.

The shorelines of the inland lakes are dominated by boulders. Fish species found in the inland lakes on East Island include Lake Trout, Round Whitefish, Cisco, Lake Whitefish, Lake Chub and Longnose Sucker. Of the 11 inland lakes surveyed on East Island, one is of high importance to the maintenance of inland lake fisheries, two are of moderate importance, and five are of low importance to inland lake fisheries (DDMI 2007).

No sentinel fish species were observed in any of the streams originating from East Island during the baseline period. This is likely due to the ephemeral nature of the streams on the island. Even during spring melt, the flow in streams on East Island is dispersed through sedge meadows with no distinct channel.

3.4.4.1 Fish Habitat Evaluations

3.4.4.1.1 Evaluation of Shoreline Habitat

Detailed habitat maps were drawn in 1996 for the shorelines in Lac de Gras to classify shoreline fisheries habitat (Golder 1997g,h). Two study areas were used: an intensive study area and an extensive study area. The intensive study area encompassed 100 km of Lac de Gras shoreline, which included 32 km of East Island shoreline, 39 km of West Island shoreline and approximately 30 km of shoreline along the mainland east of the Project site.

The extensive study area included 700 km of Lac de Gras shoreline outside the intensive area. The shoreline habitat key map (Figure 3-22) summarizes information from 15 more detailed habitat maps; the detailed habitat maps can be found in Golder (1997g,h).

For the intensive and extensive areas of Lac de Gras, shorelines were classified into five habitat types:

1. Boulder ledge at shoreline; drop-off composed of boulders leading into sand and boulder patches.

2. Gravel ledge at shoreline, shifting to cobble, then boulders. Drop-off composed of boulders leading to mixed sand and boulders.

3. Bedrock outcrops surrounded by boulder and cobble leading to a mixture of large boulders and sand.

4. Mixture of boulders and sand.

4a. Boulders dominant over sand.

4b. Sand dominant over boulder.

5. Mixture of boulder, cobble and gravel. Elevated gravel mounds alternate through the other substrates in a linear, winding fashion.

Shorelines in the intensive and extensive study areas of Lac de Gras are dominated by boulders (Type 1). The next most common shoreline habitat in the study areas are bedrock outcrops surrounded by boulder and cobble leading to a mixture of large boulders and sand (Type 3). Sandy areas with some interspersed boulders (Type 4b) are the third most common shoreline habitat types in the study areas.

Fish use of shoreline habitat types depends on both the specific habitat conditions present and the life history strategy of individual species. Four primary activities include spawning, nursery activities, rearing and foraging. Boulder shorelines are the most abundant shoreline habitat type in Lac de Gras and are moderately suitable for Lake Trout spawning, nursery/rearing and foraging. However, they are poor to moderately suitable for the various activities of Round Whitefish, Cisco and Arctic Grayling. Bedrock outcrops surrounded by boulder and cobble leading to a mixture of large boulders and sand, the second most abundant shoreline habitat, are poorly suited for any of the four primary activities undertaken by the four sentinel species. Sandy areas with some interspersed boulders, the third most abundant shoreline habitat, range from unsuitable to poor as areas for the spawning and nursery activities of Lake Trout, Round Whitefish and Cisco. However, these areas are good rearing areas for Round Whitefish and Cisco. Sandy areas are also poor to moderately suitable for foraging by the four sentinel species.

3.4.4.1.2 Evaluation of Shoal Habitat Quality

Three of the four sentinel species, specifically Lake Trout, Cisco and Round Whitefish, spawn in lakes. Shoals in lakes can be characterized as good, fair, poor or unsuitable spawning habitat for the three sentinel species depending on the degree to which characteristics of a given shoal match the spawning criteria. Maps summarizing shoal habitat for Lake Trout, Cisco and Round Whitefish throughout the RSA can be found in Golder (1997i).

The intensive study area of Lac de Gras has a slightly higher incidence of good and fair-quality shoals for Lake Trout (55%) and Cisco (62%) compared with the extensive study area (48% and 58%, respectively). In contrast, potential spawning habitat for Round Whitefish occurs more frequently in the extensive rather than intensive study area of Lac de Gras (39% and 23%, respectively).

Based on the number of good and fair-quality shoals, Lac de Gras has a higher occurrence of potential spawning habitat on shoals compared to Lac du Sauvage. Approximately 52% and 61% of the shoals in Lac de Gras displayed the characteristics required to support Lake Trout and Cisco spawning activity, respectively, whereas 43% of the shoals in Lac du Sauvage would provide potential spawning habitat.

3.4.4.1.3 Recent Monitoring of Fish Health and Tissue Chemistry

Monitoring of indices of fish health and tissue concentrations occurs every three years as part of the AEMP (Golder 2014a). The goal of the fish component is to evaluate potential changes and effects in both the health and tissue chemistry of Slimy Sculpin and the mercury concentration in Lake Trout. These fish have been monitored in Lac de Gras since 2007.

Significant differences have been encountered in some Slimy Sculpin traits between the fish exposed to Mine effluent and those in the far-field areas, which were previously used as reference areas for Lac de Gras, but there has been no consistent trend in these differences among years. In 2007, there were few differences observed (DDMI 2008b). In 2010, differences were found that suggested that the fish were responding to nutrient enrichment (DDMI 2011b). In 2013 and 2016, the observed effects were consistent with a toxicological response (Golder 2014b, 2017). This response is not the same as that seen in previous years, and no constituents were measured in water or fish tissue that would indicate an effect of the Mine (Golder 2015b).

Concentrations of bismuth, lead, strontium and uranium have consistently been elevated in Slimy Sculpin in the exposure area and concentrations of bismuth, strontium and uranium have increased above the normal range in recent years. The concentrations of these metals in water are consistently below guideline values. Mercury in Lake Trout has increased over time in Lac de Gras; however, a similar increase has also been observed in Lake Trout captured in Lac du Sauvage.

3.4.5 Wildlife

Mammals that reside in the Lac de Gras region year-round are generally denning animals such as wolverine, grizzly bear, fox, ground squirrel and ermine that are able to seek shelter from the harsh winter conditions. Caribou migrate to their calving grounds in the spring, look for food and avoid predators and insects during the summer through autumn and then typically move to forested areas during the winter. Wolves follow the caribou to the treeline.

Ground squirrels and lemmings are widely distributed on the islands of Lac de Gras and on the mainland. In contrast, Arctic hare abundance is greater on the islands than on the mainland. Grizzly bear, wolverine and wolf regularly travel, hunt and forage on the East and West Islands and east mainland. Fox den on the islands and are often sighted near the Diavik site.

Only two bird species (ptarmigan and raven) reside year-round in the vicinity of the mine site due to the scarcity of food during the long winter. However, many bird species migrate into the Lac de Gras area to take advantage of the productive, yet brief, warm summer.

3.4.5.1 Caribou

In 1996, the population size of the Bathurst caribou herd was estimated at 349,000 ± 95,000 with periodic changes in seasonal migration routes and winter range (Case et al. 1996; Gunn et al. 1997). Population surveys undertaken every three years since 2003 have shown a steep decline in the Bathurst caribou population size. The estimated population size was 186,000 in 2003, 128,000 in 2006, 32,000 in 2009, 35,000 in 2012 and approximately 16,000 to 22,000 in 2015 (ENR 2016a). Caribou move through the study area during the northern migration to the calving grounds near Bathurst Inlet, and during the subsequent post-calving migration to the wintering grounds below the tree line (Figure 3-23). Individuals from the Ahiak herd may also migrate through or overwinter near the southern portion of the RSA. The Bathurst and Ahiak herds are listed as “Threatened” by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2016). They are currently “Under Consideration” for listing under the Federal *Species at Risk Act* (SARA) (SARA 2016) and their general status in the NWT is considered “Sensitive” (ENR 2016b). They are scheduled to be re-assessed in 2017.

Up to 100,000 caribou have been observed in the RSA during the spring migration. Large waterbodies such as Lac de Gras have an influence on local caribou migration patterns. Spring migration movements across the ice on Lac de Gras tend to be towards nearest points of land including East Island and West Island. In the fall when return movements from the north are often deflected by Lac de Gras, caribou seek the easiest route to by-pass the lake. Occasionally this takes caribou onto East Island and West Island before they return to the north mainland and are deflected either east or west around Lac de Gras.

The Lac de Gras area lies within the broad spring migration, summer return and fall movement corridors of the Bathurst caribou herd (Figures 3-24, 3-25 and 3-26). The timing, duration and abundance of caribou movements in the Lac de Gras area vary among years in response to variables such as weather, insect harassment, winter ranges used in that year, calving and post-calving distributions and unpredictability of caribou movements.
The variability of caribou movements and use of different parts of their range between years has been emphasized by Case et al. (1996) and Urquhart (1981). Therefore, spring migration and summer return and fall movements were examined from fall 1995 through the summer of 1997, to gain perspective on year-to-year variation. As well, caribou that were fitted with satellite radio-collars, as part of the West Kitikmeot Slave Study regional study, were traced from satellite data and through density-association surveys of collared cows while they were in the study area.

Construction and operation of the Diavik Mine was predicted to cause a ZOI for caribou around the mine site. It was predicted that caribou would tend to avoid the mine site and area around it for 3 to 7 km (DDMI 1998c). Results of aerial survey and satellite collar monitoring data have suggested that the ZOI may actually range from 11 to 14 km (Boulanger et al. 2012). The larger ZOI means a reduction in suitability of caribou habitat within the ZOI area. The affected habitat areas increased from 3.45% to 12.3% of the LSA, and from 0.14% to 2.6% in the RSA. The size of the ZOI is expected to be proportional to the level of activity at the mine site. As activity during post-closure decreases, it is expected that the ZOI will also decrease. This hypothesis will be evaluated over the next 10 years as mining activity reduces.

Recent data from satellite-collared caribou indicate that during the northern migration, all collared caribou traveled west of Lac de Gras, which supports the prediction in the EER. These results are also consistent with the long-term patterns observed since 1996 and further support the observation that the northern migration route of Bathurst caribou relative to the west and east side of Lac de Gras is influenced by their location on the winter range (Golder 2011).

During the southern migration in 2015, most satellite-collared caribou remained well north of the study area from July to November 30. By the end of November, two collared females moved west and the remaining caribou moved east of Lac de Gras. The results in 2015 are inconsistent with the prediction in the EER of eastern movement of caribou around Lac de Gras during the southern migration. However, the 2011 comprehensive analysis and subsequent annual Wildlife Monitoring Program (WMP) reports indicated that from 2002 to 2014 the majority of collared caribou traveled adjacent to or through the southeast corner of the study area (Golder 2011, 2012, 2013, 2014c, 2015c). This provides general support for the prediction in the EER.

The most recent comprehensive report indicated that from 2009 to 2013, collared caribou females from the Bathurst herd have remained further north than historically recorded and have arrived in the Lac de Gras area later in the year (Golder 2014c). Caribou are considered sensitive to disturbance during the post-calving period because calves are maturing and still dependent on maternal cows. A northern shift during the post-calving period may be associated with a reduction in encounter rates with industrial activities in the Slave Geological Province and lower energetic costs for females and calves from human-related disturbance (Golder 2014c).

A single incident of direct Mine-related caribou mortality has occurred at the mine site since 1996. This suggests that current operations at the Mine are not influencing the population demography of caribou, and provide support for the prediction made in the EER. Caribou advisory signs are posted on all haul roads to protect caribou migrating near the mine site. Caribou, and other wildlife, have the right of way. DDMI's environmental team also conducts routine caribou monitoring with the assistance of elders from local Aboriginal communities.

3.4.5.2 Grizzly Bear

Barren-ground grizzly bears in the Slave Geological Province have the largest annual home ranges and likely the lowest density of any grizzly bear population in North America (McLoughlin et al. 1999). Visual locations of radio-collared grizzly bears and sightings of un-collared bears were used during the baseline monitoring period to identify sites for the investigations of bear habitat use (McLoughlin et al. 1997) (Figure 3-27). It is believed that the large home ranges of grizzly bears in the Slave Geological Province are correlated with the relatively low productivity of habitat available to bears on the barren-grounds compared to coastal or alpine areas. Although the population of grizzly bears in the Slave Geological Province appears to be currently stable or slightly increasing, any increase in mortality may place the population at risk (McLoughlin et al. 2003). The western population is listed as a species of “Special Concern” under COSEWIC (COSEWIC 2016) with “No Status” under SARA (SARA 2016). Their general status in the NWT is considered “Sensitive” (ENR 2016b).

Relative to pre-development conditions, monitoring results have indicated that direct and indirect (sensory disturbance) seasonal habitat loss for both male and female grizzly bears in the LSA and RSA has been negligible. Thus, the level of effects predicted prior to development is similar to the levels observed during monitoring (DDMI 2009a).

Monitoring results indicate that direct Mine-related mortality of grizzly bears has been low (DDMI 2009b). Currently, direct Mine-related bear deaths per year is 0.06, which is below the range of 0.12 to 0.24 predicted in the EER (Golder 2016b). The results suggest that current operations at the Mine are not influencing the population persistence of grizzly bears, and provide support for the prediction made in the EER (DDMI 2009a).

Diavik no longer has a regional Mine-related effects monitoring program related to grizzly bears. This was agreed upon by stakeholders in the 2013 Grizzly Bear Workshop (GNWT 2013).

3.4.5.3 Wolf

Wolves on migratory caribou ranges in the NWT generally prefer to den near the treeline where access to caribou during the summer is more reliable. The Lac de Gras area, which is about 50 to 100 km north of the treeline, appears to be within the zone of regular and abundant denning by wolves. In 1996 and 1997, 38 wolf denning sites were identified in the esker and intensive den search area (Figure 3-28). Many other wolf denning sites have been reported within the area north of Lac de Gras (Banci and Moore 1997; BHP Diamonds Inc. 1995; Mueller 1995). Detailed information on regional distribution of wolf dens, denning activities and litter sizes of wolves is described in the baseline report (Penner and Associates 1997a).

All wolf dens identified were located in glaciofluvial materials. About half the dens were associated with esker systems (48%) and half were located in discontinuous glaciofluvial deposits (52%). Dens associated with eskers were more often located on terraces, side deposits or esker ends than on the main body of prominent, continuous eskers. Most denning sites were characterized as low mounds of exposed soils and a variable amount of vegetation cover dominated by grasses (32%), dwarf birch (13%) and crowberry (6%). Fox burrows were associated with about half the denning sites and most denning sites had ground squirrel burrows. Detailed information on den site characteristics is available in Penner and Associates (1997b).

3.4.5.4 Wolverine

Wolverines are year-round residents in the Lac de Gras region (DDMI 1998c). Wolverine are listed as a species of “Special Concern” under COSEWIC (COSEWIC 2014) and currently are not listed under SARA (SARA 2016). Their general status in the NWT is considered “Sensitive” (ENR 2016b). Wolverine inhabiting the Arctic and sub-Arctic have large home range requirements and depend primarily on carrion, especially caribou, for food (Pasitschniak-Arts and Larivière 1995; Mulders 2000). Subsequently, populations generally exhibit low densities.

Monitoring data from snow track surveys near the mine site have indicated that wolverine track density has fluctuated annually and that wolverine have becomes less attracted to Diavik over time (Golder 2014d). The probability of wolverine track occurrence and distance to Diavik-Ekati complex was stronger in 2003, 2005, 2006, and 2009 than in other years. More recently, in 2011 and 2013, the relationship with distance to the Mine has become weaker (Golder 2014d). This suggests that mitigation, such as diligent management of food waste and preventing access to on-site denning is effective (Golder 2014d).

Results from a recent genetic hair sampling study indicated that there is a declining trend in wolverine population size in the study area from 2008 to 2014 (Golder 2015c). However, this decline may be explained by mortality or relocation of wolverine, as 27 wolverine were killed or relocated from the Lac de Gras region from 1998 and 2011 (Boulanger and Mulders 2013) and six of these occurred at the Diavik Mine. Overall, the monitoring results suggest that current operations at the Mine are not influencing the presence of wolverines in the study area and provide support for the prediction made in the EER (Golder 2014d).

Management of waste products through proper handling, storage, and disposal is an important mitigation measure for reducing effects on wildlife, particularly carnivores (DDMI 2009b). Diavik is committed to taking all the necessary steps so that the collection, storage, transportation and disposal of wastes generated at the mine site are conducted in a safe, efficient and environmentally compliant manner.

3.4.5.5 Raptors

Raptors were included in the WMP because they are considered valuable indicators of environmental change and occur in the RSA and LSA. Gyrfalcons and peregrine falcons are known to nest in the Lac de Gras region. The species status of gyrfalcons is currently not listed either in the NWT or federally. Peregrine falcons (anatum/tundrius complex) are listed as a species of “Special Concern” under COSEWIC (COSEWIC 2007). Their status in the NWT is considered “Sensitive” (ENR 2016b).

Results of recent monitoring of raptor nest occupancy and production indicate that changes to the presence and distribution of raptors related to the Mine are consistent with local-scale effects predicted in the EER, which predicted no changes to magnitude and duration within the LSA (Golder 2011; Coulton et al. 2013). At the scale of the RSA, results from monitoring suggest that the magnitude of effect predicted in the EER should be changed from low to moderate, and the expected ZOI increased from local to regional.

Only one raptor mortality has been reported at the mine site from construction through to current operations. In 2013, a peregrine falcon carcass was discovered and appeared to have three wounds. An investigation of the incident suggested that the peregrine falcon may have hit a power line. On three occasions (in 2004, 2012 and 2013) partially consumed carcasses of juvenile peregrine falcons were discovered, but whether their death was related to Mine activities or to predation could not be determined (Golder 2013, 2014c). The results indicate that mortality related to the Mine supports the prediction in the EER.

Analysis of Diavik and Ekati peregrine falcon and gyrfalcon nest data from 1998 to 2010 determined that sensory disturbance was not influencing nest occupancy and success (Coulton et al. 2013). Instead, the study concluded that the patterns of use and success were associated with the spatial distribution of nest site quality and the age of nest sites, respectively, in the study area and is consistent with findings of other long-term studies (Wightman and Fuller 2005). The results confirmed the decisions at the 2010 Diamond Mine Wildlife Monitoring Workshop that annual collection of raptor nest occupancy and success in the study area should be removed from the WMP and data collection should focus on mitigating effects to raptors nesting in open pits and on Mine infrastructure, and contribution to broader regional monitoring programs.

The revised impact predictions presented in Handley (2010) are to:

- determine nest site occupancy and productivity of historic peregrine falcon nest sites in the study area to contribute to the Canadian Peregrine Falcon Survey (CPFS);
- determine if pit walls or other infrastructure are utilized as nesting sites for raptors;
- determine nest success in areas of development and document effectiveness of deterrent efforts; and
- document and determine the cause of direct Mine-related mortalities of raptors.

Beginning in 2015, monitoring of raptor occupancy and production within the RSA will be completed as part of the CPFS. The revised impact predictions for raptors have been incorporated into the annual WMP and results are reported in the annual reports.

3.4.5.6 Waterfowl and Shorebirds

Many waterfowl (ducks, geese, swans, and loons) and shorebird (sandpipers and plovers) species use the Lac de Gras area for feeding, reproduction, and/or staging during migrations. A number of habitats surrounding East Island were identified as important for waterfowl and shorebirds including shallow bays, melt water ponds, mudflats and shorelines (DDMI 1998c). Two species of waterfowl and shorebird that occur in the Lac de Gras area are currently listed in the NWT or federal status reports: red-necked phalarope (*Phalaropus lobatus*) and horned grebe (*Podiceps auritus*) are both listed as species of “Special Concern” under COSEWIC (2014, 2009). Both species have a general status rank in the NWT of “Sensitive” (ENR 2016b). Recent monitoring has indicated that the cumulative loss of shallow and deep water habitats is currently 0.37 km^2 and 2.16 km^2, respectively. Thus, direct habitat loss is 2.53 km^2, which is 35.7% less than the 3.94 km^2 loss of habitat predicted in the EER (Golder 2016b).

Mine activities appear to have had a negligible influence on waterfowl and shorebird communities on East Island based on monitoring annual changes in species richness (DDMI 2009a). There was little variation in species richness of waterbirds from 1996 to 2013 at the East and West bays. Sixteen species of shorebirds and 24 species of waterfowl have been encountered. Overall, the results suggest that Mine activities have had a negligible effect on waterfowl and shorebird communities in the East and West bays, which is consistent with the impact prediction in the EER. The construction and alteration of various waterbodies was part of the design of the Mine and necessary for operations and footprint runoff catchment. It was anticipated that waterbirds might use these waterbodies due to the potential that they would provide useable habitat earlier in the season than the surrounding waters of Lac de Gras. This was expected because the presence of surface dust or warm water discharge at Mine-altered waterbodies might advance spring thaw.

Annual comparisons of relative abundance of waterbirds among waterbody types has indicated that diving ducks show the strongest pattern of use of Mine-altered waterbodies, whereas shorebirds prefer shallow bays (DDMI 2009b). Patterns of all other waterbirds either varied annually or showed no preference. Possible explanations for these patterns are that Mine-altered waterbodies have deeper water and shoreline features that are more suitable for nesting diving ducks, while the East and West bays have more extensive vegetation and shallow water areas suitable for feeding and nesting by shorebirds. Overall, the results indicate that waterbirds are using Mine-altered waterbodies, which supports the prediction in the EER.

Direct Mine-related mortality of waterfowl occurred in 2002 and in 2006 when five and one red-throated loons, respectively, became entangled in a gill net and drowned during fish out activities (DDMI 2009b). In 2006, an unidentified species of duck died after it collided with a haul truck (DDMI 2009b). Since 2009, no waterfowl or shorebird mortalities have been reported. Collectively, these mortalities result in a Mine-related mortality rate of 0.38 individuals per year, which is consistent with that predicted in the EER.

In 2013, Diavik consulted with Environment Canada about whether monitoring of bird species abundance and diversity at the East and West bays should be continued given the negligible effects observed to date (Golder 2014c). Environment Canada approved Diavik’s proposal to discontinue monitoring activities at the East and West bays (DDMI 2014). Diavik will continue to monitor health risks to water birds at Mine-altered waterbodies.

3.5 Social (Human) Environment

Land use in the region includes very limited hunting and fishing by northern communities; natural resource exploration and development, consisting mostly of diamond and gold recovery, with some base metal exploration; and recreation, consisting of several outfitting camps located in the area.

3.5.1 Recent and Traditional Land Use

Aboriginal people have used the Lac de Gras area for many centuries. First use of the area may have been by the Taltheili Tradition, ancestors of the modern Dené, about 2,500 years ago. The area has and is currently used by the Tlicho, Yellowknives Dené First Nation, Lutsel K’e Dené First Nation, Inuit, North Slave Métis and others to hunt caribou, fish and trap for furs.

The Slave Geological Province is an area of increased mineral exploration and development. In 1996, there were about 65 exploration activities in the Slave Province (EMPR 1995). Most of the past and present gold operations in the NWT are also located within this area (e.g., Lupin, Colomac, Giant, Con, and Ptarmigan). Major exploration and development projects in the Central Arctic are shown in Figure 3-10.

The Tibbett Lake to Contwoyto Lake winter road is the primary winter (ice) road that traverses the RSA. Echo Bay Mines originally established this road in 1983 to provide transportation to the Lupin Mine at Contwoyto Lake. The road is typically open from January to March with an average of 70 “open” days during that period. The primary consideration that determines dates of road opening and closure is ice thickness. In addition to DDMI, BHPB and DeBeers Mining Canada Inc. use the road to transport equipment and supplies. Other exploration companies, outfitters and resident hunters also use the road to access the Lac de Gras area.

Several outfitting operations conduct seasonal sport hunting, fishing and wildlife observation excursions within and around the Lac de Gras area. Sports hunting outfitters have camps located on northeast shore of Lac de Gras, and nearby on Contwoyto, Point, Courageous, Clinton-Colden, Desteffany, Jolly and MacKay lakes. Licenced canoeing/rafting outfitters offer trips of varying length and duration on the Coppermine River system. Most trips start at points downstream from Lac de Gras, but some start at the west end of the lake and cover the entire river system.

3.5.2 Archaeological and Cultural Sites

During the baseline study, 195 archaeological sites were identified in the RSA (Figure 3-29). These sites consisted of 17 isolated finds, 71 artifact scatters, 96 quarries, 7 campsites, 1 meat cache, 1 burial, 1 site consisting of wooden poles and 1 stone marker identified as a burial by the Yellowknives Dené. Of these sites, 66 occurred on the mainland, 1 occurred on a small island adjacent to the northern mainland, 21 occurred on West Island and 107 occurred on East Island.

The site types present in the LSA included three isolated finds, 14 artifact scatters and 40 quarries. Of these 57 sites in conflict with the proposed Project footprint, 21 (about 37%) were associated with scientific heritage values. With the assistance of Aboriginal groups, these sites were further examined and documented in the summer of 1998.

3.5.3 Protected and Heritage Sites

Eleven proposed protected areas or significant conservation-sites have been identified within the Slave Geological Province. These consist of one tribal park proposed by the Yellowknives Dené First Nation, three International Biological Program sites, and 10 areas identified by World Wildlife Fund (WWF). The Diavik Mine site is near the proposed tribal park, a corridor extending south-westward from the MacKay Lake area to the Gordon Lake area. The Diavik Mine site is also within an area identified by the WWF as having high conservation interest. The proposed tribal park and the WWF site overlap. Important biological features include main and sub-watershed divides, and forest-tundra transition areas (WWF 1996).

One hundred and thirty-four heritage resource sites have been identified on East Island and West Island combined. Of these, 61% are located where exposed quartz veins were used by first nations to obtain material for tool manufacture. They occur almost exclusively on elevated areas in the central and southern portion of East Island. Thirty-two percent of the sites are either scatters of stone tool manufacturing debris or isolated artifacts where a single episode of tool manufacture or use took place. Generally, these manufacturing sites are concentrated around the central valley and near interior lakes on East Island, or on elevated landforms around the central wetland on West Island. The remaining 7% comprise more unique sites, including eight campsites, two with hearth structures, and a stone trap marker. Of these, only the two sites with hearths are considered significant enough to warrant avoidance and would be considered special.

4 Project Description

4.1 Location and Access

The Diavik Diamond Mine is located on East Island, a 17 km^2 island in Lac de Gras, NWT, approximately 300 km northeast of Yellowknife (64º31’ North, 110º 20’ West) (Figure 2-1). The area is remote, and major freight is trucked over a seasonal winter road from Yellowknife. Worker access is by aircraft.

The Diavik Diamond Mine involves mining four diamond-bearing kimberlite pipes. The pipes, designated as A154N, A154S, A418 and A21, are located directly off shore of East Island (Figure 2-2). All mining, diamond recovery, support activities and infrastructure are located on the East Island.

In total, the mine site at full development was expected to have a footprint of 12.76 km^2. The current footprint is 10.56 km^2.

4.2 Site History

The Diavik Diamond Mine is an unincorporated joint venture established by DDMI and Dominion Diamond Diavik Limited Partnerships (Dominion) to develop a diamond mine at Lac de Gras, in the NWT, Canada.

DDMI is a wholly owned subsidiary of Rio Tinto plc of London, England, and Dominion Diamond Diavik Limited Partnership is controlled by Dominion Diamond Corporation. Under the Joint Venture Agreement, DDMI has a 60% participating interest in the Project and Dominion a 40% participating interest. DDMI has been appointed Manager and is the corporate entity responsible for conducting Project activities.

Aber Resources Ltd. began staking mineral claims in the Lac de Gras area of the Mackenzie Mining District, NWT, in November 1991. Through an option agreement dated June 1, 1992, Kennecott Canada Inc. (“Kennecott”) acquired the right to earn a 60% Joint Venture interest in the Diavik claim blocks of Aber Resources Ltd. Kennecott exercised its rights under the option agreement following the discovery of the four diamond-bearing kimberlite pipes immediately off the eastern shore of East Island. The Joint Venture was consummated on March 23, 1995, with Kennecott initially appointed as Manager. Kennecott assigned its rights and interests to DDMI on November 29, 1996. Aber Resources Ltd. assigned its rights and interests to Aber Diamond Mines Ltd. on January 30, 1998. On November 9, 2007, Aber Diamond Corporation changed its name to Harry Winston Diamond Corporation reflecting the re-branding of the company and subsequently became Dominion Diamond Corporation (DDC).

On the basis of a Feasibility Study completed in July 1999, DDMI and now DDC began actively proceeding with implementation of the Project. The Diavik Diamonds Project Environmental Agreement documents were formally submitted to the Federal Government in September 1998, and in early November 1999 the Federal Minister of the Environment approved the Diavik Diamonds Project for permitting and licensing. On March 8, 2000, the EA was signed and the Department of Indian Affairs and Northern Development (DIAND), now INAC, issued permits to allow DDMI to begin construction activities.

The Diavik Diamond Mine started production in January 2003 producing approximately 3.8 million carats in 2003. Full production began in 2004 with a production target of 7 to 8 million carats. It is expected that the mine will produce approximately 107 million carats of diamonds over a 16 to 22 year mine life.

A historical summary of Project milestones leading to the start of production is provided in Table 4-1.

Table 4-1 Project Milestones

Date	Milestone
1991 to 1992	Aber stakes mineral claims
March 1992	Exploration begins
June 1992	Aber Resources forms joint venture with Kennecott Canada Exploration
1994 to 1995	Pipes A21, A154N, A154S and A418 discovered
February 1996	75-person exploration camp erected on-site
July 1996	5,900 metric tonne bulk sampling of A418 and A154S pipes completed
November 1996	Diavik Diamond Mines Inc. created, with head office in Yellowknife
March 1997	Bulk sample transported over the winter road to Yellowknife for processing. Approximately 21,000 carats of diamonds discovered
June 1997	Environmental baseline studies completed
September 1997	Pre-feasibility study completed
March 1998	Project description submitted to Federal Government triggering formal environmental assessment review under *Canadian Environmental Assessment Act*
September 1998	Environmental Assessment Report submitted and Comprehensive Public Involvement Plan initiated
November 1999	Federal Government approves project for permitting and licensing
September 2000	All necessary permits and licenses required to bring mine into production received
December 2000	Investor approvals to build the mine received
January 2001	Mine construction begins
October 2001	Earthworks for the A154 dike completed
July 2002	A154 dike complete and dewatering begins
December 2002	Mine infrastructure construction virtually complete
January 2003	Start of diamond production

4.3 Site Geology

The Lac de Gras RSA is located in the central part of the Slave Geological Province of the Precambrian Shield.

The surface expression of East Island is controlled by bedrock, with bedrock outcrops occurring over about 40% of the surface of the island. The bedrock geology of the island is dominated by granitic rock, with volcanic rocks such as diabase present as dikes in small proportions (Figure 3-9).

The Diavik diamond deposits occur as kimberlite pipes intruding in the granitic country rock located under Lac de Gras adjacent to East Island. Kimberlite ore is found in four pipes located under Lac de Gras just offshore of East Island; A154N and A154S (collectively identified as “A154”), A418 and A21 (Figure 2-2). The kimberlite pipes are the roots of relatively young volcanoes dated at approximately 55 million years old. The host rocks are ancient Precambrian granites and metamorphosed sedimentary rocks that are approximately 2 billion years old. Material within the kimberlite pipes comprises three broad classes: hypabyssal kimberlite, volcanic and epiclastic kimberlite and xenoliths. Volumetrically the kimberlite pipes are dominated by volcaniclastic and epiclastic material, often with a significant xenolithic component. The hypabyssal phases are volumetrically less significant, occurring as feeders to the pipes at deeper levels and as contact intrusions along the pipe margins.

Glacial till is the dominant surficial material on East Island, and overlies most of the bedrock. Glaciofluvial deposits are in the form of eskers and kames, and are most common on the north end of the island. Glaciolacustrine deposits occur mainly in lowland areas, and organic deposits typically overlie glaciolacustrine deposits near the lake shore. Shallow (less than 1 m) organic deposits typically have large stones exposed at the surface.

All of the soils that have developed on East Island are cryosols which have been influenced by varying degrees of cryoturbation. There are also numerous solifluction lobes on East Island. These lobes typically occur on slopes ranging from 10% to 25%, although they may occur on slopes as shallow as 2%.

Lake bottom sediments consist of a layer of organic-rich lake silts and clays underlain by bouldery glacial till. The organic silts and clays vary in thickness from 5 to 8 m and the underlying till may reach a thickness of between 20 m and 30 m.

4.4 Mine Plan

A mine plan describes the method and sequence for extracting the kimberlite resource from the ground. A broad range of mining methods was initially evaluated including both conventional and non-conventional methods. Non-conventional methods included jet boring, raise boring, blind drilling and dredging. Conventional methods included open-pit and underground mining methods. DDMI did not advance any non-conventional mining methods beyond the initial studies because, in general, they were experimental and found to have an unacceptably high level of technical and economic risk to be used as the basis for a comprehensive mine plan.

Three options based on conventional mining approaches were developed:

- *All underground* – Mining would advance from underground only. Declines or shafts would be developed to gain access to underground workings. A layer of kimberlite (referred to as a crown pillar, about 100 m thick) would be left in the top of the kimberlite pipe to separate the underground workings from the water of Lac de Gras. Lac de Gras would be immediately above the active mine. Water retention dikes are not a part of this alternative.
- *Underground with open pit crown pillar* – Underground mining would advance the same way as Option 1. Additionally, open-pit mining would be used to mine to a depth of 100 m. Three water retention dikes would be constructed and water removed from the open-pit areas.
- *Open pit and underground* – Open-pit mining would be used to mine the kimberlite pipes to an elevation of 190 m (A418), 130 m for A154S, 265 m for A154N and 220 m for A21. At these depths it would become economical to shift to underground mining in A154S/N and A418. Three water retention dikes would be constructed and water removed from the open-pit areas.

One of the clear advantages with Option 1 was that dike construction in Lac de Gras would not be required. Option 1 would eliminate any effects on fish habitat and water quality associated with the dikes and their construction. However, because the health and safety of workers is of primary importance to DDMI, it was determined that it would be cost prohibitive and may not be technically possible to achieve a satisfactory level of safety for an all underground alternative without a dike.

Underground mining displaces less waste rock than open-pit mining. Although both Options 2 and 3 would require storage areas on the East Island for waste rock, the storage area for Option 2 would be less than Option 3.

Communities have consistently described the importance of using resources wisely. Whereas their comments usually referred to the use of land and water, concerns were also expressed about the use of mineral resources. Communities requested that if the natural environment of the East Island is to be disturbed to recover diamonds, that DDMI maximize resource recovery and not just take the best parts. Option 3 would be the alternative that comes closest to matching this community value.

From a diamond recovery perspective, Option 3 produces the most diamonds. Based on estimated capital, operating costs and the value of diamonds produced, it was determined that the mine would not be economically viable without water retention dikes and removal of water from above the crown pillar.

With the removal of the water, the most attractive method of mining was a larger open pit followed by underground mining in the later years. From an economic perspective, Option 3 was preferred because it resulted in the lowest overall operating cost per carat recovered and was therefore the most financially robust. Option 3 was clearly the preferred option based on health, safety, environment, community and business considerations.

The final decision from the EA was to proceed with Option 3, a mine plan that involved water retention dikes with open-pit mining and underground mining. It was noted that mine planning is an ongoing process and that alternate mining technologies should be re-evaluated periodically, including alternative or emerging technologies to recover currently uneconomic resources (Canada 1999). The Water License and Land Leases are based on dewatering a portion of Lac de Gras for the purpose of mining the A154 North and South, A418 and A21 kimberlite pipes, as per Option 3.

The current mine plan utilizes two open pits for initial access to the A154N, A154S and A418 kimberlite pipes, and then underground mining to access the lower portions of the kimberlite pipes. The A21 mine is currently under construction with first ore expected in 2018.

4.4.1 A154 and A418 Mine Plans

The diamondiferous kimberlite pipes in the current mine plan are located near the shoreline of East Island and are surrounded by granitic country rock. The proximity of the pipes to the surface allows for economic ore extraction by open-pit mining. At greater depths the ore will be mined by underground mining methods, subject to economics. A general layout of open pits and underground mine workings is presented in Figure 4-1.

To allow open pit and underground mining, two water retaining dikes were constructed in Lac de Gras: A154 dike; A418 dike (Figure 2-2). The A154 dike was completed in 2002 and encircles the A154N and A154S pipes. The second dike, A418, encircles the A418 pipe and was completed in 2006. Details of the A154 and A418 dike designs can be found in Nishi Khon-SNC Lavalin (NKSL) (1999) and NKSL (2004), respectively. The A21 dike is currently under construction with a completion date of December 2017.

Open-pit mining at the Diavik site involves drilling and blasting and uses conventional truck and shovel methods. The open pit excavations are separated from the toe of the dikes by an 80 - to 100-m-wide perimeter shelf. The pit bottom in A154 is 125 m elevation, about 290 m below lake level, and the planned pit bottom for A418 is 200 m elevation, about 215 m below lake level. Open-pit mining is complete in A154 and A418.

Underground mining plans are based on Underhand Cut and Fill (UCAF) methods for the A418 pipe and A154 south pipe, and a combination of UCAF and blast hole stopping in the A154N pipe. Mined stopes will be backfilled to enhance physical stability during operations and beyond closure. Underground mining is currently planned to an elevation of about 0 m. Current ore production is exclusively from underground mining.

To the end of 2016, 26.6 Million tonnes (Mt) of kimberlite have been mined from A154N/S and A418. Including A21 there remains some 16.3 Mt to be mined before the end of commercial production in 2025.

Underground facilities include maintenance shops and storage areas for fuels and lubricants. Primary underground equipment includes tunnelling machines, "load-haul-dump" vehicles, and drills. Kimberlite is transported to surface by the “load-haul-dump” trucks.

A water collection and pumping system collects water from precipitation and groundwater seepage, as well as groundwater collected from the drainage galleries that are used to dewater the rock mass ahead of mining. The collected water is pumped to the NI (see Section 4.4.5). Groundwater inflow and runoff estimates for the A418, A154 and A21 pits, as well as underground mining operations, are given in the Water Management Plan (DDMI 2016). Total flows are expected to peak at about 70,000 cubic metres per day (m^3/day) by 2021. The vast majority of this volume is groundwater collected from the drainage galleries and pit sumps. The estimated flow rates will be reviewed and updated as required based on monitoring results, findings of field investigations and mathematical modelling.

Existing and full development conditions for the A154 and A418 mine areas are also described in Section 5.2.1.

4.4.2 A21 Mine Plan

DDMI determined in 2014 that the A21 kimberlite pipe could be mined economically using a dike open-pit mining method. A21 dike construction commenced in July 2015. First ore is expected early in 2018. The A21 mine is expected to remove 27 Mt of Type I (non-potentially acid generating [non-PAG]) waste rock and 6 Mt of till to access 3.7 Mt of kimberlite. A separate South Country Rock and Till Storage area is being designed for the waste rock and till from A21. A pipeline has been constructed to carry up to 30,000 m^3/day of construction or operations water from A21 to the NI for treatment and discharge to Lac de Gras. The location of this mine is shown in Figure 2-2.

4.4.3 Waste Rock and Till Storage

The waste rock mined to access the kimberlite ore is generally granitic in nature with small amounts of pegmatite, diabase and biotite schist lithologies in the A154 and A418 host rock. The granite, pegmatite and diabase rocks which account for approximately 80% to 90% of the total rock mass are generally non-reactive with very low sulphur levels and adequate alkalinity to neutralize any potential reaction (see Section 3.3.3). Waste rock from A21 is tonalite (Type I) and non-PAG.

Waste rock and till from the A154 and A418 open pits is placed on the north side of the island in a designated storage area (Figure 2-2). Waste rock is segregated by sulphur content (Table 4-2).

Table 4-2 Waste Rock Classification

Waste Rock Classification	Criteria (Total Sulphur in wt%)	Description
Type I	<0.04 wt%S	• Predominantly granites • Considered non acid-generating ("clean") waste rock suitable for construction material
Type II	0.04 wt%S to 0.08 wt%S	• Granites with little biotite schist • Considered intermediate or mixed rock with low acid-generating potential
Type III	>0.08 wt%S	• Granites containing some amount of biotite schist • Considered potentially acid-generating

wt% = percent by weight; S = sulphur; >= greater than; < = less than.

A drainage collection system is in place around the NCRP and till area. Pond 1 is located on the southeast side and collects any runoff or seepage from the Type I rock and till area. Pond 3 is located on the southwest corner of the waste rock area and collects any runoff and seepage from the Type III rock placed in the southwest corner. Pond 2 on the northwest corner collects seepage and runoff from mixed Type I and Type II storage areas (Figure 2-2).

Type I rock is reserved for construction material including roads, laydowns most of the PKC dams and the A21 dike. Surplus Type I rock was placed in the NCRP. Currently Type I waste rock production from the underground mine development is less than required for ongoing construction (primarily due to A21 dike requirements). Shortfalls are re-mined from the NCRP. Type III rock was placed in the NCRP in designated drainage areas (Figure 5-8) with some used for the North PKC Dam construction and a small toe buttress underwater in the A21 dike. Currently Type III rock is used for underground backfill, North PKC Dam construction or if there is a temporary surplus, stored near the crusher for future underground backfill. The volume of Type II rock produced in the open pit was very low and is dumped within the Type III rock areas.

The estimated amounts of the waste rock and till that have or will be produced by the A154 and A418 open and underground mines to the end of 2015 are given in Table 4-3A.

Table 4-3A A154 and A418 Open Pit and Underground Till and Waste Rock Production to end of 2015

Year	Till (Mt)	Type I (Mt)	Type II (Mt)	Type III (Mt)	Total Tonnage (Mt)
2002	6.78	1.17	0.13	1.09	9.17
2003	5.64	6.76	2.25	10.87	25.52
2004	1.27	9.65	4.16	14.92	30.00
2005	0.00	11.88	2.33	12.90	27.11
2006	0.00	12.04	3.07	8.42	23.53
2007	4.29	10.88	2.20	5.27	22.64
2008	1.67	15.86	0.64	3.71	21.88
2009	0.00	16.26	1.11	5.99	23.36
2010	0.00	13.13	0.43	4.41	17.97
2011	0.00	4.37	0.00	4.28	9.01
2012	0.00	0.12	0.00	0.35	0.47
2013	0.00	0.14	0.00	0.25	0.39
2014	0.00	0.13	0.00	0.14	0.28
2015	0.00	0.08	0.00	0.27	0.35
Totals	19.7	102.8	16.3	72.9	211.7

a) 2011 and 2012 tonnages are from the most recent mine plan forecast.
Mt = Million tonnes (1 tonne = 1,000 kilograms).

At the completion of open-pit mining in July 2012 the waste rock and till areas were at the maximum size. The expected maximum elevation for the waste rock pile is around 500 m (about 85 m above the level of Lac de Gras). By 2012 the area contained about 140 Mt of waste rock and 4.5 Mt of till.

After July 2012 waste rock was only be produced from the underground operations. Total waste rock production from 2016 for the remainder of the underground mine life is estimated to be less than 5 Mt, with an estimated 40% Type I and 60% Type III.

Waste rock from the A21 open pit is all Type I material. The A21 mine is expected to remove 27 Mt of Type I (non-PAG) waste rock and 6 Mt of till. Once mining commences in A21 (2018) the rock and till produced will become the preferred source for ongoing construction and reclamation. Any surplus rock and till will be stored in a South Country Rock and Till Storage Area on the south part of the island in an area that is currently in the process of being finalized.

Table 4-3B provides current estimates of operational waste rock requirements from 2016 to the end of the mine life. Waste rock produced either A21 or underground would be used depending on timing and rock type required.

Currently the largest waste rock demand in operations is for A21 dike construction followed by cemented rock fill (CRF) to fill mining voids underground. Type III rock is suitable for CRF and is a preferred long term storage location for this potential ARD/ML material. Some Type III rock is also used in the PKC dam raise along the north dam where the dam abutment merges with the Type III area of the waste rock storage area. Any future PKC dam raises that cannot be constructed with Type III rock, would be constructed with A21 waste rock. Estimated operational needs for Type I and III waste rock from the NCRP or underground production are shown in Table 4-3B and include the A21 dike and feed for general site crushed rock. PKC dam requirements have not yet been determined.

Table 4-3B Estimated Operations Waste Rock Requirements 2012-2022

Area	Type I (Mt)	Type III (Mt)
A21 Construction (Aggregate)	2.6	0.0
A21 Construction (Run-of-mine)	1.3	0.0
Crusher Feed (Site Aggregate Products)	0.9	0
Underground Cemented Rock Fill	0.0	3.3
Total	**4.8**	**3.3**

Mt = million tonnes (1 tonne = 1,000 kilograms); PKC = processed kimberlite containment.

Type I waste rock and till have been identified as the primary materials required for mine closure. Cover designs for the PKC and the waste rock pile require significant quantities till and Type I. Table 4-3C provides the Type I quantities estimated for the PKC (Appendix X-5) and NCRP (Appendix X-4). It should be noted that the closure concepts have also identified smaller volume requirements of Type I rock for closure of the infrastructure area, fish habitat and collection pond reclamation. In addition, till has been identified as a possible soil material for re-vegetation and fish habitat. These concepts are still under review and as such firm quantity estimates have not been developed and so are not included in Table 4-3C.

Table 4-3C Estimated Waste Rock and Till Requirements for Closure Covers (INAC 2011)

Area	Type I (Mt)	Till (Mt)
Closure Cover - PKC	5.8	0.0
Closure Cover – NCRP	8.1	3.5
Total	**13.9**	**3.5**

Note Conversion factors: Rock = 2.04 t/m^3, Till = 1.77 t/m^3
Mt = million tonnes (1 tonne = 1,000 kilograms); PKC = processed kimberlite containment.

A21 waste rock will be source for Type I rock and till for the NCRP closure. It is planned to be direct hauled from the open-pit and placed as the NCRP cover. A21 will also likely be the source for Type I rock for PKC closure, however because the PKC facility will be active until the end of commercial production, it is not anticipated that much of the PKC cover can be placed with direct haul of A21 rock. Some re-mining will be required. A21 rock is also the preferred rock source for other closure activities discussed above but will be dependent upon timing, location and if other temporary Type I stockpiles need to be used.

The existing level of development and the expected maximum level of development of the waste rock and till storage area are described in the NCRP-WRSA Final Closure Plan (DDMI 2017).

4.4.4 Processed Kimberlite Containment

The diamonds make up about one part per million of the host kimberlite rock. After this small fraction of diamonds is removed, the kimberlite that was processed during ore recovery is placed in the PKC area (Figure 2-2). Constructed in a natural valley in the centre of East Island, the PKC area is an engineered containment area surrounded by dams on all sides. The PKC was designed to hold 42.5 Mt of processed kimberlite (PK). At the completion of mining, the PKC area will be approximately 1 km long by 1.3 km wide and contain PK up to 40 m thick.

The PK materials include a CPK fraction (10 mm to 1 mm particle sizes) and a FPK fraction (minus 1 mm particle sizes). The FPK is pumped as a slurry to the PKC and discharged from spigot points around the perimeter of the facility to form long beaches around a central pond. Coarse PK is deposited by truck in the southwest area of the PKC. Containment of the entire PKC area is provided primarily by perimeter dams. In addition to the low permeability diaphrams (combination of till and synthetic liners) in the dams, the cold arctic temperatures will result in long-term freezing of the FPK beaches and CPK, further limiting potential seepage.

To the end of 2016, 22.2 Mt of FPK and 5.2 Mt of CPK have been produced and placed within the PKC. By the end of the mine life it is expected that there will be a total of 28.6 Mt of FPK and 14.8 Mt of CPK.

The PKC pond functions as an equalization reservoir for inflows from four sources:

- PK slurry from the Processing Plant;
- treated and disinfected sewage effluent;
- surface runoff from PKC watershed; and
- surface runoff transferred from the Collection Ponds.

The PKC facility includes a pond that is designed to accommodate a normal operating water volume of between 500,000 m^3 and 1.4 Million cubic metres (Mm^3), while leaving sufficient freeboard to safely pass design event water volumes through a spillway to Pond 3.

A floating barge is located within the PKC pond to reclaim water, which is pumped via an insulated pipeline to the Processing Plant for re-use in ore processing. Water can also be transferred to the NI, if required. In addition, a pipeline from the NI can supply mine water directly to the Processing Plant for ore processing.

Collection Ponds 4, 5 and 7 (Figure 2-2) and piping systems have been constructed downstream of the PKC dams to provide secondary containment to collect PKC seepage. Collected seepage is pumped back to the PKC. Seepage monitoring and interception wells have been installed in the East, West and South dams.

4.4.5 Water Management Facilities

Water management is the collection, storage, recycling, treatment and controlled release of water in a safe and compliant manner. The Water Management Plan (DDMI 2008b) discusses the water collection system constructed around East Island. Through a system of sumps, all-weather seepage pump-back systems, piping, storage ponds and reservoirs, Diavik collects runoff water and groundwater seepage which can be used in the Processing Plant or is treated in the North Inlet Water Treatment Plant (NIWTP) before being released to Lac de Gras.

The Water Management Plan (DDMI 2016) summarizes the current water sources. Water sources are divided into two areas as shown in Figure 4-2:

- NI Subsystem; and
- PKC Subsystem.

The water inflows reporting to the NI are:

- runoff from the till storage area and the NI watershed;
- runoff from the waste rock area;
- runoff transferred from Pond 2, 3 and 13;
- groundwater inflow to the A154 pit;
- dike seepage collected at the toe of the A154 dike;
- groundwater inflow to the A418 pit;

- water transferred from the PKC via Pond 3;
- dike seepage collected at the toe of the A418 dike; and
- groundwater inflows to underground development and mining of A418/A154.

Pit inflows, underground inflows and dike seepage are essentially continuous flows to the NI, while the other flows described above are intermittent.

The water sources that will report to the PKC pond include:

- FPK transport water (PK Slurry);
- surface runoff within the PKC facility sub-catchment;

Water outflows include treated water to Lac de Gras, surface runoff, seepage and evaporation.

Freshwater is drawn from Lac de Gras. Freshwater volume requirements will reduce as reclaim water and mine water are further utilized in kimberlite processing. The following are current uses of freshwater:

- potable water;
- processing plant makeup water as required;
- fire suppression;
- dust suppression; and
- drill water for underground drilling if necessary.

The NI is located between the waste rock area and the airstrip (Figure 2-2). The NI is an inlet of Lac de Gras that has been dammed off to use as a sedimentation/equalization basin ahead of the NIWTP. The NI water storage reservoir currently has a live capacity of about 2.5 Mm^3.

The NIWTP was constructed at the northeast end of the NI to treat mine water to meet compliance requirements before discharge to the environment. The NIWTP is designed for removal of fine solids and dissolved phosphorus in cold water conditions with a proven treatment capacity of 90,000 m^3/day. The NIWTP has contingency design to reduce pH through the addition of acid if required. Major system components include coagulant and flocculent preparation equipment, and four high-capacity clarifiers.

A by-product of the water treatment process is clarifier thickener underflow or “sludge” material. Sludge is removed from the bottom of the thickeners and transported hydraulically to the NI for deposition at the bottom of the NI.

Treated mine water is discharged into Lac de Gras via two submerged outfalls located 200 m offshore at a depth of 20 m. Treatment flow rates, influent and treated effluent quality values of pH, turbidity and conductivity are monitored continuously and alarmed if outside acceptable limits. Equipment faults and pH levels at points within the circuit are also monitored and alarmed. Effluent is physically tested by the operator regularly for turbidity, pH, conductivity and alkalinity. The NI water levels and inflow rates from mine areas are regularly monitored. Treatment rates are adjusted to maintain water levels within planned levels.

4.4.5.1 Collection Ponds

The Collection Pond characteristics are summarized in Table 4-4.

Table 4-4 Runoff Collection Pond Summary

Drainage Area	Pond No.	Drainage Basin Area (ha)	Total Volume (m^3)
Waste Rock and Till Area	1	86	64,280
	2	106	367,460
	3	60	1,304,240
PKC Seepage	4	15	47,610
	5	20	16,310
	7	40	230,000
Plant Site Area	10	21	15,060
	11	7	18,660
	12	20	52,590
North Site - Underground Area	13	15	123,110

ha = hectare; m^3 = cubic metre; PKC = processed kimberlite containment.

Water levels in the ponds are inspected daily during May and June. Ponds are pumped down as required during the spring freshet period. Water quality is monitored when water is present. The ponds are pumped substantially dry by October each year to provide additional storage capacity for the following spring freshet.

4.4.6 Plant Site, Accommodation Complex and Fuel Storage

The main plant site is located on East Island and includes a Processing Plant, a permanent Accommodation Complex, a Maintenance Complex, six 18-Million litre (ML) diesel fuel storage tanks, two power plants, and the Power House (Figure 2-2). Elevated arctic corridors carry services and provide enclosed walkways that connect all major buildings.

4.4.6.1 Processing Plant

Three modules make up the Processing Plant: a small run-of-mine building; the main dense media separation plant; and a smaller recovery building that removes the diamonds from the host kimberlite. The Processing Plant is 35 m high (11 stories).

The diamond-bearing kimberlite ore is trucked to a stockpile area located outside the Processing Plant. A loader places the ore into the run-of-mine building where it is crushed before entering the Processing Plant. In the Processing Plant the ore is mixed with water and further crushed to less than 25 mm in size. The ore is then conveyed to the dense media separation circuit where fine-grained, heavy and magnetic ferro-silicon (FeSi) sand is added to the crushed ore and water mixture. The FeSi magnifies the gravity effect and enhances diamond and other heavy mineral separation. A large magnet recovers the FeSi, which is recycled.

The less dense waste kimberlite fraction is directed to the PKC area for permanent storage. The heavy mineral concentrate (containing diamonds, garnet, diopside, olivine and spinel) is conveyed to the recovery circuit.

The diamonds are separated from the waste heavy minerals in the recovery building using X-rays. Diamonds glow under X-rays and photo-electric sensors direct strategically placed air blasts to blow the diamonds off the conveyor belt into diamond collection receptacles. The diamonds are then shipped to Yellowknife to be cleaned and sized. Waste minerals are re-crushed or directed to the PKC.

The Processing Plant is designed to maximize the use of water reclaimed from the PKC pond. Reclaim water is used for essentially all process services in the Processing Plant. A portion of reclaim water is filtered for use in clean services, such as pump gland water. The recovery process uses reclaim water for most services, but does use raw water for critical services including water for the X-ray sorter and grease table. Raw water is also used in case of shortages of reclaim water, but a pipeline from the NI to the Processing Plant installed in 2009 provides a reliable feed of mine water to the Processing Plant and reduces freshwater use for Processing Plant requirements. The NI pipeline enables DDMI to process kimberlite with only minimal requirements for fresh water from Lac de Gras.

4.4.6.2 Accommodation Complex

The permanent accommodations complex was built in several stages. The dormitory units were prefabricated off-site as a training program under a northern Aboriginal joint venture. A total of 156 modules were constructed and trucked to site, where they were assembled into four wings. Recent expansions have increased the capacity to 380 dormitory rooms. Each floor has a laundry facility. The accommodations core complex was built on-site under a separate Northern contract. It houses security offices, cafeteria, and recreational facilities including a gymnasium with running track, and a squash court. The location of the Accommodation Complex is shown in Figure 2-2.

The Emergency Response Vehicle garage is located in a separate building attached to the Accommodation Complex.

Numerous contractors and subcontractors are mobilized to site for ongoing construction and research activities. Additional accommodations are available in the South Camp complex (Figure 2-2).

4.4.6.3 Maintenance Complex

The Maintenance Complex is 25 m high, 127 m long and 60 m wide. The height of the building allows the large haul trucks to raise their boxes for maintenance. Equipment service bays (10 in total), maintenance shops and warehousing are located on the main floor, and operations support facilities, utility rooms and additional warehouse space are on the second floor. The third floor houses administrative and mine planning offices.

4.4.6.4 Fuel Storage

Diesel fuel is the primary fuel for the site. Six 18-ML diesel fuel tanks are located at the South Tank Farm which provide fuel for mobile equipment, diesel power generators, and heating.

Gasoline storage is also provided for smaller equipment, boats, snowmobiles and gas-powered tools. Jet fuel is stored near the airstrip for helicopters and fixed-wing aircraft.

All fuel tanks are housed within secondary containment facilities that include berms, release prevention barriers and impervious liners.

4.4.6.5 Power Plants

Two power plant buildings, each 25 m high, 60 m long and 36 m wide are also located on site (Figure 2-2). They house 11 diesel engines capable of producing a total of 46.2 megawatts (MW) of power.

Waste heat is recovered and is used to heat the plant site buildings.

Power is carried throughout the plant site through the arctic corridors, and elsewhere on the site along 13.8 kilovolt (kV) lines supported by over 200 wooden poles or on-surface cables.

4.4.6.6 Boiler Plant

The Boiler Plant (Figure 2-2) houses three boilers, each capable of producing 23,000 British Thermal Units (BTUs) per hour. The boilers are held in reserve and can be used to keep the buildings from freezing if a failure occurs within the main Power Plant. The Boiler Plant also houses four backup generators each capable of producing 1.25 MW of power.

The boilers use a 60:40 glycol/water mix which is pumped through the system at a rate of 84 litres per second. The temperature of the glycol mix leaving the plant is 90°C and it returns at 70°C.

4.4.7 Infrastructure

The Project is supported by a variety of infrastructure including:

- plant yard;
- arctic corridors, which carry services and provide enclosed walkways between major buildings;
- communication system;
- ammonium nitrate storage, explosive mixing plant and caps magazine storage;
- batch plant;
- paste plant and crusher;
- airstrip with helicopter pad and fuel storage;
- roads, which form a perimeter containment for most of the facilities;
- water pipelines;
- raw water intake and potable water treatment plant;
- sewage treatment plant with treated sewage outfall;
- hazardous wastes storage facility;

- Waste Transfer Area (WTA) and inert landfill; and
- miscellaneous administration, storage, repair shops and laydown areas.

The mine site buildings and their foot print are listed in Table 4-5. This is the expected full building development, which is being used as the basis for decommissioning planning.

Table 4-5 Mine Site Buildings and Approximate Sizes

Building Name	Area (m^2)
1. Processing Plant	8,525
2. Accommodation Complex	17,285
3. Maintenance Complex	6,560
4. Backfill Plant	2,655
5. Power House 1	2,050
6. Power House 2	2,180
7. Boiler House	540
8. Crusher Building	800
9. Lube Oil Storage	864
10. Batch Plant	646
11. NIWTP Acid Storage	367
12. NIWTP	3,704
13. Tank Farm	8,167
14. SCAP Fab Shop	2,380
15. UG Dry	154
16. ERT Building	336
17. Sewage Treatment Plant	720
18. Emulsion Plant	920
19. Ammonium Nitrate Building	2,850
20. SCAP Warehouses	1,100
21. Potable Water Treatment	81
22. Raw Water Intake	490

Table 4-5 Mine Site Buildings and Approximate Sizes (continued)

Building Name	Area (m^2)
23. A21 Offices	570

24. Airport	800
25. Old Site Services	720
26. Enviro Field Lab	200
27. North Inlet Water Intake	102
28. Mine Air Heaters	1,050
29. Windfarm	95
30. Incinerator	455
31. Communications	72
32. Core Storage Area	670

m^2 = square metre

4.4.7.1 Explosive Management

Explosives on-site are managed and stored at three separate facilities: the Ammonia Nitrate Storage; the Caps/Explosive Storage; and the Emulsion Plant. These facilities are located southwest of the PKC area, away from the south camp and plant site (Figure 2-2).

Explosives are used for mining waste rock and kimberlite ore. The required emulsion blends are manufactured in the Emulsion Plant and are delivered to the blast holes in bulk delivery trucks.

4.4.7.2 Paste Plant and Crusher

A Paste Plant and Crusher were recently commissioned on the north side of the mine site and include a crusher area, product storage area, and a Paste Plant (Figure 2-2). These facilities prepare various sizes of crushed rock and underground backfill materials. Underground backfill can be a trucked cemented rock fill or a pumped paste backfill. Crushed materials are used for both backfill products and ongoing surface construction and road maintenance.

4.4.7.3 Airstrip and Roads

The transportation facilities for the Project include:

- airstrip with helicopter pad and fuel storage; and
- roads, which form perimeter containment for most of the facilities.

The airstrip is 1,600 m long and has a 45-m-wide granular (crushed rock) surface. It is capable of accepting Boeing 737 jet and Hercules transport aircraft. A host of smaller aircraft also bring freight and workers to and from several northern communities. Adjacent to the airstrip are a terminal building, helicopter pad, fuel storage and navigational aids.

Approximately 25 km of construction haulage and service roads have been built for operations. The roads are constructed above grade from crushed Type I waste rock and run-of-mine Type I waste rock. Road widths range from 12 m for service roads, to 40 to 42 m for main haul roads. Access roads vary between 20 m and 22 m in width. Typical granular thickness ranges from 1.0 to 1.4 m. Roadbed thickness increase locally over ice-rich soils, as required for performance.

Many of the roads serve as containment for the perimeter surface water collection system. Where applicable, the roads are lined with till blankets on the contained and up-slope side, and have ditches to direct water to collection ponds.

4.4.7.4 Water Pipelines

The site has some 35 km of pipelines to convey water between various locations. Approximately 21 km (60%) of all the pipelines are related to collection of seepage and runoff water from the open pits and dikes, and transport to the NI area and the NIWTP. Some 3.5 km of pipe (10%) are used for the transport of FPK slurry, and the remainder (30%) of the pipelines are utility service pipelines in the Processing Plant area. These pipelines include above ground lines for treated sewage, fire protection, potable water, and raw water for process makeup.

4.4.7.5 Potable Water Treatment Plant

Raw water is pumped from Lac de Gras to a Potable Water Treatment Plant consisting of deep bed multimedia filters, polishing filters (carbon), and chlorine dosing (Figure 2-2). Pressurized water pipelines deliver potable water from the Potable Water Treatment Plant to the major buildings on-site, while a water truck is used to deliver potable water to the Air Terminal Building, NIWTP and Explosives Handling facilities, and other support facilities on the mine site.

4.4.7.6 Sewage Treatment

The South Sewage Treatment Plant is an activated sludge system with tertiary filtration to remove phosphorus when required. The treated effluent is also disinfected with chlorine when treated water is directed to the Processing Plant for reuse within the plant.

Waste (“sewage sludge”) from the Sewage Treatment Plant is stored in the WTA. A rough estimate is that there is currently 100 to 200 m^3 of sewage sludge with up to 1,000 m^3 more being generated over the remaining life of the mine. Sewage sludge is a potential soil ameliorate for re-vegetation as the material contains elevated nitrogen and phosphorus. No final decision has been made regarding the suitability/practicality of sewage sludge as a soil ameliorate and so no closure requirement quantities have been estimated.

4.4.7.7 Solid Waste and Hazardous Waste Management

The main disposal methods for solid wastes generated on-site include incineration of all food wastes, categorical segregation of all non-food waste for storage and subsequent removal from site, and the on-site disposal of non-burnable inert wastes.

Incineration, segregation and storage of waste takes place at the WTA (Figure 2-2), which was established to ensure proper handling and storage of waste on-site. The WTA is approximately 130 m x 130 m, and is surrounded by a gated, 3-m-high chain link fence erected to control wind transportation of any litter and to minimize wildlife intrusion. The WTA includes: two incinerators for food waste; a burn pit for non-toxic/non-food contaminated burnable material; a contaminated soils containment area; a treated sewage containment area; and sea cans, sheds, and storage areas for drums, crates, bins and totes. The majority of wastes are inventoried and stored at the WTA while awaiting backhaul on the winter ice road. Hazardous wastes are not incinerated on-site.

On-site disposal of non-burnable wastes such as steel, plastics and glass currently occurs at the inert landfill located within the Type III waste rock pile. These materials are regularly covered with waste rock to prevent wildlife attraction.

The inert landfill will remain operational within the waste rock area until final closure.

Hazardous wastes are classified, labelled and temporarily stored within the WTA (Figure 2-2) before being transported off-site for recycle, treatment or disposal in a licensed waste disposal facility.

Hydrocarbon-contaminated soils from spills or other releases are land-treated in a designated cell within the WTA. The cell is bermed and lined with an impermeable liner. The hydrocarbon-contaminated soil is placed within the cell and spread during the summer months to allow for remediation to acceptable levels by using natural micro-biological processes (bio-remediation). From 2012-2016 it is estimated that 39 to 57 m^3 of hydrocarbon contaminated soil has been excavated. Over the life of the mine this might total 1,000 to 1,500 m^3. This is well within the landfarm design capacity of 3,780 m^3.

4.4.7.8 Potentially Contaminated Areas

DDMI has a Waste Management Plan and Hazardous Materials Management Plan that include strategies for managing hazardous and non-hazardous waste streams. The primary objectives of these plans are to collect, store, transport and dispose of wastes generated by the Project in a safe, efficient and environmentally responsible manner.

Where hazardous materials are stored or used there is potential for contamination through accidental spills or storage contact, which can create areas to be addressed at closure.

4.4.7.8.1 Spills

Spills at Diavik are primarily related to equipment mechanical failures. These spills are typically hydrocarbon products. Spills are cleaned up when they occur, and soil/rock impacted from spills are managed through landfarming (soil) in the WTA and encapsulation in the Type III Waste Rock Dump (rock).

DDMI is currently managing hydrocarbon contaminated soil in the WTA (i.e., no material disposed in the current WTA has been removed). Soil from the former WTA (which was located in the PKC South Cell) landfarming operation was disposed in the Type III Waste Rock Dump in 2010. DDMI uses Canadian Council of Ministers of the Environment (CCME) Agricultural standards (CCME 1999a) for guidance and obtain Inspector approval before disposing of the material.

Coarse material that has been impacted from a spill but is too large to manage by landfarming (e.g., rock in the open pits) is disposed in the Type III Waste Rock Dump. Volume/tonnage of waste rock that has been affected from spills each year is very difficult to estimate. Due to the nature of the material (large cobbles/boulders with very low surface area compared to till and other fine-grain materials), most of what is hauled to the Type III dump is not actually “affected”. Instead, the rocks have typically been partially sprayed or partially covered with the spilled product.

In all spill scenarios, DDMI attempts to recover much of the spilled product instead of allowing soil to absorb it, or for it to flow into permeable areas between rocks. Drip pans and absorbent pads are used at spill sites to recover spilled products.

DDMI maintains records of historic spill locations so applicable areas can be revisited for additional follow-up if necessary.

4.4.7.8.2 Hazardous Materials Storage and Other Areas With Potential for Impacts

Locations where hazardous materials are regularly handled and stored could potentially be impacted from small (unnoticed) spills and leaks or improper handling/storage of materials. These areas include:

- bulk fuel storage;
- waste transfer facilities;
- explosives storage and manufacturing areas;
- chemical storage areas (includes the airport apron/helipad, NIWTP chemical storage building and acid building, North Chemical Storage building and warehouse sprungs); and
- equipment parking/storage areas (ready-lines and maintenance shops/parking lots).

Areas where there could be elevated risk for potential effects are shown in Figure 4-3. Many of these areas will remain active through the operations phase of the Project and will need to be assessed when they are decommissioned or at closure. In some cases, assessment could include detailed environmental site assessment, while some areas may only require inspection following decommissioning. Results of the post-closure assessments will identify areas that require further remediation or risk management.

In addition to the above referenced locations, minor amounts of hazardous materials and petroleum products are stored and used at many locations around the mine site. Products such as kitchen and bathroom cleaners, laboratory reagents or ink cartridges are present at site in relatively low volumes, and although they pose only minor environmental risks, they will need to be properly packaged and disposed at closure.

4.4.7.8.3 Closure

The volume/tonnage of impacted material that will require remediation or management at closure will depend on several factors:

- spill performance;
- success of land farming during operations; and
- the amount of material that exceeds the Agriculture CCME Soil Quality Guidelines.

Based on recent performance, an estimated 200 m^3 of hydrocarbon-impacted soil is generated annually, however, it is expected that land farming in the WTA can reduce concentrations to levels acceptable for disposal on-site. Golder (2011) provides a *Risk-Based Approach for Managing Hydrocarbon Contaminated Soils.* This document was prepared as part of Diavik's closure research and was submitted to the WLWB as Appendix II-8 of the 2012 Annual Closure Progress Report. The report identified three options for on-site disposal of hydrocarbon contaminated soils:

- Option 1: Surface Placement (upper 1 m).
- Option 2: Subsurface/Active Zone Placement (depth >1 m but above permafrost).
- Option 3: Subsurface/Deep Placement (at depth where permafrost is expected to form and persist).

Option 3 is identified as the safest option for long-term disposal however options 1 and 2 which minimize exposure pathways for humans and wildlife may also be viable under certain conditions and contaminant levels.

4.4.7.9 North Construction Area

Several office and storage buildings, laydown areas and repair shops are located on the north side of the mine site (Figure 2-2) near to the A154 and A418 pits and underground. Some of these facilities are buildings reused from original construction camp facilities.

4.5 Reclamation Materials

The predominant materials required for closure activities are Type I rock and till.
The availability and current closure requirements for these materials are described in Section 4.4.3.

Significant quantities of coarse processed kimberlite (CPK) and fine processed kimberlite (FPK) will exist for possible use at closure. The availability and current closure requirements for these materials are described in Section 4.4.4.

By-products from the South Sewage Treatment Plant and NIWTP have also been identified as possible re-vegetation materials. The availability and current closure requirements for these materials are described in Section 4.4.7.6 and 4.4.5 respectively.

Lakebed sediments are also a possible reclamation material. Some lakebed sediment was dredged from the A154 and A418 dike alignments and deposited in the On-Land Sediment Storage Facility that is now Pond 3. Dredged lakebed sediment from A21 dike construction was deposited in Pond 3. When Pond 3 is dewatered and decommissioned some of the lakebed material may become available, however quantities are unknown. An additional amount of lakebed sediment was excavated with the till from the top if the A154 and A418 kimberlites and stored intermixed with the till in the till storage area.

In addition to reclamation materials generated from the mining activities, surficial materials may be available for closure activities. An inventory of surficial materials was completed in 1996 prior to mine development (see ICRP V3.2 - Appendix X-8). The most suitable surficial materials for reclamation were determined to be the organic, organic over glaciolacustrine and glaciolacustrine materials. It was initially envisaged that some of these materials could be pre-stripped from areas like the waste rock storage area and the PKC, prior to their development, and stockpiled for use in closure reclamation. A trial was conducted on the south slope of the PKC area to attempt to pre-strip reclamation materials. Progress was very slow because layers could only be stripped as the material thawed. The trial identified a significant issue with the generation of large volumes of high suspended solids melt/runoff water and the program was discontinued.

5 Requirements for Permanent Closure and Reclamation

5.1 Definition of Permanent Closure

Permanent closure is defined as the final closure of the mine site. At permanent closure there would be no foreseeable intent by DDMI to use the site for active exploration or mining, although permanent closure would not preclude renewed or future mining. Permanent closure also means that site activities will be limited to post-closure monitoring and, possibly, contingency closure actions. Throughout this document the terms “closure” and “closure and reclamation” are used synonymously.

Closure actions will largely commence following the end of commercial operations at the Diavik site. Currently this is anticipated around mid-2025.

Progressive Reclamation is the process of commencing closure actions concurrent with ongoing operations and prior to the end of commercial production. DDMI will endeavour to carry out progressive reclamation as soon as it is reasonably practical. DDMI will include financial considerations in the determination of when progressive reclamation is reasonably practical.

Post-closure activities, such as monitoring and maintenance, are those that will occur following the closure actions. These could occur before the end of commercial operations (in the case of progressive reclamation) or after the end of commercial operations and are expected to be complete with the acceptance of the final Performance Assessment Report (Part K Item 6).

At this time DDMI anticipates relinquishment would occur around 2032. While no long-term care requirements have been specifically identified at this time, future Performance Assessment Reporting may recommend a long-term monitoring and maintenance program. DDMI has considered what the scope of this program might include and estimated costs. These have been included with the North Country Rock-Waste Rock Storage Area Final Closure Plan (Version 1.1) referenced in Section 5.2.5.

5.2 Permanent Closure Requirements for Specific Components and Facilities

This section presents the current plans for the permanent closure of the mine site. Mining operations are expected to continue until around 2025. Although it is important to be planning for closure, it is premature to have detailed engineering plans for all areas. Final plans are required prior to implementation of a progressive reclamation.

Section 5.2.1 provides an overview of the closure planning process, a general description of the current closure concepts for each closure area, the main closure activities that have been identified to date, key uncertainties and a summary of research plans. The summary is intended to provide a reader with a quick reference of the current plans.

Sections 5.2.2 through 5.2.8 offer more detailed descriptions of the anticipated closure activities for each of the five mine areas. They include a history of closure planning for each component from initial mine design to the current plan, and provide a rationale for initial decisions and any changes that have occurred over the mine life. Also included are specific closure objectives for the site and for each of the five mine site areas. For context, relevant information identified in the Northwest Territories Mine Closure Guidelines and recent Environment Canada industry standards have been summarized and appended. Uncertainties, risks, monitoring programs and linkages to research programs are also provided.

5.2.1 Overview of Current Closure Plans

5.2.1.1 Closure Management Areas

The mine site has been divided into five management areas for the purpose of closure planning:

- Waste Rock and Till Storage Area.
- PKC Area.
- Open Pits, Underground and Dike Area.
- NI Area.
- Mine Infrastructure.

These general areas are shown in Figure 5-1.

5.2.1.2 Closure Goals and Objectives

DDMI's overall goal is to operate and close the mine responsibly, leaving behind a positive community and environmental legacy. Regulatory requirements for closure are described in the *Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories* (MVLWB 2013) under three general categories: physical stability; chemical stability; and future use and aesthetics. DDMI's eight stated closure goals are listed in Table 5-1.

Table 5-1 DDMI Closure Goals

	Closure Goals
1.	Land and water that is physically and chemically stable and safe for people, wildlife and aquatic life.
2.	Land and water that allows for traditional use.
3.	Final landscape guided by traditional knowledge.
4.	Final landscape guided by pre-development conditions.
5.	Final landscape that is neutral to wildlife – being neither a significant attractant nor significant deterrent relative to pre-development conditions.
6.	Maximize northern business opportunities during operations and closure.
7.	Develop northern capacities during operations and closure for the benefit of the north, post-closure.
8.	Final site conditions that do not require a continuous presence of Mine Staff.

For clarity it should be noted that the WLWB have specified that the INAC policy goal which states, “Returning mine site and affected areas to viable and, wherever practical, self-sustaining ecosystems that are compatible with a healthy environment and with human activities” also applies to the mine site (WLWB 2010).

More specific closure objectives for the Diavik mine site have also been developed through a consultative process. These objectives were approved by the WLWB with ICRP V3.2. Objectives are both site-wide, meaning they are applicable to all five closure management areas, and area-specific. The closure objectives, both site-wide and area-specific, are shown in Table 5-2. Together these objectives cover all applicable aspects of physical stability, chemical stability, aesthetics and future use. The objectives may change over time as circumstances change and new information becomes available. DDMI has removed NI1 from Table 5-2. Objective NI1 previously stated “Reconnect the NI with Lac de Gras”. It is DDMI’s view that this closure objective should have properly been included as a closure option. That is to say, it is one closure approach that could be used to achieve the closure objective. Removing objective NI1 is consistent with MVLWB (2013). The closure option of reconnecting the NI with Lac de Gras is a closure option considered in Section 5.2.7.

Table 5-2 DDMI Closure Objectives

Site-Wide Closure Objectives

SW1.	Surface runoff and seepage water quality that is safe for humans and wildlife.
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.
SW3.	Dust levels safe for people, vegetation, aquatic life and wildlife.
SW4.	Dust levels do not affect palatability of vegetation to wildlife.
SW5.	Re-vegetation targeted to priority areas.
SW6.	Ground surface designed to drain naturally follow pre-development drainage patterns.
SW7.	Areas in and around the site that are undisturbed during operation of the mine should remain undisturbed during and after closure.
SW8.	No increased opportunities for predation of caribou compared to pre-development conditions.
SW9.	Landscape features (topography and vegetation) that match aesthetics and natural conditions of the surrounding natural area.
SW10.	Safe passage and use for caribou and other wildlife.
SW11.	Mine areas are physically stable and safe for use by people and wildlife.

Table 5-2 DDMI Closure Objectives (continued)

Open Pit, Underground and Dike Area Closure Objectives	
M1.	Water quality in the flooded pit and dike area that is similar to Lac de Gras or, at a minimum, protective of aquatic life.
M2.	Pit and dike closure that do not have adverse effects on water uses in Lac de Gras, the Coppermine River or groundwater use.
M3.	Enhanced lake-wide fish habitat to offset fish habitat temporarily lost during operations.
M4.	Safe small craft navigation through dike and pit area.
M5.	Physically stable pit walls and shorelines to limit risk of a failure impacting people, aquatic life or wildlife.
M6.	Pit fill rate that will not cause adverse effects on water levels in Lac de Gras and Coppermine River.
M7.	Pit fill rate that will not cause adverse effects on fish or fish habitat in Lac de Gras and Coppermine River.
M8.	Wildlife safe during filling of pits
Waste Rock and Till Area Closure Objectives	
W1.	Physically stable slopes to limit risk of failure that would impact the safety of people or wildlife.
W2.	Rock and till pile features (shape and appearance) that match aesthetics of the surrounding natural area.
W3.	Contaminated soils and waste disposal areas that cannot contaminate land and water.
Processed Kimberlite Containment Closure Objectives	
P1.	No adverse effects on people, wildlife or vegetation.
P2.	Physically stable Processed Kimberlite Containment area to limit risk of failure that would affect safety of people or wildlife.
P3.	Prevent processed kimberlite from entering the surrounding terrestrial and aquatic environments.
North Inlet Area Closure Objectives	
NI2.	Water quality and sediment quality in the North Inlet that is safe for aquatic life, wildlife, and people.
NI3.	Suitable fish habitat in the North Inlet.
NI4.	Water quality in the North Inlet that is as similar to Lac de Gras as possible.
NI5.	Water and sediment quality in the North Inlet that will not cause adverse effects on aquatic life or water uses in Lac de Gras or the Coppermine River.
NI6.	Physically stable banks of the North Inlet to limit risk of failure that would impact the safety of people or wildlife.

Table 5-2 DDMI Closure Objectives (continued)

Mine Infrastructure Closure Objectives	
I1.	Opportunities for communities to re-use infrastructure, allowable under regulation and where liability is not a significant concern.
I2.	On-site disposal areas that are safe for people, wildlife and vegetation.
I3.	Prevent remaining infrastructure from contaminating land or water.

As work on improving closure criteria and finalizing closure activities progresses, the need to change objectives may arise. The WLWB has indicated that DDMI or any other party may recommend a change to the objectives with supporting rationale, and that in general all parties should have the opportunity to provide input on proposed changes.

5.2.1.3 Closure Planning

The closure planning framework that DDMI uses is an iterative process that requires identifying a design concept, evaluating the expected performance of the design against objectives and criteria, considering input from communities and the TK Panel and then developing options to revise the design. The expected performance is assessed under existing climate and possible climate change conditions. The climate change scenario currently envisaged for this evaluation was included in ICRP V3.2 - Appendix X-8. The climate change scenario is added to existing temperature monitoring records to forecast a climate change design condition. In this way any short-term trends in local climate are also accounted. The resulting climate design change condition is used to evaluate long-term thermal performance of closure design. Figure 12 of Appendix XI from the NCRP-WRSA Final Closure Plan Version 1.1 provides a recent example.

Information from the research plans are expected to help understand the expected performance of a specific design, refine closure objectives and criteria, and inform changes to design options. Research plans can be revised based on outcomes from design iterations.

The design iteration process is an internal process with important outcomes periodically reported externally though updates to this CRP document. Timing of the updates will be based on WLWB requirements and timing of key results from the design process. If significant design revisions are identified, it will be helpful to communicate these to all parties through the Annual Closure and Reclamation Plan Progress Report. Overall the schedule is to have a final closure plan by 2020.

5.2.1.4 Currently Approved Design Concepts

The following summarizes the currently approved design concept for each closure area. A table is provided that shows how aspects of the closure design contribute to each of the closure objectives. Some currently approved designs are under review by DDMI and a request to revise designs will likely occur as soon as sufficient information is available to support a design change. The following sections include discussions of these areas of possible design changes. As the designs evolve, additional aspects will be identified and added to this summary. Key closure uncertainties that have been identified to date are provided and are followed by a summary of the research plans to reduce these uncertainties.

5.2.1.5 Open Pits, Underground and Dike Area

Dikes were constructed into Lac de Gras and the area behind the dikes was dewatered to allow open-pit and underground mining. At closure the underground, pit and dike areas will be flooded. When the water quality has been confirmed, small breaches will be cut into the dikes to allow fish and aquatic life from Lac de Gras to return to the area. Work to confirm that the expected water quality will be suitable for closure is currently underway. Fish habitat construction within the dike areas is also underway.

Although this closure design is still in development, there are few significant uncertainties compared to the other closure areas. The closure design for the pits, underground and dike areas remains unchanged from the original mine design.

The closure objectives and the activities that have been identified that contribute to achieving each of the closure objectives for this area are listed in Table 5-3.

Table 5-3 Closure Activities Identified for the Pits, Underground and Dike Areas

Closure Objective	Identified Closure Activities
M1. Water quality in the flooded pit and dike area that is similar to Lac de Gras or at a minimum protective of aquatic life.	• Construct fish habitat in area between pit crest and inside toe of dike. • Remove equipment and pipelines from pit/dike area. • Remove hazardous materials and mobile equipment from underground. • Clean and inventory materials that will remain underground. • Fill pit/dike area with Lac de Gras water. • Locate fill pipeline to minimize erosion and introduction of suspended solids. • Excavate breaches to allow exchange of water between dike/pit area and Lac de Gras. • Breach dikes after water quality can be confirmed at acceptable levels.
M2. Pit and dike closure do not have adverse effects on water uses in Lac de Gras, the Coppermine River or groundwater use.	• Construct fish habitat in area between pit crest and inside toe of dike. • Remove equipment and pipelines from pit/dike area. • Remove hazardous materials and mobile equipment from underground. • Clean and inventory materials that will remain underground. • Fill pit/dike area with Lac de Gras water. • Locate fill pipeline to minimize erosion and introduction of suspended solids. • Limit fill rate, if necessary, to maintain Lac de Gras levels above 415 m. • Excavate breaches to allow exchange of water between dike/pit area and Lac de Gras. • Breach dikes after water quality can be confirmed to be within acceptable levels.
M3. Enhanced lake-wide fish habitat to offset fish habitat temporarily lost during operations.	• Construct fish habitat in area between pit crest and inside toe of dike. • Excavate breaches in dikes to allow fish from Lac de Gras to use dike/pit area.

Table 5-3 Closure Activities Identified for the Pits, Underground and Dike Areas (continued)

Closure Objective	Identified Closure Activities
M4. Safe small craft navigation through dike and pit area.	• Excavate breaches in dikes to allow small craft navigation. • Stabilize shorelines, as required, to reduce risk of slope failure.
M5. Physically stable pit walls and shorelines to limit risk of a failure impacting people, aquatic life or wildlife.	• Stabilize shorelines, as required, to reduce risk of slope failure. • Confirm long-term stability of underwater pit slopes.
M6. Pit fill rate that will not cause adverse effects on water levels in Lac de Gras and Coppermine River.	Limit fill rate, if necessary, to maintain Lac de Gras levels above 415 m.
M7. Pit fill rate that will not cause adverse effects on fish or fish habitat in Lac de Gras and Coppermine River.	Limit fill rate, if necessary, to maintain Lac de Gras levels above 415 m.
M8. Wildlife safe during filling of pits.	• Remove any observed wildlife from pit/dike area before filling. • Monitor area for approaching wildlife during filling. • Employ deterrents such as herding as required. • Excavate ramps into the A418 wall that will remain as a shoreline.

5.2.1.6 Waste Rock and Till Storage Area

Waste rock and till from the open-pit mining of the A154 and A418 kimberlite pipes are stored on the north side of the mine site. Waste rock has been segregated based on sulphur content to ensure than rock that is used for the construction of roads and other structures does not have the potential to generate acidic drainage. Waste rock that is permanently stored is also segregated by sulphur content. The waste rock pile has been constructed with the expectation that seepage from the area will be limited by permafrost conditions within the pile. Seepage that may occur is expected to be water that moves through the seasonal active thaw zone and exits the pile at the perimeter toe. Till from the till stockpile is expected to be fully utilized as a reclamation material and a till stockpile is not expected to exist post-closure.

Closure plans for the north country rock pile waste rock area (NCRP-WRSA) is at a Final Design level to enable progressive reclamation as soon as practical. The design which is currently under review by the WLWB is for the construction of a till/rock thermal cover over a re-sloped rock pile. The design is intended to mitigate poor seepage/runoff water quality by limiting the annual thaw zone (“active zone”) to within the rock/till cover. The cover is to be constructed from lakebed till and Type I rock. The NCRP-WRSA is not to be actively re-vegetated but it is recognized that it will re-vegetate naturally in time.

The closure objectives and the approved activities that have been identified that contribute to achieving each of the closure objectives for the waste rock area are listed in Table 5-4.

Table 5-4 Closure Activities Identified for the Waste Rock Area

Closure Objective	Identified Closure Activities
SW1. Surface runoff and seepage water quality that is safe for humans and wildlife.	• Flatten top of waste rock pile to reduce snow accumulation and infiltration. • Reduce side slope angles. • Place cover on Type II - Type III rock (1.5 m till and 3 m Type I rock).
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.	• Flatten top of waste rock pile to reduce snow accumulation and infiltration. • Reduce side slope angles. • Place cover on Type II-III rock (1.5 m till and 3 m Type I rock). • Decommission water collection structures at Ponds 1, 2 and 3 after acceptable water quality is confirmed.
W1. Physically stable slopes to limit risk of failure that would impact the safety of people or wildlife.	• Re-slope waste rock piles sides • Install signage to identify area as previous mine site.
W2. Rock and till pile features (shape and appearance) that match aesthetics of the surrounding natural area.	• Remove equipment, buildings and other materials. • Cover landfill area with till/rock cover. • Leave surfaces of materials native to the area. • Round edges of waste rock and till piles.
W3. Contaminated soils and waste disposal areas that cannot contaminate land and water.	• Remove or bury/encapsulate surface materials that exceed closure criteria. • Cover landfill area with till/rock cover. • Flatten top of waste rock pile to reduce snow accumulation and infiltration. • Decommission water collection structures at Ponds 3 after acceptable water quality is confirmed.

5.2.1.7 Processed Kimberlite Containment Area

After the diamonds have been removed the PK waste is pumped (fine fraction) and trucked (coarse fraction) to the PKC, a lined storage facility located in a central valley on the east island. Long beaches are formed from the perimeter of the facility and water is reclaimed from a central pond. The current approved closure approach for the PKC is to cover the exposed beaches with a layer of waste rock to separate wildlife from PK and to protect against wind/water erosion. A centralized pond will remain over the FPK that will be slow to consolidate. Overflow from the pond will pass safely through a designed spillway. The PKC is not to be actively re-vegetated but it is recognized that it will re-vegetate naturally in time.

DDMI is considering modifications to the closure concept described above. These include but are not limited to placing FPK/CPK in a completed open-pit/underground mine and/or not leaving a pond at closure. These options will be considered in more detail over the next few years. The uncertainties related to the current plan primarily relate to the stability of the central pond shoreline, the design of the spillway and the quality of the overflow water.

The closure objectives and the approved activities that have been identified to-date that contribute to achieving each of the closure objectives for the PKC facility are listed in Table 5-5.

Table 5-5 Closure Activities Identified for the Processed Kimberlite Containment

Closure Objective	Identified Closure Activities
SW1. Surface runoff and seepage water quality that is safe for humans and wildlife.	• Remove free water, treat and discharge towards end of operations. • Maintain as much PK material in a frozen or saturated state as practical. • Type I erosion cover on PK beaches.
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.	• Remove free water, treat and discharge during operations. • Decommission water collection structures at Ponds 4, 5, 7 and 12 after acceptable water quality is confirmed.
P1. No adverse effects on people, wildlife or vegetation.	• Remove pipelines, building and equipment. • Type I erosion covers on beaches. • Construct wildlife movement routes when constructing final surfaces. • Eliminate, isolate and/or reduce identified wildlife hazards. • Remove free water, treat and discharge during operations.
P2. Physically stable processed kimberlite containment area to limit risk of failure that would affect safety of people or wildlife.	• Remove free water, treat and discharge during operations. • Retain a central pond over unconsolidated PK materials • Place Type I over beaches to separate PK from people/wildlife.
P3. Prevent processed kimberlite from entering the surrounding terrestrial and aquatic environments.	• Place Type I rock over beaches to prevent erosion. • Decommission water collection structures at Ponds 4, 5, 7 and 12 after acceptable water quality is confirmed.

5.2.1.8 North Inlet Area

The NI function is water treatment equalization and settling basin. Operationally it is part of the NIWTP where mine water is treated before it is discharged to Lac de Gras. The NI was a bay in Lac de Gras and was isolated from Lac de Gras by constructing dams across the bay so the NI could be used during mining operations as part of the site water management system. At closure, DDMI would like to reconnect the NI with Lac de Gras but only if conditions within the NI sediments are appropriate for reconnection.

Most recent monitoring results indicate that the sediments in the NI are not optimal for benthic invertebrates that live on the sediment and it is prudent to assume that they will not become suitable. However, future sediment quality it is uncertain at this time. Sediment quality is a key closure uncertainty to be addressed for the NI. The current proposed closure plan is only allow a hydraulic connection between the NI and Lac de Gras and prevent the fish of Lac de Gras from interacting with NI sediments. This is a change from the current approved plan of a full reconnection and is discussed further in Section 5.2.7

The closure objectives and the activities that have been identified that contributes to achieving each NI closure objective are listed in Table 5-6. Note that objective NI1 was removed as discussed in Section 5.2.1.2.

Table 5-6 Closure Activities Identified for the North Inlet

Closure Objective	Identified Closure Activities
NI2. Water quality and sediment quality in the North Inlet that is safe for aquatic life, wildlife and people.	• Confirm during operations that sediment quality remains acceptable for closure. • Treat and discharge the water in the North Inlet and replace with Lac de Gras water. • Stabilize shorelines, as required, to reduce risk of erosion.
NI3. Suitable fish habitat in the North Inlet.	• Confirm during operations if sediment quality becomes acceptable for closure. • Stabilize shorelines, as required, to reduce risk of erosion.
NI4. Water quality in the North Inlet that is as similar to Lac de Gras as possible.	Treat and discharge water in the North Inlet and replace with Lac de Gras water.
NI5. Water and sediment quality in the North Inlet that will not cause adverse effects on aquatic life or water uses in Lac de Gras or the Coppermine River.	• Confirm during operations that sediment quality remains acceptable for closure. • Treat and discharge water in the North Inlet and replace with Lac de Gras water. • Stabilize shorelines, as required, to reduce risk of erosion. • Excavate breach in North Inlet dam after acceptable water and sediment quality are confirmed. Backfill breach with coarse rock to limit fish passage
NI6. Physically stable banks of the North Inlet to limit risk of failure that would impact the safety of people or wildlife.	Stabilize shorelines, as required, to reduce risk of failure.

5.2.1.9 Mine Infrastructure and Site-Wide Closure

Buildings and infrastructure will be removed and either salvaged or buried on-site. Roads, airstrip and laydown areas may be re-contoured to remove steep sides, scarified where human and wildlife access routes are not envisaged, and areas may be targeted for re-vegetation. Roads will be scarified however a single lane width of road will be left to enable future travel by people and/or wildlife. Natural drainage paths will be restored and landform features enhanced with boulders etc. to better match the natural surroundings. Note that the footprint of the mine site will remain discernable post-closure.

This area will be one of the last to be closed because much of the basic infrastructure including roads, accommodation, truck shops and power will be required to support the closure activities. Key uncertainties related to mine infrastructure and site-wide closure include re-vegetation procedures, quantities of non-salvageable materials intended for on-site burial and opportunities for re-use/sale of infrastructure.

The closure objectives and the activities that have been identified that contribute to achieving each objective are listed in Tables 5-7 and 5-8. Tables are included for both the mine infrastructure specific objectives and the site-wide objectives.

Table 5-7 Closure Activities Identified for the Infrastructure Areas

Infrastructure Closure Objectives	Identified Closure Activities
I1. Opportunities for communities to re-use infrastructure allowable under regulation and where liability is not a significant concern.	• Ensure final decommissioning plans facilitate reuse of infrastructure off-site. • Assist communities to identify, plan for and obtain ownership of salvageable equipment, buildings, materials and supplies that could be re-used in or by communities.
I2. On-site disposal areas are safe for people, wildlife and vegetation.	• Control the materials that are disposed during operations and closure. • Cover on-site disposal areas with run-of-mine rock. • Eliminate, isolate and/or reduce identified wildlife hazards.
I3. Prevent infrastructure from contaminating land or water.	• Remove buildings and equipment. • Add wind erosion protection for final surfaces that have erosion potential. • Decommission water collection structures at Ponds 10, 11 and 12 after acceptable water quality is confirmed.

Table 5-8 Closure Activities Identified Site-Wide

Site-Wide Closure Objectives	Identified Closure Activities
SW1. Surface runoff and seepage water quality that is safe for humans and wildlife.	• Control materials used for all on-island construction; only confirmed non-acid generating material used. • Add erosion protection to final surfaces with erosion potential. • Safely dispose or remove from site materials that could be a source of contamination.
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.	• Control materials used for all on-island construction and closure to ensure only confirmed non-acid generating material used. • Add erosion protection for final surfaces with erosion potential. • Safely dispose or remove from site materials that could be a source of contamination.
SW3. Dust levels safe for people, vegetation, aquatic life, and wildlife.	Add protection from wind erosion to final surfaces with erosion potential.

Table 5-8 Closure Activities Identified Site-Wide (continued)

Site-Wide Closure Objectives	Identified Closure Activities
SW4. Dust levels do not affect palatability of vegetation to wildlife.	Add protection from wind erosion protection to final surfaces with erosion potential.
SW5. Re-vegetation efforts targeted to priority areas.	• Re-vegetate using indigenous species, substrate amelioration and islands of pilot vegetation community. • Target infrastructure areas for re-vegetation. • Leave waste rock pile and PKC to re-vegetate naturally.
SW6. Ground surface designed to drain naturally follow pre-development drainage patterns.	• Decommission water collection structures at Ponds 1,2,3,4,5,7,10,11 and 12 and remove any culverts. • Re-establish natural drainage channels in areas where collection structures have been decommissioned.
SW7. Areas in and around the site that are undisturbed during operation of the mine should remain undisturbed during and after closure.	• Flatten safety berms and edges of roads and laydowns inward. • Limit re-sloping outward to areas of potential geotechnical instability and wildlife hazard/access. • Decommission roads to enable post-closure access without additional disturbance.
SW8. No increased opportunities for predation of caribou compared to pre-development conditions.	• Eliminate or reduce features in the PKC, waste rock pile and roads that can be considered predation hazards. • Post-closure wildlife access routes aligned with recommendations from Traditional Knowledge, communities and biologists.
SW9. Landscape features (topography and vegetation) that match aesthetics and natural conditions of the surrounding natural area.	• Remove building and equipment. • Leave surfaces of materials native to the area. • Return pit, dike and North Inlet (sediment quality permitting) areas to productive lake habitat. • Round off engineered angles from surface structures, as required. • Focus re-vegetation efforts on roads, laydowns and plant sites avoiding areas of potential contamination. • Use indigenous plant species.
SW10. Safe passage and use for caribou and other wildlife.	• Leave wildlife movement routes when scarifying roads and laydowns. • Use sections of existing roads for wildlife movement routes as much as possible. • Eliminate, isolate and/or reduce identified wildlife hazards. • Remove building and equipment.

Table 5-8 Closure Activities Identified Site-Wide (continued)

Site-Wide Closure Objectives	Identified Closure Activities
SW11. Mine areas are physically stable and safe for use by people and wildlife.	• Use sections of existing roads for safe movement through the area post-closure. • Install signage to identify area as previous mine site. • Re-slope surface structures, as required, to conform to engineering stability specifications. • Leave wildlife movement routes when scarifying roads and laydowns • Remove buildings and equipment. • Use sections of existing roads for wildlife movement routes. • Eliminate, isolate and/or reduce identified wildlife hazards. • Link roads for wildlife movement to pre-development wildlife access routes. • Block wildlife and human access from surface opening to underground workings.

5.2.1.10 Research Plans

Six closure research plans were included in ICRP V3.2, one plan for each of the five closure areas (waste rock and till, PKC, NI, infrastructure, and the pit, underground and dike area) and one specific to community engagement and TK. For the most part these research plans have been completed and have been used to inform closure planning. The status of each task of each plan is summarized in Appendix VIII-1 and provides the references for the research results.

DDMI has established a Traditional Knowledge Panel that has been helpful with closure planning. DDMI expects to continue to engage with the Panel but has not included a specific research plan. The Panel with input from DDMI and the Panel facilitators identify topics for the consideration. DDMI expects to continue this practice.

The outstanding closure research plans are included in Appendix VIII-2 are summarized as follows:

- Processed Kimberlite Containment – The current closure plan for the PKC facility is at a conceptual level of engineering. Research studies have focused on characterizing the PKC using field studies and laboratory studies. Geochemical research will continue to better understanding of the geochemical characteristics of PK to support estimates of confirm acceptable water quality.
- Pit Lake Modelling – mathematical modelling of the final open-pit underground mine configurations will be completed to verify that deep water will not frequently circulate to the surface and impact on surface water use post-closure.
- Re-vegetation Procedures – re-vegetation research will be combined with TK Panel input to develop a final re-vegetation procedure to be applied to target areas.

Most of the closure planning effort going forward will be with regard to engineering aspects of final closure designs, predictions of closure performance and/or technical evaluations of remaining closure option. Updates will be provided through the Annual Closure and Reclamation Plan Progress Reporting.

5.2.2 Closure Objectives and Criteria

The requirements for mine closure are driven by the closure goals and closure objectives, and defined by closure criteria. Closure goals are broader statements of intended outcomes (Table 5-1).

Closure criteria serve both to better define the objective, and to describe the conditions when the objective has been achieved. Objectives and criteria must also be consistent with, and inclusive of, specific terms and/or conditions specified in permits, licenses and authorizations (Section 2.5). The Water License (Part K) specifically references the MVLWB and Aboriginal Affairs and Northern Development Canada's *Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories* as guidance for the content of a closure plan. DDMI reviewed this guidance when considering closure objectives.

Similarly, Environment Canada recently issued recommendations on "Environmental Codes of Practice for Metal Mines" including closure phases (Environment Canada 2009) and there are previous Mine Site Reclamation Guidelines for the NWT (INAC 2007). These recommendations were also considered in establishing closure objectives. Relevant aspects of both the INAC (2007) guidance and the Environment Canada (2009) code of practice are referenced in Section 5.2.4 through 5.2.8 for each of the mine closure areas.

Closure objectives specific to the Diavik mine site have been developed through a process involving DDMI, reviewers and WLWB Staff. The WLWB approved the closure objectives as submitted in ICRP V3.2. The WLWB recognized that the closure objectives must be sufficiently flexible to accommodate potential changes identified during ongoing work on the ICRP or as a result of changes during mine operations. DDMI has made one change to the closure objectives in this CRP; removal of objective NI1 (see Section 5.2.1). Closure objectives and criteria are detailed in Appendix V.

For each objective in Appendix V there is also a proposed closure criterion. The criterion is intended to describe the conditions when the objective has been achieved. The WLWB did not approve the closure criteria included in ICRP V3.2 as it was recognized that these required further discussion and time to consider fully. To that end the WLWB hosted a closure criteria workshop in December 2016 to advance these discussions. DDMI used information from this workshop and ongoing engagement with various reviewers, to advance closure criteria; particularly closure criteria for the NCRP-WRSA. DDMI has requested approval of the NCRP-WRSA to provide certainty for planned construction of the closure cover so that this work could proceed as progressive reclamation. While most of the progress on closure criteria has been with regard to the NCRP-WRSA, the approaches used for that closure area were generally applied to the other closure areas as well. DDMI suggests that the closure criteria for these other areas be considered as "work in progress". It is expected that there will be learnings from the review of the NCRP-WRSA proposed closure criteria that will apply to these other areas as well. Until the review of the NCRP-WRSA criteria is complete and approved by the WLWB, it would be inefficient for DDMI or reviewers to focus on criteria in other areas. Regardless, DDMI has included current proposed criteria in Appendix V for further discussion.

DDMI retained external experts to prepare Site-Specific Risk-Based Closure Criteria (SSRBCC) that can be considered for closure criteria in addition to or as alternatives to available standards or guidelines as initial closure criteria; for example CCME Guidelines (CCME 1999b). The SSRBCC have been revised to address concerns raised by reviewers and the revised version the documents describing the proposed values and derivation methods are included as Appendix X-8.1 and Appendix X-8.2. DDMI notes in Appendix V when SSRBCC have been proposed as closure criteria.

Concern was expressed by reviewers with regard to using SSRBCC as closure criteria for protection of aquatic life given the existence of WLWB approved AEMP Benchmarks. DDMI accepts this and has exclusively used AEMP Benchmarks as the basis for deriving the proposed closure included in Appendix V.

DDMI understands that water quality closure criteria for the protection of aquatic life are likely the most important closure criteria for the Diavik site given the mine site location on an island in Lac de Gras and the fact that many of the closure designs/concepts have water quality as a key driver. As such DDMI revised the approach for developing water quality closure criteria from that proposed in ICRP V3.2. The approach used to derive the criteria in Appendix V is fully described in the NCRP-WRSA Final Closure Plan referenced in Section 5.2.5 and a summary provided of the approach provided here.

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:

$$CC = EM \times (DF + 1) - (REFO \times DF)$$

where:

CC = Closure Criteria (mg/L)
EM=Effects Magnitude (mg/L)
REFO = Reference Condition – Median Open Water (mg/L)
DF = DF=Dilution Factor (dimensionless).

The Effect Magnitude is defined as being 20% greater than current AEMP Benchmark. This is the defined High Effects Magnitude from Canada (1999). Background water quality for the calculation was assumed to be the median open water concentration as defined in the AEMP Reference Condition Report (DDMI 2015). The DF has been assumed at 85. This value is from the EA (DDMI 1998a - 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 EA (DDMI 1998a - Figure 1-4) and is defined as the “local” assessment area in Canada (1999).

The next step in the approach was to consider “achievability”. Achievability is a specified consideration for both MVLWB and AANDC (MVLWB 2013) and MVLWB (2011). At this time achievability was only considered for the NCRP-WRSA closure criteria because it is the only closure area where final estimates of water quality are available. For all other areas closure criteria achievability will be considered during evaluation of final designs. For the NCRP-WRSA the back calculated closure criteria (described above) was compared against both the predicted NCRP runoff/seepage quality and a graphical compilation of measured seepage results from DDMI's research program. Where the back calculated closure criteria was determined to be not achievable, the water quality parameter was noted and the criteria replaced with a proposed achievable value with rationale.

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. For closure criteria the approach DDMI has taken is that where back calculated closure criteria are substantially greater than the expected future condition, rather than arbitrarily lowering the criteria the parameter was identified as not requiring a closure criterion. As with the achievability review discussed above, consideration of water quality parameters that do not require closure criteria require final estimates of water quality. Again removal of parameters was only considered for NCRP-WRSA closure criteria. For all other closure areas closure criteria are proposed for all back calculated water quality parameters.

Exceptions identified through the process are identified and noted. pH is an example of a parameter where the back calculation approach is not directly applicable. For pH, DDMI has proposed that the water quality closure criteria be the same as the current operations runoff criteria (Part H Item 28).

Additional criteria are proposed to describe how the success of other, non-chemical 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 500 m. 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.

Some of the closure criteria in Appendix V have been developed based on the rationale described above.

5.2.3 Closure Management Areas

For the purpose of closure planning the Diavik mine site has been divided into five closure management areas. These areas are shown in Figure 5-1 and defined in Table 5-9.

Table 5-9 Description of Closure Management Areas

Closure Management Area	Associated Infrastructure/Feature
Waste Rock and Till Storage Area	• Waste rock pile; • Till pile, • Collection Ponds 1, 2, and 3; and • Perimeter roads.
Processed Kimberlite Containment Area	• PKC structure and contents; and • Collection Ponds 4, 5 and 7.
Open Pits, Underground and Dike Area	• A154 and A418 open pits; • A154 and A418 dikes; • Underground mine and all underground infrastructure; • Portal; and • A21 mine area.
North Inlet Area	• North Inlet; and • East and west dikes.

Table 5-9 Description of Closure Management Areas

Closure Management Area	Associated Infrastructure/Feature
Mine Infrastructure	• Collection Ponds 10, 11, 12 and 13; • Ammonium nitrate storage and Explosives Plant; • North Inlet Water Treatment Plant and Sewage Treatment Plant; • Processing Plant; • Paste Plant; • Accommodations buildings; • Power House; • Waste Transfer Area including landfarm; • Roads, airport and air strip; • All other surface buildings, pipelines, power, fuel storage, laydowns, etc.; and • Any infrastructure not included in the other closure areas.

5.2.4 Permanent Closure Requirements – Open Pit, Underground and Dike Area

5.2.4.1 Pre-disturbance, Existing and Final Mine Site Conditions

The A154/A418 and A21 mine areas pre-disturbance are shown in Figure 5-2a. The image is from June 2000. Pre-disturbance conditions are summarized in Section 3 with additional references provided in that section for additional, specific information. There are no specific or unique environmental conditions in these areas.

The existing extent of mine development is shown in Figure 5-2b based on an image from August 2015. Currently the A21 dike embankment is in place with pool dewatering planned for later in 2017 with pre-strip and mining to follow. Figure 5-2c shows the three open-pits at full development (2024). The A418 and A154 mine plans are described in Section 4.4.1 and underground development, which does not show in a plan view, is included in Figure 4-1.

Fish habitat enhancements in the A154, A418 and A21 areas would largely be complete by 2024 as shown in Figure 5-3 and detailed in Appendix X-1, X-2 and X-3 respectively.

5.2.4.2 Closure Objectives and Criteria

Closure objectives applicable to the DDMI underground, open-pit and dike areas include both the site-wide objectives and the area-specific objectives (Appendix V). The guidance provided by INAC (2007) relevant to the underground and open-pit closure objectives is listed in Appendix XIII, Table 1A, and Environment Canada (2009) recommendations for closure practices are listed in Appendix XIII, Table 1B. The DDMI closure objectives for the underground, open-pit and dike areas are consistent with both the INAC and Environment Canada references.

Possible closure criteria are described in Appendix V. Closure criteria are intended to be used to evaluate success in achieving the objective. Closure criteria must be specific and measurable. As discussed in Section 5.2.2, it is recognized that these criteria will be refined over time. The process of ongoing refinement of the criteria will include further discussions with communities and regulators.

5.2.4.3 Preferred and Alternative Closure Options

Closure planning began with the initial mine design work from 1996 to 1998, and many of the important design decisions related to closure occurred at that time. As the mine develops and more is learned about the physical, chemical and biological characteristics of the site, engineered structures and the PK, waste rock and till being managed, the preferred closure options also develop. Closure planning typically involves reviewing benefits and risks for possible closure options. These reviews are both internal to DDMI and external with communities, government and regulators.

The following chronology describes the closure option considerations related to the mine plan, and the resultant preferred option.

5.2.4.3.1 Mine Plan 1996 to 1998

A mine plan describes the method and sequence for extracting the kimberlite resource from the ground. The mining method and sequence are important early decision points for closure. In addition to general footprint and waste rock closure considerations, the mining method also defines the mine workings that will require closure.

A broad range of mining methods was initially evaluated including both conventional and non-conventional methods. Non-conventional methods included jet boring, raise boring, blind drilling and dredging. Conventional methods include open pit and underground mining methods. DDMI did not advance any non-conventional mining methods beyond the initial studies because, in general, they were experimental and found to have an unacceptably high level of technical and economic risk to be used as the basis for a comprehensive mine plan.

Three options based on conventional mining approaches were developed:

- *All underground* – Mining would advance from underground only. Declines or shafts would be developed to gain access to underground workings. A layer of kimberlite (referred to as a crown pillar, about 100 m thick) would be left in the top of the kimberlite pipe to separate the underground workings from the water of Lac de Gras. Lac de Gras would be immediately above the active mine. Water retention dikes were not a part of this alternative.
- *Underground with open pit crown pillar* – Underground mining would advance the same way as Option 1. Additionally, open-pit mining would be used to mine to a depth of 100 m. Three water retention dikes would be constructed and water removed from the open pit areas.
- *Open pit and underground* – Open-pit mining would be used to mine the kimberlite pipes to an elevation of 190 m (A418), 130 m for A154S, 265 m for A154N and 220 m for A21. At these depths it would become economical to shift to underground mining in A154S/N

and A418. Three water retention dikes would be constructed and water removed from the open-pit areas.

One of the clear advantages with Option 1 was that dike construction in Lac de Gras would not be required. Option 1 would eliminate any effects on fish habitat and water quality associated with the dikes and their construction. However, because the health and safety of workers is of primary importance to DDMI, it was determined that it would be cost prohibitive and may not be technically possible to achieve a satisfactory level of safety for an all underground alternative without a dike.

Underground mining displaces less waste rock than open-pit mining. Although both Options 2 and 3 would require storage areas on the East Island for waste rock, the storage area required for Option 2 would be less than Option 3.

Communities have consistently described the importance of using resources wisely. Whereas comments usually referred to the use of land and water, concerns were also expressed about the use of mineral resources. Communities requested that if the natural environment of the East Island was to be disturbed to recover diamonds, that DDMI maximize resource recovery and not just take the easiest parts. Option 3 provided the best opportunity for this community value.

From a diamond recovery perspective, Option 3 produces the most diamonds. Based on estimated capital, operating costs and the value of diamonds produced, it was determined that the mine would not be economically viable without water retention dikes and removal of water from above the crown pillar.

With the removal of the water, the most attractive method of mining was a larger open pit followed by underground mining in the later years. From an economic perspective Option 3 was preferred because it resulted in the lowest overall operating cost per carat recovered and was therefore the most financially robust. Option 3 was clearly the preferred option based on health, safety, environment, community and business considerations.

No significant closure alternatives were evaluated for the open pit, underground and dike areas when selecting the mining method. The obvious closure concept was to flood the open pit and underground mine workings and breach the water retention dikes to rejoin these areas with Lac de Gras.

The final decision from the Environmental Assessment was to proceed with Option 3, a mine plan that involved water retention dikes with open-pit mining and underground mining. It was noted that mine planning is an ongoing process and that alternate mining technologies should be re-evaluated periodically, including alternative or emerging technologies to recover currently uneconomic resources (Canada 1999). The Water License and Land Leases are based on dewatering a portion of Lac de Gras for the purpose of mining the A154 N, A154S, A418 and A21 kimberlite pipes, as per Option 3.

5.2.4.3.2 Original Closure Design – 2001

The original closure design for the open pits, underground and dikes areas are documented in the *Initial Abandonment and Restoration Plan* (DDMI 1999b), the 2001 *Interim*

Abandonment and Restoration Plan (DDMI 2001a), and the 2006 *Interim Closure and Reclamation Plan – Version 2* (DDMI 2006).

Details of the original closure design for the open pits, underground and dike areas described in the references above include:

- Hazardous materials, mobile equipment, pumps and other equipment would be removed from the underground mine workings including lubricants, explosives and glycol. Mobile equipment, pumps and pipelines would be removed from the open pit areas. Thermosyphons, power and instrumentation would be removed from the dikes.
- Surface openings to the underground mine area including all access/egress openings such as vent raises and drill holes would be appropriately sealed to prevent access.
- The end use objective for the closed dike/pit areas would be to create, where appropriate, nursery and rearing fish habitat. Habitat features such as shallow shoals and reefs would be constructed during mining operations in the area between the pit crest and the inside toe of the dike.
- Each of the three open pit mines would be flooded at closure by siphoning water from Lac de Gras into the pit and dike area until water levels inside the pit/dike area equalled the levels in Lac de Gras. Siphon rates would be established to manage water quality in the flooded dike/pit area and ensure no significant drawdown effects on Lac de Gras.
- After adequate water quality was verified in the dike/pit area, each dike would be breached with series of small excavations to reconnect Lac de Gras with the dike/pit areas to facilitate use by aquatic life and navigation by people. Breaches would be kept small to limit water currents and provide preferred fish habitat.
- This closure design was to apply to the A154, A418 and A21 mine areas with the exception that there was no planned underground mining at A21.

The closure design described above is the currently approved closure plan for the open pit and underground area (DDMI 2001a).

5.2.4.3.3 Open Pit, Underground and Dike Area Closure Options

Guidance on generic options for closure of open pits, and underground mine workings are provided in INAC (2007) and those relevant to this area are included in Appendix XIII, Table 1C. These generic options are provided as context for the reader regarding different approaches to closure of open pit and underground mine areas.

5.2.4.3.4 Recent Review

The closure approach for the A418 and A154 open pits, underground and dike areas was not the focus of recent review, in DDMI's understanding. In DDMI's view the closure concept for these areas are appropriately defined for an interim plan and are generally supported by communities and regulators.

It has always been expected that post-closure these areas of the lake behind the breached dikes would form a stable, permanently stagnant lower monimolimnion underlying an upper mixolimnion that circulates regularly (see DIAND 1999 for example). This condition known as meromixis is anticipated because of the combination of higher salinity groundwater continually entering the pits at depth, the pit geometry resulting in very deep water with steep sides, and a relatively small lake surface area protected from wind-driven mixing by the residual dike sections.

An external review of the ICRP in January 2010 raised questions regarding the desirability of meromixis as a post-closure condition for the area and suggested that DDMI should consider options to avoid meromixis. The reviewer states that "*Although we concede this* [meromixis] *is a likely condition, it is certainly not a preferred condition"*. The reviewer also suggested that DDMI consider alternatives to mitigate meromixis including: 1) more openings in the dikes, and 2) prevention of saline mine water discharge into the pit (SENES 2010).

External reviewers also questioned the potential for vertical mixing in the flooded open pits. In response, an initial modelling evaluation was undertaken to determine the mixing potential.

Another study was undertaken to determine how different approaches to filling the pit lakes could influence mixing and turnover characteristics and to determine how water quality in the upper portions of the pit lakes may be affected by different rates of internal mixing and exchange with Lac de Gras. The study found that the depth of the pit lakes relative to the surface dimensions minimize the opportunity for rapid, full turnover events. Additionally, the internal stability of the pit lake appears to increase as its groundwater content increases. (ICRP V3.2).

WLWB (2011) recommended that DDMI "*define and discuss options for avoiding meromixis and clearly articulate why encouraging meromixis is superior to these options*".
DDMI provides the following:

1. Meromixis is the most likely post-closure limnological condition for the pit lakes given the extreme bathymetry formed by the pits: steep sides and very deep water relative to the surface dimensions of the pit lake It is likely only the strength or persistence of the meromixis and the depth of the mixolimnion that can reasonably be influenced by the options suggested. DDMI suggests that the preferred condition is a stable meromixis and a mixolimnion that is deep enough to maintain water quality for aquatic life (especially fish) expected to use the upper reaches of the pit lake, as opposed to a limnological condition that overturns frequently.

2. Post-closure dissolved constituents in the groundwater will diffuse into the flooded pit until the concentration in the flooded pit equals the concentration in the groundwater.

3. Higher total dissolved solids concentrations in the monimolimnion, relative to the mixolimnion, will be caused by groundwater movement into the pit area.
   This concentration difference strengthens the meromixis through differences in density.

4. Water depths of greater than 10 m are considered to be lower suitability habitat for the fish species of Lac de Gras (DDMI 1998e). The closure focus is therefore on the water quality conditions in the upper 10 m zone.

5. A weak meromixis could result in periods of turnover where poorer quality water from the monimolimnion can come to the surface and reduce the water quality conditions in the mixolimnion. The mixolimnion is expected to be greater than 10 m in depth (see ICRP V3.2 - Appendix X-3). A stronger meromixis would provide the best water quality in the surface 10 m because there would be a reduced likelihood of turnover.

6. Fish habitat designs approved for the interior of the dikes intentionally includes small dike breaches. Small dike breaches limit movement of larger fish into the nursing and rearing habitat (DDMI 1998e) and increase primary productivity through shelter from the effects of wind driven currents.

7. The option of providing more or larger breaches in the dikes would negatively impact post-closure conditions both with respect to higher probability of turnover and deviating from the intended function of the approved fish habitat designs.

8. In the absence of a differential head, diffusion of dissolved constituents from groundwater into the flooded pits will continue until an equilibrium exists between flooded pit water and groundwater chemistry. During closure this equilibrium can be obtained sooner by adjusting the mix of lake and groundwater used to flood the pit. The strongest meromixis will occur when this equilibrium is achieved.

9. DDMI is not aware of any practical option to prevent the dissolved elements from groundwater into the flooded pits. Extending the time it takes before a chemical equilibrium is obtained between the groundwater and flooded pit water would reduce the strength of the meromixis and would be less favourable than a strong meromixis.

10. No reviewer has identified a benefit to mitigating meromixis.

For these reasons, DDMI continues to prefer a closure design that enhances a meromixis condition instead of one that weakens the meromixis condition. There does not appear to be sufficient rationale for further consideration or research related to options that weaken meromixis, as such none is planned.

More detail has been developed recently with regard to fill rates and methods (below and Appendix X-7.1 and X-7.2) and DDMI has received input from the Traditional Knowledge Panel regarding pit closure (Appendix IX-1.7). A valuable recommendation was to include additional wildlife ramps in the A418 pit wall that will form part of the post-closure shoreline. DDMI has accepted this recommendation and included it in this CRP.

A related closure option that was considered in the Options Workshop hosted by DDMI in May 2009 was an option to locate an inert landfill in one or more of the open pits at closure (ICRP V3.2 Appendix IX-4). DDMI proposed the option of an in-pit landfill as an additional or alternate landfill site. In concept, inert waste materials would be hauled to the pit bottom at closure, covered with several metres of mine rock and hundreds of metres of water. Opposition was raised at, and subsequent to, the workshop. The opposition seems to be based on what were expressed as: a) DDMI commitments made in the Comprehensive Study Report; and b) conditions of the DDMI Land Leases. It was noted that environmental rationale, as to why an open pit landfill location was inferior to a land-based location, were not provided. DDMI has decided to not advance this in ICRP V3.2. The WLWB has since clarified the on-site burial of inert waste is an approved closure activity (WLWB 2013) however, DDMI continues to hear concerns with the planned burial in the NCRP-WRSA. It appears that all parties understand that during closure it will be necessary to dispose of inert materials at site but it is not clear if in-pit disposal may be a preferred alternative. As noted below in Section 5.2.8, DDMI intends to consider, more fully, in-pit disposal as an alternative as the CRP advances.

Another closure option under consideration by DDMI that could impact on the open-pit and underground closure is the option of returning processed kimberlite to the underground and/or open pit mine areas. This option is discussed further in Section 5.2.6. Post-closure water quality of the flooded pit will be a consideration for this closure option as well as the required depth of water and/or other mitigations to limit the risk that deposited processed kimberlite would be re-suspended and impact on Lac de Gras water quality.

Since ICRP V3.2 DDMI has proceeded with construction of a water retention dike to enable open-pit mining of the A21 kimberlite pipe. The closure plan for this area is the same as for the A154 and A418 dike and open-pit areas and is included in this CRP.

5.2.4.3.5 Preferred Design Concept

The preferred design concept for the underground and pit area is unchanged from the approved concept in the 2001 ICRP.

Designs have been developed for the creation of fish habitat within the A154, A418 and A21 dike areas (see Design Reports included in Appendices X-1, X-2 and X-3). Specific requirements for these areas include:

- the development of shallow rearing habitat and shoreline habitat; and
- ensuring that habitat features within the dikes areas are modelled after features found in other productive areas of Lac de Gras, including depth, substrate type, size and configuration.

The design for the areas between the crest of each pit and the respective dikes is shown in Figure 5-3. Before breaching the dike, run-of-mine rock and till will be placed to create a long narrow reef in the area between the inside toe of the dike and the pit crest. These reefs will be built approximately 2 to 3 m high from run-of-mine rock and will be in areas where the water depth is 5 m. Areas of granular and soft substrates between reefs will be constructed with a 0.5-m-thick layer of till to replicate conditions that existed in the NI. Disturbance of the shoreline may require modification in areas to establish conditions similar to pre-development conditions, which may require the placement of boulders in water depths up to about 5 m.

Breaching the dikes (about 2 to 3 m depth from low water and 30 m wide) will create entrances for fish and some circulation of water. The breach sizes and number have been minimized to restrict water circulation to allow a higher productivity quiescent (motionless) habitat to develop. The minimum size, number and locations of the breaches were determined by Transport Canada based upon requirements for navigation and are a condition of their approval to construct the dikes (*Navigable Waters Protection Act* Approval of August 3, 2000).

The following breaches are planned:

- A154: Two breaches on the north side, three breaches on the east; and
- A418: One breach on the south side and two breaches on the east.
- A21: Breach of causeway and three breaches in the dike.

Breaching will consist of approximately 30-m-wide slots with a minimum water depth of 2 m. Breaching will involve:

- installing turbidity barriers local to the breach construction area;
- excavating granular fill;
- breaking and excavating concrete wall installation guides; and
- breaking and excavating upper portions of the plastic concrete wall.

There are no plans to revisit the number, size or location of these breaches.

Overall, the area will present an opportunity for the creation of shallow water fish-rearing habitat for species such as whitefish. Earthworks associated with habitat creation within the dikes will take place progressively during mining where is practical and safe to do so; however, the actual habitat will not be realized until the dikes are breached and fish can access the area.

Closure of the open pits and underground will begin when underground mining operations end. The decommissioning work for the open pits will consist of:

- removal of mining equipment;
- removal of instrumentation; and
- removal of pipes and pumps from the pit dewatering system.

The underground mine workings within the kimberlite ore will be progressively backfilled during operations in some mine areas but will remain open in others. At closure all underground workings will be flooded. Specific actions proposed for the closure of the A154/A418 underground workings include:

- ventilation raises will be capped with reinforced concrete fitted with ventilation pipes, covered with granular material and re-graded;
- the main decline access on East Island will be closed by constructing a concrete plug and removing ground supports from the portal to prevent public and wildlife access;
- fixed equipment such as piping and wiring that cannot be salvaged will be cleaned and left in place;
- mobile equipment will be removed to surface;
- fuel, lubricants and hydraulic fluids will be removed from all underground locations and shipped off-site;

- explosives and accessories will be removed from the underground storage magazines to off-site locations;
- unused ammonium nitrate and areas with excessive hydrocarbon contamination will be removed or cleaned to the satisfaction of the Inspector;
- after all salvageable equipment has been removed metal mobilization will be suppressed by flooding underground workings to prevent oxygen access; and
- decommissioning of the underground mine will be reviewed by the Inspector before flooding.

After the A418/A154 open pit and underground workings have been fully decommissioned and fish habitat within the open pits completed, the area will flooded. Water will be introduced to the open pit by controlled siphons with discharge pipe ends located in such a way as to minimize surface erosion and reduce the creation of suspended solids in the pool water. It is expected that the A154/A418 open-pit and underground would be flooded at the same time and would require around 6 months (Appendix X-7.1) with two siphon pipelines in A418 and four in A154 (Appendix X-7.2). The flooding rate will ensure that there are no adverse effects on Lac de Gras or Coppermine River water levels. A21 will be flooded separately from A154/A418 and later. Flood time and piping arrangements have not yet been detailed for A21.

The end target for the lake area within the A418/A154/A21 open pit and dike area is productive fish habitat with surface water quality similar to Lac de Gras. The lake area will be very deep with steep sides and relatively small surface area and will be protected from wind-driven mixing by the residual dikes. This lake configuration should result in stable permanently stagnant lower monimolimnion underlying an upper mixolimnion that circulates regularly. Mathematical modelling presented in ICRP V3.2 supports this anticipated condition.

It is anticipated that minor amounts of chemicals dissolved in pit seepage water, such as residual ammonium nitrate, dissolved phosphorus or trace metals, will be introduced into the pool water during flooding. These dissolved and/or suspended constituents will include any residue or precipitates that may have formed on the exposed rock. Because the volume of in-flooding water will be very large compared to the amount of residual elements, the initial water quality is expected to be similar to Lac de Gras (Blowes and Logsdon 1998; Smith 2013). Once the breaches have been excavated into the dikes, water will circulate with Lac de Gras. Preliminary modelling has shown that this circulation will result in a surface layer where the water quality inside the dikes becomes the same as water quality in Lac de Gras. The water deep within the flooded pits is not expected to mix with the overlying water (ICRP V3.2). Over time the deep water in the pit will equilibrate with the natural groundwater chemistry. This meromictic condition will provide better aquatic habitat conditions than if the entire water column regularly mixed as this would introduce more groundwater constituents into the surface waters.

Flooding will continue until the open pits and underground tunnels and mine voids have fully flooded and the water level inside the dike area equals the water level of Lac de Gras. After the filling is complete, water quality monitoring will begin in order to determine chemical profiles within each pit area. The flooded open pits and underground will remain behind the dikes for a minimum of 12 months to allow settling of any generated suspended solids.

After water quality conditions in the open pit meet water license criteria, or are to the satisfaction of the Inspector and following review by the Traditional Knowledge Panel, decommissioning of the dikes will begin to join the pool area with Lac de Gras.

Further work was completed to assist with prediction of water quality conditions after filling the pit and post-closure. The focus was on quantifying the geochemical load from the pit walls to the flood water (see Appendix VIII-1). The studies confirmed that the geochemical loads will not adversely affect final closure water quality given the large volume of water that will be introduced.

The A154/A418 dike wall stability is expected to increase as the dike enclosure is flooded because any differential head across the structure will be removed. Long-term sediment load from the dike embankments is not expected to be a concern because the lake-side of the dikes will have been exposed to wave action since construction, and the mine-side of the dikes will have been washed by precipitation for approximately 10 to 20 years. Post-closure geotechnical stability of the dikes and mine areas will be confirmed by a geotechnical engineer. This stability analysis will be conducted for the Final Design Concept.

Thermosyphons, instrumentation and power lines will be removed from the surface of the A154/A418 dikes.

The anticipated final landscape for the preferred closure option described above is depicted in Figure 5-4. Not shown in Figure 5-4 are the wildlife access ramps to be constructed in the A418 pit along the west shoreline.

5.2.4.4 Reclamation Activities and Associated Engineering and Environmental Work

The general schedule of activities that is currently envisaged for advancing and implementing the preferred closure plan for the open pit, underground and dike area is shown in Figure 5-5. A brief description of each activity is provided here:

- *Mining Activities* – The mine areas are currently expected to be active until 2025 limiting the closure activities.
- *Community and Regulatory Engagement* – Continued engagement is anticipated to refine the closure plans for the mine area. In particular, engagement is envisaged to strengthen Traditional Knowledge review of in-pit disposal, and input into, final fish habitat configuration. Final engagement is anticipated around 2032 to confirm final closure performance.
- *Final Engineering* – Engineering to prepare final design drawings and construction specifications for closure activities would be completed for inclusion with the Final CRP.
- *Complete Fish Habitat Construction* – Any final fish habitat construction work not completed during operations will be completed before back flooding.
- *Decommissioning of Surface Mine Infrastructure* –Mining equipment and associated infrastructure for A418A154/A21 open pits will be removed.

- *Decommissioning of Underground Mine Infrastructure* –A418/A154 underground mining equipment and associated infrastructure will be removed, and surface access locations will be sealed in preparation for flooding.
- *Flood Mine Areas – Clarify Water* –The open pit and underground mine areas will be flooded. Water quality of A154/A418 and A21 pool areas will be monitored. Two years has been allocated to provide time for settling of particulate material.
- *Decommissioning of Dikes* –Breaches in the dikes will be excavated to re-connect Lac de Gras with mine area.
- *Performance Monitoring* – As soon as filling in the pit/dike areas is complete, performance monitoring will begin in preparation for decommissioning the dikes. Emphasis will be placed on water quality in the mine areas followed by monitoring of fish habitat use.
- *Engineering Inspections* – The A154/A418/A21 mine areas will be inspected before flooding and in the years immediately following to review the closure performance.
- *Environmental Effects Monitoring* – In addition to specific performance monitoring, environmental effects monitoring will be conducted on a three-year cycle as a continuation of the Wildlife and Aquatic Effects Monitoring Programs. The frequency of specific elements and the completion date for monitoring would change based on results. Monitoring will continue from operational monitoring but will emphasise closure effects. Key programs will be aquatic effects in Lac de Gras, and wildlife effects.
- *Reclamation Completion Reporting* – Report detailing the work completed, any deviations from the approved design and CRP, “as-built” reports and description of any monitoring still required.
- *Performance Assessment Reporting* – Reports providing a detailed comparison of conditions at site against closure objectives and criteria, identify any residual risk, describe monitoring and maintenance activities and update the security estimate.

5.2.4.5 Residual Effects

Post-closure environmental conditions in the open pit, underground and dike area are expected to improve measurably over the environmental conditions exhibited during operations. Residual environmental effects from operations will, however, still exist post-closure. Potential residual effects of note may include:

- open pits will create areas within Lac de Gras with water depths greater than 200 m and water quality potentially different from the surface water in Lac de Gras;
- initial water quality in the mine areas that may be different from Lac de Gras and may experience turbidity events during high wind/wave events greater than experienced elsewhere in Lac de Gras;
- development of higher primary productivity zones within the original mine areas that is uncommon in Lac de Gras (but beneficial for fish);
- the mine areas will appear differently than pre-development, particularly with regard to the remnants of the dikes and changes to the shoreline; and

- no anticipated residual effects on groundwater (DDMI 1998d).

An assessment of environmental effects at closure was conducted during the EA for the mine (DDMI 1998c). Residual effects are part of the initial assessment of the cumulative effects from all closure areas, which is summarized in Section 9. The identified residual effects fall within the general range of effects considered in the EA.

5.2.4.6 Uncertainties, Risks and Research Plans

Currently, two notable uncertainties have been identified in relation to the open pit, underground and dike areas:

- method for decommissioning the underground workings, recognizing that there is limited time from when pumps are shut off to when the underground area is flooded.
- extent to which materials (processed kimberlite and/or inert building materials) disposed in pit bottom or underground workings may impact on surface or groundwater quality.

Additionally, the "possibility that landslides from pit walls would cause mixing within the pit" is a potential closure uncertainty that needs to be confirmed during final design.

As specifics of the closure designs evolve, other uncertainties will be identified and addressed as part of the engineering process.

The key risk identified by DDMI for this area is:

- risk that deep water from within the mine area will mix with overlaying surface water and create water quality conditions that would impact on aquatic life of Lac de Gras.

Closure Research Plans specific to this area include:

- application of recognized pit lake predictive models to final configurations for flooded A154/A418/A21 pit/dike areas (Appendix VIII-2).

Specific engineering design items to be addressed include:

- approach to disposal of processed kimberlite in underground and/or open pit;
- approach to disposal of inert building waste in underground and/or open pit; and
- evaluation of pit wall stability after flooding with specific emphasis on risk of a wall failure causing mixing of deep water with surface water.

5.2.4.7 Post-Closure Monitoring, Maintenance and Reporting

Specific post-closure monitoring, maintenance plans and reporting requirements will be developed with final closure designs and submitted for approval with the Final Closure and Reclamation Plan. DDMI current concepts for post-closure monitoring and reporting plans for the open pits, underground and dike area are summarized below and in Appendix VI-1.

General guidance relevant to post-closure monitoring of the open pit and underground area provided by the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007) are included in Appendix XIII, Table 1D as general reference material. DDMI anticipates that there will be two types of post-closure monitoring programs: performance monitoring specific to the open-pit, underground, dike areas and environmental effects monitoring which will include combined effects from all post-closure areas. The scope of the performance monitoring will include:

- surface water quality in mine areas and depth profiles to monitor chemocline;
- Total suspended particulate (TSP) and dust deposition/quality measurements;
- geotechnical inspections including observations of subsidence, erosion and thermal condition; and
- wildlife use of the area.

In addition to area-specific monitoring, environmental effects post-closure will be monitored through a continuation of a Post-Closure AEMP in Lac de Gras and a Post-Closure Wildlife Effects Monitoring Program. Monitoring methods will be based on the operations monitoring programs and will be revised along with the monitoring frequency, as appropriate, to focus on any post-closure effects.

Post-Closure maintenance requirements might include:

- repairs to any erosion of dikes or shoreline; and/or
- correction of identified wildlife hazards.

Results of all monitoring and maintenance will be documented in the Performance Assessment Reports. These reports will include any recommendations for future corrective actions or changes to monitoring programs.

5.2.4.8 Post-Reclamation Landscape

The current view of the preferred post-closure landscape for the open-pit, underground and dike area is shown in Figure 5-4. This landscape shows the breach locations in the A21, A154 and A418 mine areas and the sections of the dikes that will remain. DDMI does not expect this final landscape to change considerably moving forward.

5.2.4.9 Contingency Program

Possible contingency actions have been developed based on our current understanding of uncertainties and risks (see Section 5.2.4.6):

- aerial application of lime, alum or a synthetic polymer to assist in clarifying mine area pool water to achieve acceptable water quality before dike breaching;
- surface water extraction from mine area with treatment in the NIWTP and simultaneous replacement with water from Lac de Gras. This would be all be done before dike breaching;
- longer time frames for pool areas to clarify before breaching dikes; and/or
- possibility of not breaching dikes if breaches would put Lac de Gras at significant risk.

DDMI has a relatively high level of confidence that water quality in the mine area will be suitable for the protection of aquatic life in Lac de Gras. The preferred contingency will be to delay breaching the dikes, presuming the water quality issue is related to particulate material that is expected to settle naturally with time.

5.2.5 Permanent Closure Requirements – Waste Rock and Till Storage

At full development there will be two waste rock and till storage areas (WRSA); one on the north of the island containing waste rock and till from mining in A154 and A418, and one on the south of the island with waste rock and till from mining in A21.

A final closure plan has been developed for the NCRP-WRSA and is currently under review by the WLWB. To avoid any confusion or overlap the description of the closure requirements for the NCRP-WRSA have been removed from the CRP V4 and a reader is referred to the NCRP-WRSA Final Closure Plan V1.1 (April 2017). The NCRP-WRSA Final Closure Plan will be integrated into CRP V5 once both plans have been approved.

Development of the South Country Rock Pile (SCRP) WRSA will commence with the pre-stripping of the A21 pit late in 2017. Closure plans for the SCRP-WRSA are not available for CRP V4 because the SCRP-WRSA design must first be submitted and approved. DDMI expects to submit initial closure concepts for review with one of the Annual Closure and Reclamation Plan Progress Reports, since it does not time with the submission of CRP V4.

5.2.6 Permanent Closure Requirements – Processed Kimberlite Containment Area

5.2.6.1 Pre-disturbance, Existing and Final Mine Site Conditions

The valley on the East Island where the PKC was located is shown in a pre-disturbance condition in Figure 5-11a. The image is from June 2000. Pre-disturbance conditions are summarized in Section 3 with additional references provided for more specific information. Lake e10, noted in Figure 5-11a, was identified as being a representative inland lake for fish habitat. Features of this lake were modelled for possible inland lake fish habitat enhancement efforts. Some archaeological sites were identified in the PKC area (Figure 3-29).

Currently the PKC dams have been developed typically to the 465 m elevation as shown in Figure 5-11b using an image from August 2015. The south barge access road, the area for FPK deposition, coarse kimberlite placement and Collection Ponds 4, 5 and 7 are also shown in Figure 5-11b. Coarse PK is currently also being deposited on the FPK beaches on a trial basis.

At maximum development the PKC dams would be raised to an elevation of 475 m. A representation of the PKC at final development in 2024 is shown in Figure 5-11c.

5.2.6.2 Closure Objectives and Criteria

Closure objectives applicable to the PKC area include both site-wide objectives (Appendix V, Table V-1) and area-specific objectives (Appendix V, Table V-4). The guidance provided by INAC (2007) relevant to the PKC closure objectives is listed in Appendix XIII, Table 3A and Environment Canada (2009) recommendations for closure practices are listed in Appendix XIII, Table 3B. These references are included to assist the review of the DDMI PKC objectives.

Appendix V, Tables V-1 and V-4 also describes possible closure criteria. Closure criteria are intended to be used to evaluate success in achieving the objective. The intent of a closure plan is to have closure criteria that are specific and measurable. As discussed in Section 5.2.2, it is recognized that these criteria will be refined over time. The process of ongoing refinement of the criteria will include further discussions with communities and regulators.

5.2.6.3 Preferred and Alternative Closure Options

Closure planning began with the initial mine design work in 1996 to 1998, when many of the important design decisions related to closure were made. As the mine develops and more is learned about the physical, chemical and biological characteristics of the site, engineered structures and the PK being managed, closure plans also advance. Closure planning typically involves reviewing benefits and risks for possible closure options. These reviews are both internal to DDMI and external with communities, government and regulators.

The following chronology describes the closure considerations related to the PKC, and the resultant preferred option.

5.2.6.3.1 Processed Kimberlite Containment Closure Options 1996 to 1998

Two important decisions were made as a part of the original mine design that affect the PKC and closure: the location of the PKC, and the site water management approach.

Three PKC site options (Figure 5-7) were considered in the original mine design and the EA (DDMI 1998c):

- T-lake, a natural topographic feature on the mainland, east of the East Island;
- the central valley on the East Island; and
- a dammed/diked area within Lac de Gras between East Island and West Island.

Option 1 was initially identified as having the best natural features for design of an on-land PKC facility. The steep hills surrounding the lake combined with the deep lake bottom could both accommodate the required storage volumes, and limit the number and extent of engineered structures. The development of a causeway extending from the East Island to the mainland would be required to access the facility. However, T-lake is located toward the mouth of a sizeable drainage basin, which would require water diversion around T-lake for closure.

Option 2 was identified because the only appreciable topography on the East Island was the central valley. Option 2 would provide less natural storage volume than Option 1 but, Option 2 was closer to the open pits, would not require a causeway, and was located in a smaller drainage basin than T-lake (Option 1), thereby providing some water management advantages.

Option 3 was identified as a PKC storage option by damming off as a series of cells and depositing PK into the cells and thus displacing Lac de Gras water. Ultimately, the area would be filled with PK and capped with water. Option 3 would manage any potential geochemical concerns by storing the PK sub-aqueously. This option would also provide the best assurance of long-term (post-closure) physical and geochemical stability. The material would be physically stable because it would be placed below lake levels, and would be geochemically stable because sub-aqueous disposal limits leaching and has a low potential for generation of poor-quality leachate.

All three Options were discussed with communities during initial meetings in June 1997. From the comments and discussions, it was the understanding of DDMI that water is considered to have a very high value, and that it was not appropriate to use areas of Lac de Gras for disposal of significant volumes of PK. These discussions gave Diavik a clear indication that Option 3, while advantageous from a geochemical and closure perspective, would not be considered acceptable by communities. DDMI also understood that there was a general preference to minimize the extent of the development and to keep the footprint of the mine as small as possible. This guided the decision to locate the PKC on the East Island (Option 2) rather than using T-lake (Option 1).

Options for the PKC location were discussed with DFO and reviewed by fisheries biologists. Concern was expressed over the Lac de Gras option because the area between the East and West Islands is shallow, sheltered habitat that is uncommon in Lac de Gras. Permanently removing this habitat for use by fish in Lac de Gras was deemed undesirable. From a fisheries perspective, locating the PKC in either T-lake (Option 1) or the central valley of the East Island (Option 2) was preferred over Lac de Gras (Option 3).

The final decision from the EA and the basis for the Water License and Land Leases is Option 2.

Water management within the PKC was an important consideration in the original mine design 1996 to 1998 (DDMI 1998c). Water management alternatives were reviewed based on the anticipated quality and quantity of the possible source waters. A priority was to match water use requirements with wastewater sources to identify opportunities to recycle and reuse water. Any surplus water quality was evaluated for water treatment requirements and alternatives, and considered for discharge to Lac de Gras. Three primary water sources were identified that required management:

- Runoff from the waste rock areas and plant site infrastructure. This water was expected to contain elevated concentrations of metals leached from the waste rock areas and would require treatment before discharge. Volumes were expected to be around 2,000 m^3/day.
- PK water ponded in the PKC. This water was expected to contain some metals leached from the kimberlite during kimberlite processing and from the containment area. Estimated excess water was expected to be around 2,500 m^3/day, after accounting for recycling and storage within the PKC.
- Mine water. This water was identified as primarily groundwater that seeps into the open pits and underground developments. At full development water volumes were expected to reach 30,000 m^3/day.

The two identified options for water management were based on the general water qualities and quantities and included:

- treat and release the runoff and PK water, and use mine water as makeup for ore processing; or
- treat and release mine water, and use PK and runoff water as makeup for ore processing.

PK contact water and runoff water were identified as having relatively low volumes but the potential to contain elevated metals concentrations. The total estimated water volume of PK water and runoff was very similar to the expected makeup water demand for ore processing. As such, PK and runoff water was considered to be the best waters to use for recycling within the Processing Plant. However, excess water was expected to develop in the PKC. Some of this water would ultimately be contained within the PK, and the remainder would possibly require treatment before discharge.

Option 2 had some distinct advantages over Option 1. Mine water was expected to have the largest volume and to be of good quality, requiring only filtration to remove suspended solids. Mine water was considered to be the higher quality water to discharge.

The final decision from the EA and the basis for required water management was that Option 2 was most favourable.

5.2.6.3.2 Processed Kimberlite Containment Closure Options

Guidance on generic options for closure of tailings areas provided in INAC (2007) and relevant to the PKC area are included in Appendix XIII, Table 3C. These generic options are provided as context for different approaches to closure of the PKC.

5.2.6.3.3 Approved Closure Design – 2001

The closure design approved for the PKC is documented in the *Initial Abandonment and Restoration Plan* (DDMI 1999b), the 2001 *Interim Abandonment and Restoration Plan* (DDMI 2001a), the 2006 *Interim Closure and Reclamation Plan – Version 2* (DDMI 2006) and the *Processed Kimberlite Containment Facility Engineering Updated Design Report* (NKSL 2001).

The 2001 approved closure design concept is shown in Figure 5-12. Note from the figure that the final surface of the PKC facility is domed in the centre and graded downwards towards the perimeter to promote drainage of meteoric waters to a single controlled discharge point. This plan includes a 5 m thick rock spacer over the central pond that has been filled with CPK and/or FPK. Final covers are then placed over the rock spacer, consisting of 1 m of till and 3 m of Type I rock. The PK beaches are covered by a 0.5 m thick till cover and a 3 m thick cover of Type I rock. The spacer allows for consolidation and storage of seepage water expelled during consolidation. The intent of they cover system is to prevent infiltration, prevent wind/water erosion and keep PK permanently frozen.

The PKC is not included as an area for re-vegetation.

5.2.6.3.4 2009 to 2010 Review

DDMI undertook a critical review of the approved closure design concept for the PKC facility. Operational considerations were also included in this review. The review was guided by information, review and experience gained to date from the following:

- PKC pool water chemistry;
- operational PKC seepage;
- PKC water balance;

- 2006 and 2009 ICRP review comments;
- PK deposition and material balance; and
- the physical properties of FPK.

Identified challenges associated with the domed approach included:

- constructability, particularly the rock dome over the slimes area;
- ability to keep rain and snow melt separated from expelled pore water using a till barrier given the degree of anticipated differential settlement; and
- ability to maintain a graded, positive drainage channel on the surface of the facility because of the expected formation of thermokarst topography above the central pond/slimes area of the PKC facility.

The approved closure design concept for the PKC was based on an impermeable till cover over the PKC such that rain and snowmelt would be shed from the facility without infiltrating to the underlying PK material. However, it is unlikely that either a till or impermeable cover could maintain its integrity over the long term given the expected amount of consolidation and settlement. In this case it would not achieve the expected performance objective of preventing snow melt and rain fall from contacting PK. Because of the unlikely reliability of an impermeable layer, DDMI has determined that the intended performance objective for the approved closure design concept is not achievable.

Furthermore, the 2009 to 2010 review questioned the requirement to prevent snow melt and rain fall from coming in contact with PK. The current chemistry of the PKC pond (Surveillance Network Program [SNP] 1645-16, 2011-2016, N=72) is listed in Table 5-10. The probable range of water quality is represented as the range between the low (25^{th} percentile) and the high (75^{th} percentile). Excluding values lower than or higher than this range eliminates focus on possible outliers. This PKC pond water has been recycled through the Processing Plant where the water is slurried with PK, and has been stored within the PKC where the water is in direct contact with PK. Using operational effluent quality criteria as a benchmark, the water currently within the PKC pond, with partial removal of suspended particulate material, is generally of suitable quality to discharge to Lac de Gras. Parameters of note that currently approach or exceed the operation discharge criteria are zinc and pH.

Table 5-10 Processed Kimberlite Containment Water Quality (SNP 1645-16, 2011-2016, N=72)

	Units	Total		Dissolved	
		25th Percentile	75th Percentile	25th Percentile	75th Percentile
Silver (Ag)	mg/L	<0.000005	0.00001	<0.000005	<0.000005
Aluminum (Al)	mg/L	0.0646	0.250	0.00125	0.00840
Arsenic (As)	mg/L	0.00121	0.00261	0.00131	0.00314
Barium (Ba)	mg/L	0.103	0.165	0.0871	0.131
Beryllium (Be)	mg/L	<0.00001	<0.00001	<0.00001	<0.00001
Bismuth (Bi)	mg/L	<0.0001	<0.0001	<0.00005	<0.00005
Boron (B)	mg/L	0.0250	0.0590	0.0250	0.0551
Calcium (Ca)	mg/L	27.85	42.50	27.05	40.70
Cadmium (Cd)	mg/L	0.00001	0.00005	<0.000005	0.00002
Chloride (Cl)	mg/L			73.5	105.0
Cobalt (Co)	mg/L	0.00038	0.00131	0.00014	0.00027
Chromium (Cr)	mg/L	0.00169	0.00689	0.00025	0.00092
Copper (Cu)	mg/L	0.00056	0.00154	0.00028	0.00041
Iron (Fe)	mg/L	0.1735	0.6830	0.0005	0.0025
Mercury (Hg)	mg/L	<0.00001	<0.00001	<0.00001	<0.00001
Potassium (K)	mg/L	71.0	156.5	67.9	157.5
Magnesium (Mg)	mg/L	16.55	45.35	14.15	43.00
Manganese (Mn)	mg/L	0.0097	0.0338	0.00206	0.01315
Molybdenum (Mo)	mg/L	0.215	0.313	0.216	0.317
Sodium (Na)	mg/L	69.60	120.00	65.95	116.50
Nickel (Ni)	mg/L	0.0121	0.0349	0.00671	0.0176
Lead (Pb)	mg/L	0.0001	0.0003	0.00001	0.00002
Sulphate (SO_4)	mg/L			226.5	373.5
Strontium (Sr)	mg/L	0.765	1.285	0.761	1.230
Titanium (Ti)	mg/L	0.00454	0.0205	<0.0005	<0.0005
Uranium (U)	mg/L	0.00074	0.00387	0.00046	0.00382

Table 5-10 Processed Kimberlite Containment Water Quality (SNP 1645-16, 2011-2016, N=72) (continued)

	Units	Total		Dissolved	
		25th Percentile	75th Percentile	25th Percentile	75th Percentile
Vanadium (V)	mg/L	0.00084	0.00209	0.00050	0.00115
Zinc (Zn)	mg/L	0.00165	0.00583	0.00019	0.00054
pH	pH units	7.97	9.04		
Alkalinity	mg/L	47.6	66.7		
Electrical Conductivity (EC)	µS/cm	1237.3	1936.0		
Total Dissolved Solids	mg/L			646	989
Temperature	°C	1.25	6.45		
Carbonate (CO_3)	mg/L	<0.5	<0.5		
Bicarbonate (HCO_3)	mg/L	57.4	80.9		
Total Organic Carbon (TOC)	mg/L	2.75	4.28		
Dissolved Organic Carbon (DOC)	mg/L			2.07	3.50
Dissolved Oxygen (DO)	mg/L			8.5	11.3
Total Phosphorus (P)	mg/L	0.02	0.06		
Nitrite (NO_2) (as N)	mg/L	0.76	2.22		
Nitrate (NO_3) (as N)	mg/L	14.5	30.2		
Ammonia (NH_3) (as N)	mg/L	1.15	3.75		
NO_2+NO_3	mg/L	15.0	32.8		
Total Kjeldahl Nitrogen (TKN)	mg/L	0.50	3.30		
Total Suspended Solids	mg/L	2.0	9.0		
Turbidity	NTU	2.6	8.7		

mg/L = milligrams per litre; µS/cm = micro Siemens per centimetre; °C = degrees Celsius; <= less than.

The PKC continues to have a negative water balance compared to original predictions because of the conservative assumptions for some variables, in particular, sublimation, evaporation and runoff in the PKC. Other potential water losses that are not accounted for in the water balance could include ice entrapment and seepage. Several attempts have been made to quantify ice entrapment within the PKC facility, including ground penetrating radar investigations and piezocone testing. Results have been inconclusive and further attempts are not planned. Ice entrapment affects storage capacity, the changes to which are captured in annual bathymetry and topographic surveys.

DDMI manages operational seepage from the PKC. The majority of the seepage reports to Collection Ponds 4 and 5. Some of the seepage has occurred due to damage to the synthetic liner and ponding of water directly against the impoundment structure. Repairs have been made to the liners and long beaches are developing between the PKC pond and the perimeter dams. With regard to closure planning, the seepage issues observed to date have emphasized the importance of developing long beaches but it has also shown that the seepage water is very clear and of relatively good quality, in many cases seepage water quality is well within operational discharge limits.

The closure design review resulted in DDMI developing an alternative closure design concept that was approved by the WLWB May 14, 2014.

5.2.6.3.5 Approved Closure Design – 2014

The current approved closure concept for the PKC, and the basis for it, is described more fully in Appendix X-5 *Diavik Diamond Mine PKC Facility Revised Closure Concept.* This revised closure concept was also the subject of the specific TK Panel session at the mine site in October 2013. The report from that panel session is included in Appendix IX-1.5.

This preferred closure concept for the PKC is shown as an illustration in Figure 5-14.

Processed kimberlite would be deposited into the PKC in such a way that at the end of operations the PK beaches slope inward to a low point in the southeast corner. A surface water pond would be expected to remain at this low point post-closure. The pond would be expected to vary in size and geometry with seasonal changes in water levels, with ongoing consolidation and with freeze/thaw cycles of the PK beaches.

The characteristics of the PK beaches are expected to vary from the perimeter of the facility towards the centre. A large portion will be coarser, free-draining, consolidated materials that will extend from the facility perimeter. Near the surface this material will be well drained, but at some depth it will be saturated and at some deeper depth it will likely be both frozen and saturated.

Towards the centre of the facility there would likely be ponded surface water. At some depth the ponded water would change from being relatively clear water to being unconsolidated FPK or slimes. It is expected there would be a sizeable depth of these slimes and then a growing depth of more consolidated material below.

A transitional zone would occur between the perimeter beaches and the pond shoreline. This transitional zone would be variably ice, ice lenses, thermokarst and consolidated PK.

The steps to achieve this configuration given the current development status of the PKC Facility are anticipated as follows:

- The FPK discharge lines would be extended toward the center of the facility for optimized discharge of FPK slurry during the final years of processing, with the goal of reducing the pond size from an operating to a closure configuration.
- The beach and transition areas outside the closure configuration pond area would be covered by enough Type I (non-PAG) waste rock or rock fill material (placement of which could be started during operations as progressive reclamation) to be sufficient for erosion protection of the underlying PK. The rock cover would parallel the final PK surface.
- At the end of active FPK discharge, the reclaim water pond would be lowered by pumping to the NI for treatment and discharge.
- Waste rock would be progressively placed toward the centre of the facility as the FPK beach areas start to freeze.
- The closure spillway would be constructed at an elevation that would maintain a smaller central pond, which would spill to the south via the open channel closure spillway, with the overflow then passing through a series of small ponds and streams prior to entering Lac de Gras.
- When enough rock cover is placed to meet closure objectives, with advance well into the area that will be within the closure pond, the facility would be allowed to naturally fill with water up to the spillway invert elevation. The purpose of advancing the rock cover into the closure pond area is to ensure a stable shoreline for wildlife and minimize or prevent any areas of exposed semi-fluid FPK.

Under this closure plan, the objective would be to carry out as much closure effort as possible during mine operations.

This concept was selected based on the following considerations:

- A concave “bowl” shaped waste rock cover is the preferred alternative as it provides sufficient erosion protection to the underlying FPK and would result in less consolidation than a very thick cover. The waste rock/rockfill cover over the CPK and the FPK areas is not required for geochemical or thermal purposes – solely for erosion protection.
- The FPK will begin to freeze in areas where the water pond was removed, which will support the final rock cover.
- It is preferable to keep the high silt and clay content (semi-fluid) FPK in place rather than risk the multiple uncertainties associated with rehandling and possibly treating the material. Although there is uncertainty as to the time required for sufficient freezing of the FPK transition area to achieve any significant incursion of rock cover within the limits of the current reclaim water pond, which is more extensive than the planned final water pond, it is preferable to the risks of rehandling and treating the semi-fluid FPK.
- Removal of the semi-fluid FPK material is a contingency measure. The decision to remove the material will be made if construction of the waste rock cover into the closure pond area proves impractical, either during closure construction or during final constructability analysis. The ability of semi-fluid FPK transition area to freeze under the aforementioned conditions has been predicted by thermal modelling and will be confirmed through field tests.

- Minimizing the post-closure pond size will enable the greatest extent of permafrost development within the PKC Facility, enhancing seepage control.
- Including a pond in the final design specifically plans for mitigation of long-term processes that could be problematic with a dry dome-shaped cover. These include consolidation of semi-fluid FPK, porewater freeze-out, ground ice development, etc. which could leave an unstable, dynamic, terrestrial surface landscape within the central area of the PKC Facility where the reclaim water pond was located during operations.

The advantages of this revised closure concept design are:

- Improves overall post-closure performance relative to the DDMI closure goals and objectives as compared to previous closure concepts;
- Constructability – the original concept was not constructible and in concept, the revised design is constructible in a reasonable time frame;
- Material quantities – the central pond design minimizes the need for additional materials, improving practicality and reducing costs; and
- Allows for progressive reclamation opportunities with cover placement starting during operations. Progressive reclamation allows construction procedures to be confirmed during operations when all available resources are on site.

The revised closure concept design remains at a conceptual level. Knowledge about the PKC Facility properties continues to improve along with information regarding community preferences and concerns around closure landscapes. DDMI continues to improve site knowledge through ongoing monitoring, full scale trials of different proportions of FPK to CPK and studies intended to address remaining uncertainties and advance the design from a the current approved concept to a final design (around 2020).

Most recently DDMI has advanced consideration of depositing PK back into a completed underground and/or open-pit mine area. If feasible this option could enhance closure and possibly operation of this facility. DDMI conducted initial engagement with the TK Panel, communities and regulators in this regard to ensure there were no fundamental objections to this concept. While it was recognized that DDMI will need to provide more specifics and continue this engagement, the general responses received were favourable. At least one community member noted that it makes sense to put this material “back where it came from”. Regulators noted that the depositing of PK into a completed mine area was currently being conducted on a trial basis at the Ekati Mine. DDMI was encouraged by all of the feedback and on this basis has advanced feasibility considerations.

The closure scope for the PKC also includes:

- removal of all pipelines and power lines;
- removal of reclaim barge; and
- decommissioning of collection Ponds 4, 5, 7 and 12 after acceptable water quality can be demonstrated.

5.2.6.4 Closure Activities and Associated Engineering and Environmental Work

The general schedule of activities currently envisaged for advancing and implementing the current approved closure plan for the PKC area is shown in Figure 5-15. A brief description of each activity is described in the following.

- *PK Deposition* – The PKC is an active facility and will be active until the last day of diamond production (currently 2025). Closure activities and associated works must consider these ongoing operations.
- *PKC Options Evaluations* – Includes evaluation of option to deposit PK to a completed underground/or open-pit mine area and changes to the CPK to FPK ratio. Benefits and cost to both closure and operations will be considered.
- *Community and Regulatory Engagement* – Continued engagement is anticipated to continually refine the closure plans for the PKC. In particular, engagement, which includes the integration of Traditional Knowledge, is envisaged for options and closure criteria for wildlife. Final engagement is anticipated around 2032 to confirm final closure performance.
- *Final Engineering* – A final engineering closure design for the PKC will be completed and submitted for review in 2020. This design will incorporate findings from engineering and environmental studies, research, community and regulatory engagement.
- *Placement of Final Surface and Wildlife Access* – Rock placement will be required to prepare final PK surface, construct access routes around the PKC and re-slope access ramps.
- *Outlet Preparation* – Deconstruction of a section of PKC liner and preparation of an engineered water outlet will be required.
- *Decommissioning of Collection Ponds* – When outlet and seepage water quality/quantity have been confirmed, Collection Ponds 4, 5 and 7 will be decommissioned.
- *Infrastructure Decommissioning* – The reclaim barge, water and slurry pipelines, power and any associated surface infrastructure will be removed.
- *Performance Monitoring* – A specific performance monitoring program will be conducted starting in 2026 and is anticipated to last seven years. This program will include monitoring seepage and outlet water quality, dust deposition, ground temperature, settlement and wildlife interaction.
- *Engineering Inspections* – Inspections will be conducted during the closure work and in the years immediately following to review the closure performance.
- *Environmental Effects Monitoring* – In addition to specific performance monitoring, environmental effects monitoring will be conducted on a three-year cycle as a continuation of the Wildlife and Aquatics Effects Monitoring Programs. The frequency of specific elements and the completion date for monitoring would change based on results. Monitoring will continue from operational monitoring but will emphasise closure effects. Key programs will be aquatic effects in Lac de Gras and wildlife effects.

- *Reclamation Completion Reporting* – Report detailing the work completed, any deviations from the approved design and CRP, "as-built" reports and description of any monitoring still required.
- *Performance Assessment Reporting* – Reports providing a detailed comparison of conditions at site against closure objectives and criteria, identify any residual risk, describe monitoring and maintenance activities and update the security estimate.

5.2.6.5 Residual Effects

Residual environmental effects will exist even with the full implementation of the approved closure plan for the PKC. Potential residual effects of note include the following:

- the PKC structure is a significant landscape feature that did not exist pre-development and will remain visibly different;
- a permanent loss of the vegetation and associated wildlife habitat and some archaeological information that was covered by the PKC facility;
- an increase in the area of "human disturbed" category of vegetation/land cover (VLC) type;
- seepage/runoff water quality and quantity that will be different from pre-development water quality. Water quality in some inland lakes and streams could have significantly higher concentrations of dissolved and particulate elements than pre-development;
- some small inland waterbodies and ephemeral streams will be permanently covered by the PKC facility;
- the PKC facility may become a new attractant to caribou (e.g., for insect avoidance); and
- dust may be generated from the PKC facility and from new rock surfaces, which would be deposited on adjacent vegetation or waterbodies.

An assessment of environmental effects at closure was conducted during the EA for the mine (DDMI 1998c). Residual effects are part of the initial assessment of the cumulative effects from all closure areas, which is summarized in Section 9. Changes to the closure design concept may result in changes to residual effects, particularly with a more explicit inclusion of PKC water in the outlet water from the facility. These changes will be assessed when appropriate closure design and expected performance information are available.

5.2.6.6 Uncertainties, Risks and Research Plans

There are several uncertainties that have been identified with the current approved closure approach. These uncertainties will be reduced as the engineering designs evolve and incorporate results from ongoing monitoring studies and possible inclusion of additional disposal options. Current uncertainties include but are not limited to the following:

- post-closure thermal conditions, particularly as they relate to long-term seepage control;
- post-closure pond water quality;
- post-closure shoreline stability along the residual water pond;
- closure thermal conditions of beaches and the transition to semi-fluid FPK material;

- community preferences and concerns around closure landscape;
- long-term performance of a rock drain spillway;
- optimizations of the operation of the PKC for possible improvements in expected closure performance;
- outlet water quality/quantity;
- seepage water quality/quantity;

Three primary closure risks have been identified by DDMI:

- outlet water quality/quantity that is not adequate for release into Lac de Gras;
- seepage water quality/quantity that is not adequate for release into Lac de Gras; and
- significant continued consolidation of the PK post-closure that could result in cracking and slumping of the surface, creating unsafe conditions for people and wildlife particularly in proximity to the shoreline of the planned closure pond.

Water quality has been included as closure risk because, despite the positive indications from the operational water quality monitoring and geochemistry research, post-closure water quality has not been fully evaluated. This evaluation depends on the closure configuration and design which have not yet been finalized and enhancement options are still under consideration. Once the closure configuration is defined geochemical performance can be better assessed and water quality predicted. Until then water quality will remain as a significant closure uncertainty.

5.2.6.6.1 Closure Research

Specific research activities that are anticipated to provide specific input into the PKC closure design are described in Appendix VIII and include the following:

- PK in situ geochemical properties;
- Interpretation of laboratory column studies; and
- Prediction of outlet and seepage water quality.

Separately, DDMI initiated full scale field trials to evaluate an operational change in the process plant related to the proportion of FPK and CPK produced. This trial is ongoing and reported separately to the WLWB under DDMI's management plans. The results of this trial are also expected to help inform closure planning for the PKC.

5.2.6.7 Post-Closure Monitoring, Maintenance and Reporting

Specific post-closure monitoring, maintenance plans and reporting requirements will be developed with final closure designs and submitted for approval with the Final Closure and Reclamation Plan. DDMI current concepts for post-closure monitoring and reporting plans for this area are summarized in this Section and in Appendix VI-3.

General guidance relevant to post-closure monitoring of the PKC area is provided by the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007) are included in Appendix XIII, Table 3D as general reference material. DDMI anticipates that there will be two types of post-closure monitoring programs: performance monitoring specific to the PKC area and environmental effects monitoring which would include combined effects from all post-closure areas. The scope of the performance monitoring will include:

- seepage and runoff quality and quantity using a system similar to the SNP;
- TSP and deposition/quality measurements of any dust generated from the closed PKC;
- geotechnical inspections including observations of settlement, erosion, surface drainage and thermal condition; and
- wildlife use of the area.

In addition to area-specific monitoring, post-closure environmental effects will be monitored through a continuation of a Post-Closure AEMP in Lac de Gras and a Post-Closure Wildlife Effects Monitoring Program. Monitoring methods will be drawn from the operations monitoring programs. The program and monitoring frequency will be revised, as appropriate, to focus on post-closure monitoring questions.

Post-closure maintenance requirements might include the following:

- repairs to PKC beach cover and pond shoreline areas;
- repairs to spillway or wildlife routes or barriers;
- repairs to drainage routes; and/or
- corrections to any identified wildlife hazards.

Results of all monitoring and maintenance will be documented in the Performance Assessment Reports. These reports will include any recommendations for future corrective actions or changes to monitoring programs.

5.2.6.8 Post-Closure Landscape

The current view of the current approved post-closure landscape for the PKC is shown in Figure 5-13 and includes the following:

- rock cover for wind and erosion protections;
- a PKC pond;
- a PKC drainage outlet;
- re-establishment of drainage channels at Ponds 4, 5 and 7 (Figure 5-13);
- specific barriers to access for people and wildlife (Figure 5-13); and
- removal of all pipes, buildings, power lines and reclaim barge.

DDMI accepts that the final landscape could change, in particular wildlife routings, final contours and surface textures, as a result of future Traditional Knowledge considerations. The landscape could also change depending on the outcome of the ongoing options evaluations.

5.2.6.9 Contingency Plan

Possible contingency actions have been developed based on our current understanding of uncertainties and risks (see Section 5.2.6.6):

- collect and treat outlet water until quality/quantity is adequate for release into Lac de Gras;
- collect and treat seepage water until quality/quantity is adequate for release into Lac de Gras;
- regular surface maintenance to repair surface cracks/slumps; and
- enhance passive treatment processes in drainage network downstream of PKC outlet.

Currently there is a high level of uncertainty around seepage and outlet post-closure water quality. While plans are in place to reduce this uncertainty, it is unlikely that the uncertainty related to post-closure water quality will be eliminated before the final closure plan will be submitted in 2020. However DDMI has a high level of confidence in the preferred contingency plan of continuing to collect and treat seepage and/or outlet water if the quality of these waters is inadequate. Passive wetland treatment in a northern climate is unlikely to be a significant mitigation for low quality seepage or outflow water and so has not been considered further.

The NIWTP has a limited ability to remove dissolved metals. This is not expected to be a limitation during operations. If post-closure seepage or outflow water quality requires treatment for dissolved metals that is beyond the capabilities of the NIWTP, these treatment capabilities would then need to be added as part of the contingency plan. DDMI previously developed the necessary designs for treatment of PKC water (*Diavik Diamonds Project – Supporting Documentation – Class A Water License Application Volume II-A Part C, DDMI 1999a)*.

5.2.7 Permanent Closure Requirements – North Inlet

5.2.7.1 Pre-disturbance, Existing and Final Mine Site Conditions

The NI of Lac de Gras is shown in a pre-disturbance condition in Figure 5-16a. The image is from June 2000. Pre-disturbance conditions are summarized in Section 3 with additional references provided for more specific information. No specific or unique environmental conditions were identified in this area.

Currently the NI area is fully developed with east and west dams to provide contingency water storage capacity, as shown in Figure 5-16b using an image from August 2015. Figure 5-16c shows final development of the NI in 2024 which is similar to the existing conditions (Figure 5-16b).

5.2.7.2 Closure Objectives and Criteria

Closure objectives applicable to the NI area include both site-wide objectives (Appendix V, Table V-1) and area-specific objectives (Appendix V, Table V-5). The guidance provided by INAC (2007) relevant to the NI closure objectives is provided in Appendix XIII, Table 4A and the Environment Canada (2009) recommendations for closure practices are listed in Appendix XIII, Table 4B. These references are included to assist in the review of the DDMI objective for the NI.

Appendix V, Tables V-1 and V-5 also describes possible closure criteria. Closure criteria are intended to be used to evaluate success in achieving the objective. The intent of a closure plan is to have closure criteria that are specific and measurable. As discussed in Section 5.2.2, it is recognized that these criteria will be refined over time. The process of ongoing refinement of the criteria will include further discussions with communities and regulators.

5.2.7.3 Preferred and Alternative Closure Options

Closure of the NI has been included in plans since the initial mine design work in 1996 to 1998. The following chronology describes the closure option considerations related to the NI, and the resultant preferred option.

5.2.7.3.1 North Inlet Plan 1996 to 1998

The NI was identified as an integral component of the water treatment system. The NI was designed to function as both an initial settling pond and as an equalization basin before treatment in the NIWTP. From a closure perspective it was identified that, because the NI would receive dredged sediment, wastewater and backwash sludge throughout operations, it may not be appropriate to reconnect the NI to Lac de Gras at closure. This arrangement was the basis for the Water License and Land Leases.

5.2.7.3.2 North Inlet Closure Options

Guidance on generic options for closure of water management facilities that are provided in INAC (2007), and those relevant to the NI are included in Appendix XIII, Table 4C. These generic options are provided as context for different approaches to close the NI.

5.2.7.3.3 Original Closure Designs – 2001 and 2006

The original closure design for the NI is documented in the *Initial Abandonment and Restoration Plan* (DDMI 1999b), the 2001 *Interim Abandonment and Restoration Plan* (DDMI 2001a), and the 2006 *Interim Closure and Reclamation Plan – Version 2* (DDMI 2006).

The original design for the NI included three dams: one on the east side and one on the west side to create water containment; and a third intermediate dike to separate mine water in the west from dredged sediments and any settled solids in the east. The plan for closure was that the intermediate dam would remain in place to permanently contain the settled materials. Seepage through the intermediate dam would maintain water levels in the west compartment at the same levels as Lac de Gras. Accumulated material in the east compartment would be evaluated to determine if the east area could be returned to productive aquatic habitat, similar to Lac de Gras. If habitat could be established in the east cell, the east dam would be breached to allow fish passage and water circulation. If sediment quality was not adequate for aquatic life, then a section of the east dam would be excavated and replaced with run-of-mine rock. This rock would act as a permeable barrier that would allow water movement while containing sediments within the NI and preventing fish from entering the NI.

By 2006 the operational plans had changed. An intermediate dam in the NI was no longer required because lakebed sediments from A154 and A418 dike construction had been placed in the On-Land Dredged Sediment Containment Structure. DDMI had also undertaken an initial ecological investigation to characterize backwash from the NIWTP that discharges to the NI, and a review of alternative disposal option. The ecological characterization did not identify any material properties that would be expected to prohibit the establishment of productive aquatic habitat. Ammonia was identified as the main constituent of toxicological concern in the sludge, sludge pore water and sludge leachate (de Rosemond and Liber 2005). The main disposal alternative considered was to discharge the sludge onto the waste rock pile to fill the voids in the waste rock. DDMI concluded that this alternative would increase the risk of poor-quality seepage from the waste rock area. The waste rock voids are important to facilitate convective cooling and permafrost development in the pile and to permanently store any water that infiltrates the waste rock pile.

The closure plan for the NI outlined in the 2006 ICRP (DDMI 2006) was revised to account for the elimination of the intermediate dike. The 2006 ICRP expected that discharge water quality criteria could be met in the NI, and that the east dam of the NI would be breached to allow fish passage and water circulation. If the quality of sediment collected within the NI over the mine life was not appropriate for aquatic life, a section of the east dam would be excavated and replaced with run-of-mine rock. This rock fill would act as a permeable barrier allowing movement of water but would preclude fish migration into, and sediment transport out of the NI.

5.2.7.3.4 2009 to 2010 Review

At the Options Workshop hosted by DDMI in May 2009 three closure options for the NI were discussed:

- a hydraulic connection to Lac de Gras that would allow movement of water to maintain water levels but would not allow movement of fish;
- an open connection to Lac de Gras that would allow full exchange of water and fish with Lac de Gras; and
- no connection with Lac de Gras to prevent water exchange with Lac de Gras

Advantages and disadvantages of these three options were discussed at the workshop and general conclusion was that the objective should be to reconnect the NI with Lac de Gras. Reconnecting the NI with Lac de Gras was added as the closure objective (NI-1) for this facility in ICRP V3.2. However, if NI sediment quality is not appropriate for aquatic life then a section of the east dike will be excavated and replaced with run of mine rock. This is the current approved closure design concept for the NI.

5.2.7.3.5 2011 to 2016 Review

The NI is an integral component of the site water management and water treatment system. It provides equalization of water volumes and a level of pre-treatment through particulate settling, volatilization and biological uptake. The NIWTP removes material from the NI water through chemically enhanced coagulation/flocculation before it is discharged to Lac de Gras. Material that is removed accumulates in the bottom of the clarifiers. This back wash/sludge is periodically removed, via pipeline, to the NI.

In the NI the back wash/sludge accumulates on the bottom as sediment. This accumulated sediment has the potential to impact on the suitability of the NI for closure. Possible impacts could include physical and chemical alterations to the sediment that might make them unsuitable for fish, fish habitat or become a source of contamination to Lac de Gras.

Multiple investigations of NI sediments and sludge occurred between 2011 and 2016 and these are summarized in the *Consolidated Report: North Inlet Sludge Management Report and North Inlet Hydrocarbon Investigation Report* (Golder 2016c) approved by the WLWB as a requirement of W2015L2-0001-Part H. Golder (2016) includes technical evaluations of:

- 2015 NI sediment quality investigation (an extension of previous studies)
- NI hydrocarbon investigation; and
- NI sludge management evaluation.

The main findings of the 2015 NI sediment and sludge investigation study were:

- The sediments of the NI exhibit elevated concentrations of several analytes, including metals, some individual polycyclic aromatic hydrocarbons (PAHs), and petroleum hydrocarbons (PHCs; F2 and F3). The concentrations of PAHs and metals, although above guidelines, are not of a magnitude expected to translate into substantial biological or toxicological responses. The maximum concentrations of PHCs, however, are in the range for which impairment of freshwater biological communities has been documented at other sites.
- Sediment toxicity was observed in some NI sediment samples, confirming the findings of previous studies. Survival and/or growth of *Hyalella* and *Chironomus* was affected in sediment samples from the four sites closest to the sludge discharge relatively unaffected at the one furthest site.
- A general pattern of reduced toxicity near the mouth of the inlet relative to the head of the inlet (point of sludge discharge) has been identified in multiple sampling rounds.
- Full strength and unfiltered (100% v/v) sludge samples had an effect on 10-day survival of *Hyalella* in aqueous testing of sludge. There were differences in the observed toxicity of the two sludge samples (from the two treatment plants), but the LC_{20} values were similar (i.e., sludge from both plants estimated to exhibit toxicity at the approximately 50% v/v exposure level.
- Based on concentrations of parameters (relative to reference concentrations and guidelines), chemistry-toxicity correlations, chemistry-benthic community correlations, and visual examination of patterns of exposure-response, PHC F3 appears to be the main chemical stressor causing toxicity and impairment to the benthic community in the NI. This is supported by a previous Toxicity Identification Evaluation (TIE) study that documented reduction of toxicity with treatment of NI porewater samples by solid phase extraction to remove organic compounds.
- Although several metals were initially identified as constituents of potential concern (COPCs), they were not considered likely toxicants because the concentration-response patterns did not support their role in influencing responses. Moreover, the NI porewater toxicity investigation concluded that the magnitude and pattern of metal concentrations in porewater did not explain the observed toxicity.

- The potential role of physical factors (e.g., substrate type) cannot be discounted as a contributing factor. A layer of unconsolidated material is present on the sediment surface at the western end (i.e., the head) of the NI and appears to be related to sludge discharge. The NIWTP sludge discharge occurs as a slurry-like condition near the head of the NI, with the thickness of the unconsolidated layer decreasing with distance from the zone of release. This spatial pattern matches that of the PHC exposure gradient and that of the biological effects measures. It is plausible that both chemical and physical/substrate conditions are stressors to the resident benthic communities.
- Based on comparisons of results from 2015 to those from 2010 to 2013, it appears that conditions in the NI may be improving. Several indicators support this conclusion, including the following:
    - PHC F3 concentrations in the NI were lower in 2015 than observed in 2012.
    - Sediments generally appear to be having a slightly reduced effect on laboratory toxicity endpoints in 2015 relative to previous years.
    - The health of the benthic invertebrate community (as measured by metrics such as density, taxa richness, and biomass) appears to have generally improved in 2015 compared to 2010.
    - Changes in sludge chemistry with respect to PHC F3 are not apparent from the minimal data from NI investigations (i.e., 2013 and 2015).

Concerns regarding hydrocarbon contamination of NI sediments resulted in an investigation into the source of the contamination. The main finding of the investigation were:

- PHC F3 was predicted to be the dominant hydrocarbon (by mass) in discharges to the NI.
- Based on the mass balance, and considering other potential sources of hydrocarbons, the most likely source of PHC F3 was underground (U/G) mine water, particularly from U/G A154/A418.
- The type and source of hydrocarbon contamination (i.e., PHC F3 from U/G water) is consistent with the hypothesis that these organic contaminants are from spills of lubricating or hydraulic oil from heavy equipment operating in the Mine.
- There are some limitations to the mass balance model and the semi-quantitative assessment of the hydrocarbons entering the NI within the catchment area, but the assumptions are generally conservative. Uncertainties in the analysis are unlikely to affect the overall conclusion that PHC F3 from U/G mine water is the dominant type and source of hydrocarbon contamination.
- The NI catchment (which includes the airport) is not considered to be a major source of de-icing antifreeze compounds (i.e., glycol) to the NI.

DDMI completed a risk assessment and options analysis of alternative NIWTP sludge management practices. The objective of the risk assessment was to identify risk-based screening benchmarks considered protective against unacceptable environmental risk. The following was concluded:

- Given the number of studies that place PHC effect benchmarks in the range of approximately 1,000 to 2,000 mg/kg PHC, a recommended ecological Risk-Based

Reference Criteria (RBRC) for the PHC F3 fraction is 1,500 mg/kg F3 dry weight. This concentration falls at the lower end of the site-specific range for F3, and is consistent with the other lines of evidence.

- There was inadequate information to develop a quantitative RBRC for any specific physical parameter or substrate characteristic. Instead, it is only possible to identify the physical properties of sediments in the NI that may contribute to or exacerbate PHC influences. Specifically, any NI sediments exhibiting abundant dark black-green viscous material, or slurry-like conditions with a thick unconsolidated layer of loose sediment, may contribute to impairment of invertebrate communities.
- For nearly all receptors and substances, risks to human health under the closure scenario were below the RBRCs, indicating no potential for adverse health effects. Nickel was the only exception where potential recreational dermal contact from toddlers was flagged, however Given that the maximum nickel sediment concentrations were within a factor of 2 of the RBRC for the most sensitive receptor and exposure scenario, significant health effects were assessed as unlikely for both the closure and the current exposure scenario (i.e., operations phase).

The alternatives considered for disposal of NIWTP sludge were:

- Alternative 1 – continue disposal in the NI;
- Alternative 2 – disposal in the PKC Facility;
- Alternative 3 – disposal in the (NCRP – Type 3 area);
- Alternative 4 – disposal in a new landfill; and
- Alternative 5 – combine with U/G mine backfill.

The sludge disposal alternatives were evaluated on the basis of cost (financial, environmental, and technical) and benefits (operations, environmental and closure). The conclusion from the evaluation, which has been approved by the WLWB, is to continue routing NIWTP sludge to the NI. No significant advantages were identified for the other alternatives on a cost, environmental, or technical basis. The following summarizes the findings from the evaluation:

Environmental Considerations—The analysis of Environmental Considerations indicates that all the alternatives have similar rankings for this attribute. The similarity of these rankings is attributable to the low volumes and fluxes of contaminants associated with transported sludge relative to other constituent transport pathways over the mine site. In addition, the current condition of the NI incorporates sludge deposition since 2003, so redirection of future sludge volumes would have limited effectiveness for improving habitat conditions for aquatic life that already exist in the NI. Conditions in the NI are relatively stable (or possibly improving) and irrespective of where future sludge is disposed, there is already sludge within the NI that is not likely to readily consolidate under any of the management alternatives. There is potential for additional environmental impacts (and/or permitting and monitoring) for any option that entails management or disposal of sludge outside the NI. On balance, the minor potential for environmental improvement associated with redirecting sludge is offset by these other factors.

Economic Considerations—The analysis of Economic Considerations indicates that Alternative 1 (continue to dispose of sludge in NI) ranks the best for this attribute. The system of sludge conveyance is already in place and no new equipment would be required. Alternative 3 (sludge disposal in the NCRP) and Alternative 4 (new landfill facility) score the lowest under Economic Considerations. The most significant contributors to cost include dewatering (plant and operations costs), handling of cover materials at the disposal site, construction of new facilities, and equipment to manage deposition. Overall, the economic costs of the sludge redirection alternatives are high relative to the small improvements in overall contaminant flux and volume of solids for these options.

Technical Considerations—The analysis of Technical Considerations indicates that Alternative 1 (continue to dispose of sludge in NI) ranks the best for this attribute due to its proven function (demonstrated ability to manage sludge reliably). The other alternatives evaluated have unknowns associated with requirements for dewatering and/or mixing sludge with other materials, and the uncertainties associated with these processing steps.

With the information above DDMI next conducted an evaluation of potential NI closure options. Four options were evaluated:

- Option 1: install flow-through structure in East Dam (i.e., permanent use of a permeable fish barrier)
- Option 2: dredge contaminated sediment/sludge from NI and breach East Dam
- Option 3: cover contaminated sediment/sludge in NI and breach East Dam
- Option 4: combine dredge and cover (i.e., hybrid of Options 2 and 3)

The evaluation included a detailed description of each option and how it would be implemented; an assessment of the costs (economic, financial, environmental) and benefits of each option; and a comparison of long-term monitoring and maintenance requirements for each option. Appendix X-6 provides the complete documentation of the assessment of relative strengths and weakness of each option.

The results of NI options assessment indicate that Option 1, installing a flow-through structure, is much less expensive than any of the options that involve remediation and full reconnection to Lac de Gras (Options 2 to 4). Option 1 also has relatively low uncertainty but does not provide for fish habitat in NI. The three intrusive remediation options (Options 2 to 4) provide varying degrees of expected recovery to the fisheries value of NI, and different margins of safety for health of aquatic life, wildlife, and people.

Option 2 to dredge NI is the least expensive of the intrusive remediation options, but residual sludge left behind after dredging will at best result in impaired fish habitat relative to Lac de Gras, and at worst may result in NI remaining unsuitable to reconnect with Lac de Gras. Option 4 to dredge and cover is the best option for meeting environmental objectives and is expected to result in higher quality fish habitat than the other remediation options, but it has a significant cost. Option 3 is not considered to be worth further consideration due to the very high cost and uncertainty in the technical feasibility and remediation success.

5.2.7.3.6 Preferred Closure Design

While the ideal closure plan for the NI is still to breach the east dam and allow fish passage and water circulation, hydrocarbon contamination within the NI sediment (see Section 5.2.7.3.5) precludes this from being the closure plan at this time. In the alternative, and what DDMI is proposing as the preferred closure design, is for a section of the east dike to be excavated and replaced with run of mine rock as originally approved in the 2001 ICRP (see Section 5.2.7.3.3). DDMI proposes that this will remain as the closure plan for the NI unless final sediment quality investigations can demonstrate sediment PHC concentration below 1,500 mg/kg and toxicological and benthic invertebrate monitoring supports introduction of fish. Contingency options are summarized in Section 5.2.7.9.

After the end of commercial operations and once all post-closure water treatment requirements for the site have ended, the NIWTP will be used to treat the final water in the NI and discharge the water to Lac de Gras. Lac de Gras water will be allowed to seep into the NI through the decommissioned NI west dam to replace the volumes removed for treatment. When the water quality in the NI is suitable, a breach will be excavated in the east dam and back-filled with rock to allow a hydraulic connection with Lac de Gras but block fish passage. The east dam breach will be similar in size to the breaches planned for the dikes: 30 m wide and 2 to 3 m deep. Thermosyphons in the east dam will be cut below grade and removed.

The final landscape for the NI is shown in Figure 5-17 before the east dam excavated breach has been back-filled.

5.2.7.4 Closure Activities and Associated Engineering and Environmental Work

The general schedule of activities currently envisaged for advancing and implementing the preferred closure plan for the NI area is shown in Figure 5-18. A brief description of each activity is described in the following:

- *Mine Water Treatment* – The NIWTP will continue to treat mine water until the completion of commercial operations around 2025, according to the current mine plan.
- *Closure Water Treatment* – The NIWTP be required to support closure activities including decommissioning of PKC and collection ponds.
- *Community and Regulatory Engagement* – Continued engagement is anticipated to continually refine the closure plan for the NI area. Final engagement is anticipated around 2032 to confirm permanent closure.
- *Final Engineering* – A final engineering closure design for the NI will be completed and submitted for review in 2020. This design will incorporate findings from engineering and environmental studies, research, community and regulatory engagement.
- *Final NI Sediment Investigation* – A final sediment investigation is planned for as a final check to determine if hydrocarbon contamination has been sufficiently improved to enable fish use of the NI.
- *Treat and Discharge NI Water* – NIWTP will be used to treat the final water in the NI and discharge the water to Lac de Gras. Lac de Gras water will be allowed to seep into the NI through the decommissioned NI west dam to replace the volumes removed for treatment.

- *Decommissioning of Dams* – When NI water and sediment quality have been confirmed, the east and west dams will be decommissioned.
- *Performance monitoring* – A specific performance monitoring program will be conducted for three years starting in 2030 to confirm quality of water being released to Lac de Gras and NI water levels. This program will include monitoring settlement and area wildlife interactions.
- *Engineering Inspections* – Inspections will be conducted during the closure work and in the years immediately following to review the closure performance.
- *Environmental Effects Monitoring* – In addition to specific performance monitoring, environmental effects monitoring will be conducted on a three-year cycle as a continuation of the Wildlife and Aquatics Effects Monitoring Programs. The frequency of specific elements and the completion date for monitoring would change based on results. Monitoring will continue from operational monitoring but will emphasise closure effects. Key programs will be aquatic effects in Lac de Gras and wildlife effects.
- *Reclamation Completion Reporting* – Report detailing the work completed, any deviations from the approved design and CRP, "as-built" reports and description of any monitoring still required.
- *Performance Assessment Reporting* – Reports providing a detailed comparison of conditions at site against closure objectives and criteria, identify any residual risk, describe monitoring and maintenance activities and update the security estimate.

5.2.7.5 Residual Effects

Residual environmental effects will exist even with the full implementation of the preferred closure option. Potential residual effects of note include the following:

- permanent loss of fish habitat from Lac de Gras;
- water and sediment quality in the NI that may be different from pre-disturbance conditions in Lac de Gras, which could be long-term, low-level source of hydrocarbons, nutrients and metals to Lac de Gras;
- primary productivity that may be higher in the NI than would be typical in Lac de Gras, and;
- dust may be generated from the rock surfaces of the east and west dams.

An assessment of environmental effects at closure was conducted during the EA for the mine (DDMI 1998c). Residual effects are part of the initial assessment of the cumulative effects from all closure areas, which is summarized in Section 9. The identified residual effects fall within the general range of effects considered in the EA.

5.2.7.6 Uncertainties, Risks and Research Plans

The final NI sediment quality, following the end of commercial operations, remains the key uncertainty with the preferred closure plan for the NI. In this case the uncertainty is an opportunity rather than a threat. If sediment hydrocarbon contamination conditions improve over the next ten years, there is a potential opportunity for fish from Lac de Gras to safely use the NI. This opportunity can be acted on very quickly and with little to no impact on the closure plan if sediment conditions prove to be acceptable.

There are no closure research plans specific to this uncertainty as all that remains is to implement a final sediment investigation program in 2025. The investigation scope/methods are defined as it will be a repeat of the sediment component of the 2015 investigation (Golder 2016c).

5.2.7.7 Post-Closure Monitoring, Maintenance and Reporting

Specific post-closure monitoring, maintenance plans and reporting requirements will be developed with final closure designs and submitted for approval with the Final CRP. DDMI current concepts for post-closure monitoring and reporting plans for this area are summarized in this Section and in Appendix VI-4.

General guidance relevant to post-closure monitoring of water management areas is provided by the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007) and are included in Appendix XIII, Table 4D for general reference. DDMI anticipates that there will be two types of post-closure monitoring programs: performance monitoring specific to the NI area; and environmental effects monitoring which would include combined effects from all post-closure areas. The scope of the performance monitoring will include the following:

- water and sediment quality in the NI using a system similar to the SNP;
- geotechnical inspections including observations of settlement, erosion and thermal condition;
- TSP and deposition/quality measurement of any dust generated from the closed NI area; and
- wildlife use of the area.

In addition to area-specific monitoring, environmental effects post-closure will be monitored through a continuation of a Post-Closure AEMP in Lac de Gras and a Post-Closure Wildlife Effects Monitoring Program. Monitoring methods will be drawn from the operations monitoring programs. The program and monitoring frequency will be revised appropriately to focus on post-closure monitoring questions.

Post-Closure maintenance requirements might include the following:

- repairs related to stabilization or erosion; and/or
- corrections to any identified wildlife hazards.

Results of all monitoring and maintenance will be documented in the Performance Assessment Reports. These reports will include any recommendations for future corrective actions or changes to monitoring programs.

5.2.7.8 Post Reclamation Landscape

The current view of the preferred post-closure landscape for the NI area is shown in Figure 5-17. This landscape shows the breach in the east dam that will be back-filled with rock to prevent fish movement into the NI.

5.2.7.9 Contingency Program

Possible contingency actions have been developed based on the current understanding of uncertainties and risks (see Section 5.2.7.6):

- Modify the decommissioning of the east dam and not back-fill the excavated breach and allow fish passage between Lac de Gras and the NI;
- Do not decommission the east dam and continue to treat and discharge to Lac de Gras as necessary to manage water levels in the NI. The NI is expected to have a positive water balance; and
- Dredge contaminated sediment from the NI and replace with a clean fill.

The preferred contingency plan is to modify the east dam decommissioning to allow fish passage, however there is a moderate level of uncertainty that NI sediment quality will not be suitable and therefore a good possibility this contingency will not be implemented. If the contingency can be implemented there is little to no additional engineering/design work required as the east dike breach would be the same as planned for the dikes.

5.2.8 Permanent Closure Requirements – Mine Infrastructure

5.2.8.1 Pre-disturbance, Existing and Final Mine Site Conditions

The mine infrastructure areas before the infrastructure was developed are shown in Figure 5-19. The image is from June 2000 and shows some initial pioneering roads, the original North Camp, exploration decline, original airstrip and the start of the new airstrip. Pre-disturbance conditions are summarized in Section 3 with additional references provided for more specific information. Some archaeological sites were identified in these areas (Figure 3-29). No other specific or unique environmental conditions exist in these areas.

The current extent of mine infrastructure development is shown in Figure 5-19b using an image from 2015. With the exception of a few final buildings like the new mine dry facility, the mine infrastructure is fully developed. A more complete identification of the mine infrastructure can be found in Figure 2-2. A list of buildings with estimates of size is provided in Section 4.4.7.

The same mine infrastructure at final development is shown in Figure 5-19c.

5.2.8.2 Closure Objectives and Criteria

Closure objectives applicable to the mine infrastructure areas include both site-wide objectives (Appendix V, Table V-1) and area-specific objectives (Appendix V, Table V-6). The guidance provided by INAC (2007) relevant to the closure of the infrastructure areas is listed in Appendix XIII, Table 5A and the Environment Canada (2009) recommendations for closure practices are listed in Appendix XIII, Table 5B. They are included to assist the reader in reviewing the objectives for the infrastructure areas.

Possible closure criteria are also described in Appendix V, Tables V-1 and V-6. Closure criteria are intended to be used to in evaluate success in achieving the objective. The intent of a closure plan is to have closure criteria that are specific and measurable. As discussed in Section 5.2.2 it is recognized that these criteria will be refined over time. The process of ongoing refinement of the criteria will include further discussions with communities and regulators.

5.2.8.3 Preferred and Alternative Closure Options

Closure planning began with the initial mine design work in 1996 to 1998 when many of the important design decisions related to closure occurred were made. With regard to closure aspects of mine infrastructure the guiding principal in the design was to keep the mine footprint as small and compact as possible. Options considered in this 1996 to 1998 period included infrastructure on the mainland and the west island (Figure 5-7). These options were primarily considered in association with the location of the PKC. It was expected that a larger and more widely dispersed mine infrastructure would result in greater environmental effects during operation, notably wildlife, but it would also make final closure more difficult and increase the residual environmental effects on wildlife.

The final decision from the EA and the basis for the Water License and Land Leases is that mine infrastructure will be restricted to the East Island with a limited footprint.

5.2.8.3.1 Mine Infrastructure Area Closure Options

Guidance on generic options for closure of mine infrastructure areas that are provided in INAC (2007) and relevant to the Diavik site are included in Appendix XIII, Table 5C. These generic options are provided as context for the reader regarding different approaches to infrastructure closure.

5.2.8.3.2 Original Closure Design – 2001

The original closure design for the mine infrastructure area is documented in the *Initial Abandonment and Restoration Plan* (DDMI 1999b), the *2001 Interim Abandonment and Restoration Plan* (DDMI 2001a), and the 2006 *Interim Closure and Reclamation Plan – Version 2* (DDMI 2006). These references describe the following:

- removal of all equipment, buildings, pipelines, power lines and other items for resale/reuse where practical;
- removal of all hazardous materials;
- salvageable materials recycled where practical;
- materials that are not reused or recycled safely disposed of on-site;
- materials that could not be safely disposed of on site would be hauled to approved off-site facilities;
- foundations and concrete slabs covered with rock;
- fuel tanks removed;
- contaminated soils bio-remediated and disposed of on-site or hauled off site for disposal;
- roads, laydowns, plant sites, airstrip scarified and targeted re-vegetation; and
- re-vegetation options that included use of a top soil strategy, ameliorative strategy or an adaptive strategy.

5.2.8.3.3 2009 to 2016 Review

In 2009 DDMI reviewed the approach for the closure of mine infrastructure. For this area in particular planning for most activities can, and should, be done closer to final closure. Regardless, closure aspects were identified where early planning would be helpful and include the following:

- topography and final surface texture options for roads, laydowns, plant sites and airstrip;
- landfill location options on-site and off-site;
- infrastructure use and/or decommissioning options; and
- areas for re-vegetation.

Each of these aspects of infrastructure closure was discussed at the Options and Criteria Workshop hosted by DDMI in May 2009. The full list of outcomes from this workshop are described in ICRP V3.2.

Site roads and laydowns areas are constructed from Type I run-of-mine rock. They typically have steep sides, safety berms, are up to several metres thick and can impact human and wildlife movement. Where necessary for closure the edges of these areas can be re-sloped inwards, re-sloped outwards or some of the materials can be re-mined for closure use in other areas.

DDMI was able to advance the discussion relating to closure plans for site roads and laydown areas with the TK Panel. As stated above, the edges of these areas can be re-sloped inwards, re-sloped outwards or some of the materials can be re-mined for closure use in other areas. While Panel members typically prefer to preserve natural habitat wherever possible, they identified wildlife safety as the most important consideration for closure. As such, Panel members supported re-sloping berms on roads outwards over natural ground in order to disperse material and create safe slopes for wildlife movement (Appendix IX-1.6 and Appendix IX-2). It is DDMI's view that all three options have applicability in different situations. Re-sloping inward would reduce footprint size for areas where the thicknesses are greater than about 3 m, there is a large area over which to disperse the material (e.g., laydowns) and wildlife access is planned. For areas where the thickness is less than 3 m (e.g., roads), pushing the re-sloping outward would result in a minimal impact on the footprint and allow for safe movement of wildlife. Re-mining the materials should be focused on areas such as drainage crossings where excavation will be required to return natural stream flow routes.

Independent literature reviews were conducted from both scientific and Traditional Knowledge perspectives with regard to re-vegetation. The University of Alberta evaluated reclamation projects conducted in the north, including the Ekati Mine, to determine their potential application to current or future reclamation research and closure planning for the mine. Thorpe Consulting Services evaluated documented knowledge of vegetation in the Lac de Gras area that could potentially be applicable to closure considerations.

DDMI's re-vegetation research program, led by researchers from the University of Alberta's Land Reclamation and Restoration Ecology department, was initiated in 2004. Research has been focused on identifying appropriate and effective materials and methods for re-vegetation at the Diavik site. Development of site-specific recommendations for sustainable re-vegetation methods has progressed significantly and opportunities for longer-term monitoring will further assist with refining land reclamation concepts and procedures. Research results to-date support scarification of surfaces of road and laydown areas to enhance microhabitats for vegetation, and integrate better with the surrounding landscape. However, additional substrates and amendments are required for priority areas to improve the soil structure, nutrient availability and water holding capacity that underpins long-term soil development and vegetation succession.

The University of Alberta research included studies to measure uptake of metals in plants. DDMI worked with communities to expand the existing lichen and soil monitoring program that considers metals levels for soils and lichen related to dust deposition within the vicinity of the mine and wildlife study area. A screening level ecological risk assessment was conducted to determine if lichen were within safe levels for caribou consumption. Results to-date do not indicate that post-closure metals levels in plants are likely to pose a risk to wildlife. However, they do indicate that processed kimberlite may not be preferred soil amendments due to higher metals content. Further work is required to confirm these interim conclusions (see Section 5.2.8.6).

Scarified rock surfaces are difficult for people and wildlife to travel over. DDMI has worked with TK Panel and community members to identify preferred routes where a smooth surface pathway should be maintained for both human and wildlife use. DDMI provided an initial identification of proposed connections to roadways and/or laydown areas that provide access and egress to this pathway and the surrounding tundra as areas where smoother surfaces would remain for travel after closure (ICRP V3.2 - Figure 5-20). The route over the NCRP-WRSA was revised through discussions with the TK Panel and communities when finalizing the NCRP-WRSA Closure Plan. DDMI will continue to work with the TK Panel an communities to integrate and verify preferred routes within final closure landscapes.

DDMI engaged the TK Panel to evaluate re-vegetation plans for the Diavik site in relation to their knowledge of the plants and wildlife use patterns that existed on East Island prior to the mine. The TK Panel initially struggled with the concept of re-vegetation, preferring a traditional approach of letting Mother Nature take its course and heal the area over time. Panel members were encouraged by some of the natural re-vegetation that was observed on site during their field work sessions. However, many Panel members soon acknowledged that the level of development associated with mining necessitates some assistance to help the area recover. DDMI had identified site roads, plant site, laydowns and the airstrip as target areas for re-vegetation. The Panel expanded on this concept and identified a preference to exclude areas of site where chemical or waste storage occurs (e.g., WTA, fuel tank farms) from the target areas for re-vegetation. The Panel felt that vegetation would come back to these areas on its own in the future, if conditions were safe. The Panel also supported capping the NCRP with till and rock layers and focusing re-vegetation efforts around the water collection ponds at the base of the pile. The Panel noted a preference to leave the airstrip intact so that it could be used as an emergency landing area in the future.

On-site versus off-site disposal of unwanted materials and debris from the demolition of mine infrastructure was discussed. Some viewed off-site disposal as preferable because it would remove all materials from site and would result in conditions most similar to pre-development conditions. It is DDMI's view that on-site disposal of materials in most, but not all, cases is the better environmental option.

The Comprehensive Study Report (pg. 111) includes a statement that:

> *"The approved A&R Plan will not allow burial of buildings, machinery and equipment on the mine site. It will include an estimate of implementation costs at various stages in the life of the mine."*

DDMI notes that this statement is not referenced and is not supported by an environmental, technical or legal basis for not allowing burial of buildings, machinery or equipment. In fact, DDMI currently has an approved, active, on-site landfill for disposal of inert materials.

DDMI requested an expert opinion regarding environmental trade-offs between on-site and off-site burial. This expert opinion included a preliminary estimate of closure landfill waster volumes, and supported DDMI's view that on-site disposal is generally the better option. The WLWB approved disposal of inert material from buildings, machinery and equipment in the on-site landfill (WLWB 2013) and required DDMI to update its Waste Management Plan to describe efforts that would be taken to find uses (e.g., in communities) for buildings, machinery, equipment and items no longer needed by the mine. The process DDMI developed for disposing of buildings during operations is described in the most recently approved Waste Management Plan (Version 1.2). While the process shown in Figure 1 is for buildings, the same would be true for machinery, equipment or any items no longer needed by the mine. Towards the end of commercial production at Diavik an inventory of assets will be developed. DDMI will meet with local communities to identify, plan for and obtain ownership of salvageable equipment, buildings, materials and supplies that could be re-used in or by communities. DDMI has already begun making communities aware of this potential future opportunity.

Options for the management and disposal of petroleum hydrocarbon contaminated material were evaluated and documented in the 2012 Annual ICRP Progress Report - Appendix II-8. The objectives for the study were to answer two questions: 1) Following mine closure, can petroleum hydrocarbon contaminated soil be left on site in a manner that would be safe for human and ecological receptors; and b) Will some form of remediation/risk management be required to make this possible. The results indicated that unrestricted disposal of petroleum hydrocarbon contaminated soil may not be safe for people and ecological receptors and that management options are available to mitigate these risks. For the disposal locations considered (Type III waster rock in NCRP, inert landfill and PKC) the driving exposure pathway of concern (soil contact and vapour inhalation) could be mitigated through depth of soil placement. Subsurface/deep placement at depths where permafrost is expected to form and persist was identified as the best management option.

5.2.8.3.4 Preferred Design Concept

The majority of the mine infrastructure shown in Figure 5-19 was constructed to last the duration of the mine life and will be required until end of mine production. Annually DDMI takes advantage of winter road back-hauls to remove any assets that are no longer required at the mine site. Lists of items back-hauled and/or disposed of on-site are included in the Annual Closure Plan Progress Reports (Section 6 and Appendix VI-1). DDMI's preference is to reuse as many of these assets off-site as possible with local communities and Northern businesses.

In the three years leading up to the end of mine production, detailed decommissioning plans will be developed. These plans are expected to include strategies to:

- make final reductions to on-site inventories of consumables leading up to the end of mine production;
- take final advantage of back-haul opportunities in the final years of mine operations to remove any unused equipment or infrastructure that can be salvaged or sold for re-use;
- market/advertise the resale, reuse and recycle opportunities for equipment and materials that will become available, and develop with the end consumer a specific decommissioning plan for each; and
- develop a specific site decommissioning sequence to ensure availability of equipment and infrastructure to support closure activities and post-closure monitoring, inspection and maintenance.

Mobile and fixed equipment will be removed. Buildings will removed and foundations covered with mine rock. Pipelines, power lines and poles will be removed. Fuel tanks will be removed. The approach to removing the mine infrastructure is to:

- maximize the sale/reuse of equipment, buildings, materials, fuels and chemicals with preferred market in the North;
- if sale/reuse is not practical, recycling is the next preferred option, depending on demand for materials and cost to haul to recycle facilities;
- materials and equipment with no sale or salvage value will be decontaminated (if required), broken down and disposed of in the designated waste rock landfill or underground tunnels, as appropriate; and
- materials that are not suitable for on-site disposal, such as hazardous materials, fuels, lubricants and ammonium nitrate including wastes generated during decommissioning will be hauled off-site and returned to suppliers or disposed of at approved facilities.

Non-hazardous materials with no salvage value will be disposed primarily in the landfill in the waste rock pile with smaller amounts in the underground workings. The current landfill is shown in Figure 5-6b (existing) and 5-6c (final development). With the construction of the A21 dike a significant amount of waste rock was excavated from the south west end of the NCRP-WRSA. The resulting depression is being considered as an alternate landfill location. Additionally, as noted in Sections 5.2.6 and 5.2.4 DDMI is actively evaluating the option of disposing of processed kimberlite in completed underground and/or open pit mine areas. As part of this evaluation DDMI will also investigate the option of disposing of inert building materials. DDMI will report progress and seek any necessary closure approvals for these options through the Annual Closure and Reclamation Plan Progress Reports.

Hydrocarbon-contaminated materials collected during operations and during decommissioning will be assessed to determine the most appropriate closure option. The current preferred closure plan is for this material to follow the subsurface/deep placement management option within either the PKC and/or the landfill (see Section 5.2.8.3.3).

Hazardous materials will be removed from site to a certified disposal location as appropriate for that material. When all hazardous materials and contaminated soils have been removed from the WTA, the area (including the contaminated soil landfarm area) will be cleared of equipment and the fencing will be removed. The area will be inspected for any residual contamination before a rock cover is placed.

No areas of the mine site, outside the WTA, are known to be contaminated with hazardous materials. There are also no areas or facilities where a known pollution problem exists. Storage areas such as tank farms, emulsion plant and ammonium nitrate storage will require post-closure verification sampling to confirm location specific soil conditions.

Collection Ponds will remain functional to collect site runoff during the mine infrastructure decommissioning. The NIWTP will be one of the last facilities to be removed.

The existing camp, airstrip, power and fuel storage facility will be used for as long as possible to support the closure and reclamation activities. It has been suggested by communities and the TK Panel that DDMI should plan to leave a small self-supported camp to support any long-term monitoring or maintenance work that may be required. DDMI has committed to include this in the final decommissioning plan. A possible schedule for decommissioning is included in Section 5.2.8.4.

The final landscape for the mine infrastructure area based on current closure concepts is shown in Figure 5-20. The landscapes will be designed to be compatible with the pre-mining environment and surrounding landscape. Disturbed surfaces will be contoured and scarified except where planned routes for wildlife or human movement have been identified. Surfaces will be stable and safe.

Within the mine infrastructure area stream drainage channels will be re-established, and any culverts removed, for Collection Ponds 10, 11 and 12 and the airstrip (Figure 5-20). A typical section indicating the closure concept for stream drainage channels is shown in Figure 5-21. This concept will apply for roads and Collection Pond dams.

Accumulated atmospheric deposition of particulate material that originated from mine operation emissions continues to be regularly monitored. These emissions will generally cease at the end of commercial production or in the case of dust be significantly reduced. Regardless, site surface runoff will be monitored before Collection Ponds are breached to confirm that accumulated particulate deposition has not created an unacceptable closure water quality. Soils and plants will be sampled post-closure and analyzed for metals and metals uptake as necessary (see Appendix VI).

The closure plan includes the re-establishment of boulder fields and partially vegetated land, to the extent practical. DDMI's primary goals in relation to re-vegetation are to increase vegetation growth as compared with natural recovery processes, maximize vegetation cover in re-vegetated areas and promote soil development and sustainable vegetation growth. The following three strategies for re-introducing pioneer and more advanced indigenous vegetation on disturbed surfaces are being considered.

- *A topsoil strategy* requires placement of topsoil or alternative "cultivable" anthroposol substrates (materials produced as a result of development), followed by establishing indigenous vegetation. Amendments (substances that improve substrate conditions and enhance plant growth) may also be used.
- *An ameliorative strategy* does not require topsoil to be placed, but rather promotes the establishment of stress resistant native species directly into an infertile substrate. Usually the substrates require some chemical and/or physical improvement through the use of amendments to create a soil-like condition.
- *An adaptive strategy* establishes native species directly into the substrate, similar to the ameliorative strategy, but with less requirement for chemical and physical amendments of the substrate. This strategy is more cost-effective and uses varieties of native species, which have adapted to physical and chemical disturbances that may be present at some locations. It is particularly suited to the establishment of plants directly into mineralized substrates such that adapted varieties are required for these conditions.

Research to date indicates that the topsoil and ameliorative strategies appear to be most effective for the Diavik site (Appendix VIII-2). The challenging climate of a sub-arctic environment – including a short growing season, low precipitation and strong winds – coupled with nutrient-deficient anthroposol substrates has identified a need to combine substrate and/or amendment materials to facilitate plant community development.

A general approach to re-vegetation at the mine site would consider the following elements:

- rock or rock/till mix as preferred substrates;
- Sewage sludge, peat, salvaged topsoil, fertilizer and hydrogel as amendments;
- Grasses in a seed mix: *Poa glauca* (glaucous bluegrass), *Poa alpina* (alpine bluegrass), *Puccinellia nuttalliana* (Nuttall's alkaligrass), *Agropyron violaceum* (wheatgrass), *Agropyron pauciflorum* (slender wheat grass), *Arctagrostis latifolia* (narrow leaved polar grass), *Festuca saximontana* (rocky mountain fescue), *Deschampsia caespitosa* (tufted hairgrass) and *Trisetum spicatum* (spike trisetum)
- Forbs in a seed mix: *Hedysarum mackenzii* (bear root, sweet pea/sweetvetch), *Hedysarum alpinium* (liquorice root), *Oxytropsis splendens* (showy locoweed) and *Oxytropis deflexa* (nodding locoweed);
- Shrub cuttings and seed collection: *Betula glandulosa* (bog birch), *Salix glauca* (grey leaf willow), *Salix planifolia* (diamond leaf willow), *Loiseleuria procumbens* (alpine azalea), *Vaccinium vitis-idaea* (mountain cranberry), *Vaccinium uliginosum* (bog bilberry), *Empetrum nigrum* (crowberry) and *Ledum palustre decumbens* (labrador tea);
- Moss and lichen collection and planting methods;
- Microsite development (rocks, boulders, soil clumps, rough surfaces, depressions); and
- Erosion control methods (blankets, soil additive).

A final re-vegetation research report that analyzes and compiles the results of all aspects of the research identified above is expected to be complete at the end of 2017. Of particular importance, this report will capture the long-term soil and vegetation monitoring that was conducted over 10 years after the Phase I (2004) research plots were established and provide valuable insight on reclamation success. Based on the findings from this report, DDMI expects to be able to develop a more detailed procedure for re-vegetation methods at the Diavik site. DDMI anticipates including this procedure in the 2018 Annual CRP Progress Report.

5.2.8.4 Closure Activities and Associated Engineering and Environmental Work

The general schedule of activities currently envisaged for advancing and implementing the preferred closure plan for the mine infrastructure area is shown in Figure 5-22. The following provides a brief description of each activity:

- *Accommodation/Power/Transportation Required* – Infrastructure is required to support mining operations (currently ending 2025), but will be required at a lesser intensity during closure activities (currently ending 2032).
- *Community and Regulatory Engagement* – Continued engagement is anticipated to continually refine the closure plan for the Infrastructure area. Final engagement is anticipated around 2032 to confirm permanent closure.
- *Final Engineering* – A final engineering closure design and decommissioning plan for the Infrastructure area will be completed and submitted for review in 2020. This design will incorporate findings from engineering and environmental studies, research, community and regulatory engagement.
- *Asset Inventory* – A detailed inventory of assets for sale/reuse, salvage, and recycling will be begin three years before the final closure work begins to initiate external marketing.
- *Commercial Arrangements – Sale/Transfer of Assets* – Specific arrangements will be made for sale, reuse, salvage or recycling of equipment and materials in advance of decommissioning.
- *Targeted Re-Vegetation* – Targeted re-vegetation will be conducted as series of campaigns starting in 2026 with available areas and finishing in 2031 after the final buildings are removed.
- *Decommissioning of Process and Paste Plants* – All activities associated with decommissioning this facility will occur.
- *Decommissioning of Explosives Plant and Storage* – All activities associated with decommissioning these facilities will occur.
- *Decommissioning of Accommodations and Other Buildings* – All activities associated with decommissioning these facilities will occur.
- *Decommissioning of Fuel Storage and Power* – All activities associated with decommissioning these facilities will occur.
- *Decommissioning of Waste Transfer* – All activities associated with decommissioning this facility will occur.

- *Decommissioning of Collection Ponds, and Pipelines* – All activities associated with decommissioning these facilities will occur.
- *PKC Infrastructure Decommissioning* – Removal of reclaim barge, water and slurry pipelines, power and any associated surface infrastructure.
- *Decommissioning of Airstrip and Landfill* – All activities associated with decommissioning these facilities will occur.
- *Performance monitoring* – Performance monitoring will be conducted starting in 2025. Monitoring programs will emphasise re-vegetation, hydrocarbon remediation, wildlife use, and will track success of equipment and materials reuse/recycle.
- *Engineering Inspections* – Inspections will be conducted during the closure work and in the years immediately following to review the closure performance.
- *Environmental Effects Monitoring* – In addition to specific performance monitoring, environmental effects monitoring will be conducted on a three-year cycle as a continuation of the Wildlife and Aquatics Effects Monitoring Programs. The frequency of specific elements and the completion date for monitoring would change based on results. Monitoring will continue from operational monitoring but will emphasise closure effects. Key programs will be aquatic effects in Lac de Gras and wildlife effects.
- *Reclamation Completion Reporting* – Report detailing the work completed, any deviations from the approved design and CRP, "as-built" reports and description of any monitoring still required.
- *Performance Assessment Reporting* – Reports providing a detailed comparison of conditions at site against closure objectives and criteria, identify any residual risk, describe monitoring and maintenance activities and update the security estimate.

5.2.8.5 Residual Effects

Residual environmental effects will exist even with the full implementation of the preferred closure plan the mine infrastructure areas. Potential residual effects of note include the following:

- roads, plant site, laydowns and airstrip that will remain visibly different even after surfaces are re-contoured, scarified and/or re-vegetated;
- a permanent loss of vegetation and associated wildlife habitat, and some archaeological information that was covered by the mine infrastructure;
- an increase in the area of "human disturbed" category of VLC type, despite re-vegetation activities;
- localized runoff water quality and quantity that may be different from pre-development conditions;
- some small inland waterbodies and ephemeral streams that will be permanently covered by mine infrastructure; and/or
- dust may be generated from the scarified rock surfaces that deposits on adjacent vegetation or waterbodies.

An assessment of environmental effects at closure was conducted during the EA for the mine (DDMI 1998c). Residual effects are part of the initial assessment of the cumulative effects from all closure areas, which is summarized in Section 9. The identified residual effects fall within the general range of effects considered in the EA.

5.2.8.6 Uncertainties, Risks and Research Plans

Uncertainty associated with the preferred closure plan for the mine infrastructure areas identified by DDMI include the following:

- the amount of equipment and materials that will not be economically salvageable for reuse or recycle;
- the amount of non-salvageable material that can be safely disposed of on-site;
- results of the assessment of hydrocarbon contaminated material;
- degree of natural recovery and re-vegetation that has/will occur;
- the most favourable re-vegetation strategy and any additional approvals required for implementation;
- metal uptake levels in plants and potential impacts to ecological receptors; and
- preferred wildlife movement through the area.

The risks identified by DDMI that are associated with these uncertainties are:

- the potential for insufficient on-site landfill capacity;
- significant amounts of hydrocarbon material that must be hauled off-site;
- re-vegetation efforts will be unsuccessful; and
- unintended introduction of invasive species transported to site with re-vegetation supplies.

The amount of non-salvageable material that will need to be disposed of in the on-site landfill, and the impact on the landfill capacity will be addressed by the marketing of assets for sale/reuse or recycle closure to mine closure.

5.2.8.6.1 Closure Research

Specific research activities that are anticipated to provide specific input into the closure and reclamation design for the infrastructure area described in Appendix VIII-2 and include the following:

- Re-vegetation procedures; and
- Final assessment of metal uptake in plants.

5.2.8.7 Post-Closure Monitoring, Maintenance and Reporting

Specific post-closure monitoring, maintenance plans and reporting requirements have not been developed. These program details are not required for an ICRP, but will be required and included in the Final Closure and Reclamation Plan. General post-closure monitoring and reporting plans for this area are summarized in this Section and in Appendix VI-5.

General guidance relevant to post-closure monitoring of the mine infrastructure areas provided by the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007) are included in Appendix XIII, Table 5D for general reference. DDMI anticipates that there will be two types of post-closure monitoring programs: performance monitoring specific to mine infrastructure areas; and environmental effects monitoring which will include combined effects from all post-closure areas. The scope of the performance monitoring will include the following:

- re-vegetation success;
- TSP and dust deposition/quality measurements of dust generated from mine infrastructure areas;
- on-site disposal of hydrocarbon contaminated soils;
- monitoring levels of reuse, recycle versus landfill;
- runoff water quality;
- geotechnical inspections including observations of cracking, erosion and thermal condition as described above; and
- wildlife use of the area.

In addition to area-specific monitoring, environmental effects post-closure will be monitored through a continuation of a Post-Closure AEMP in Lac de Gras and a Post-Closure Wildlife Effects Monitoring Program. Monitoring methods will be based on the operations monitoring programs and will be revised along with the monitoring frequency, as appropriate, to focus on post-closure monitoring questions.

Post-closure maintenance requirements might include:

- repairs to cracking or erosion;
- corrections to re-vegetation efforts; and/or
- correction of identified wildlife hazards.

Results of all monitoring and maintenance will be documented in the Performance Assessment Reports. These reports will include any recommendations for future corrective actions or changes to monitoring programs.

5.2.8.8 Post Reclamation Landscape

The current view of the preferred post-closure landscape for the mine infrastructure areas is shown in Figure 5-20a and 5-20b and includes the following:

- removal of all buildings, fuel storage, pipeline and power lines;
- on-site landfill;
- remediation of stream crossings;
- contouring, scarifying and target re-vegetation areas; and
- specific access routes for people and wildlife.

DDMI plans to continue to focus on closure engagement with the TK Panel and communities over the next few years. While significant progress has been made in identifying community concerns and preferences relating to various closure options, DDMI acknowledges that TK or community considerations may still influence or change the final landscape. In particular DDMI will engage with the TK Panel regarding wildlife and human pathways through the closure landscape to develop a final pathway map.

5.2.8.9 Contingency Program

Possible contingency actions have been developed based on our current understanding of uncertainties and risks (see Section 5.2.8.6):

- development of additional on-site inert building waste disposal areas: a)south-east area of NCRP-WRSA where re-mining has created a depression and within completed underground and or pit bottom (consider in conjunction with PK disposal option);
- early disposal of hydrocarbon contaminated soil to limit amount at closure;
- re-vegetation methods that do not involve additional external material sources; and
- revised re-vegetation methods and repeat effort, if appropriate, to correct cause of unsuccessful re-vegetation.

From the above list of contingency plan options, DDMI's preference is to advance both plans for additional on-site inert building waste disposal. As part of the review of re-vegetation procedures DDMI will consider extent to which the contingency of excluding methods that involve materials from external sources would impact on the success of the re-vegetation process. DDMI does not expect that early disposal of hydrocarbon contaminated soil will be necessary and would prefer to not have to repeat the re-vegetation effort as a contingency if initial efforts prove unsuccessful.

6 Progressive Reclamation

6.1 Definition of Progressive Reclamation

Progressive reclamation consists of closure activities that are done before permanent closure to advance the closure and/or decommissioning of areas or facilities that are no longer required for the current or future mining operation. These activities can be done during operations with the available resources to reduce future reclamation costs, minimize the duration of the environmental exposure and enhance environmental protection. Progressive reclamation can also reduce time for achieving reclamation objectives, and provides valuable experience on the effectiveness of measures which might be implemented during permanent closure.

All closure planning from initial mine design through to detailed closure design and closure studies or research could be considered as progressive reclamation activities. These are all activities done during operations to improve the implementation of permanent closure. Planning for closure and closure research are addressed in Section 5. This section describes the physical closure activities that are planned to occur before the end of commercial mine production (currently planned as 2025) that are considered as progressive reclamation activities.

6.2 Prospective Facilities/Areas and Reclamation Activities

The following sections identify, by closure management area, closure activities that are considered progressive reclamation activities. The specifics of these activities and how they contribute to achieving permanent closure objectives are described in Section 5.2.

6.2.1 Open Pits, Underground and Dike Areas

The open pits will not be flooded until final closure. Progressive reclamation activities for the open-pit area are limited to the construction of fish habitat. Designs for fish habitat in the A154, A418 and A21 mine areas are included in Appendix X. Identified progressive reclamation activities include the following:

- Infilling deep areas of original lake bottom between the pit crest and the inside toe of the dike in both A154 and A21 areas.
- Constructing of fish habitat features (reefs) in filled areas.
- Excavating wildlife ramps into the A418 shoreline.
- Backfilling underground workings as mining operations proceed to limit extent of open kimberlite excavations.
- Segregating waste rock by sulphur content during mining operations. This ensures site facilities are constructed using only Type I rock which eliminates the need for further closure activities for these areas and enables management of waste rock piles.

6.2.2 Waste Rock and Till Areas

Identified progressive reclamation activities in this area include:

- placing segregated waste rock into designated locations;
- re-sloping waste rock areas to final design slopes as required;
- constructing closure cover system using direct placement of till/Type I rock on identified final Type III rock areas;
- re-mining Type III waste rock for underground backfill; and
- re-mining waste rock following an area plan to achieve as much of final landscape design as practical.

6.2.3 Processed Kimberlite Containment Area

Identified progressive reclamation activities in the PKC area include:

- Changing the water management practices to draw makeup water from the NI may reduce the amount of ponded water in the facility during operations and enhance consolidation and permafrost development. Before the pipeline from the NI was added, water had to be stored in the PKC to ensure adequate supply for the processing plant.
- Constructing of south barge road to be used for long term drainage management.
- Depositing of fine and CPK in final years to create planned closure landscape.

6.2.4 North Inlet Area

The NI is as integral component of the site water management system and it will be required after completion of mining. As such no progressive reclamation activities have been identified for this area, at this time.

6.2.5 Mine Infrastructure Areas

Identified progressive reclamation activities in this area include:

- back haul equipment or facilities as they are identified as no longer being required for operations;
- engaging with local communities and northern businesses regarding reuse of mine assets once they are no longer required; and
- reduce inventories of consumables leading up to the end of mine production.

6.3 Progressive Reclamation Monitoring, Maintenance and Reporting Program

Two types of progressive reclamation monitoring are anticipated:

- Engineering Inspections –tracking, recording and inspecting the work done so that it can be documented as part of Reclamation Completion Reporting.
- Performance Monitoring – where appropriate monitoring will be done to document how a closure activity is performing with regard to achieving a closure design, objective or criteria.

Specific progressive reclamation monitoring will include:

- material moved or placed for construction of fish habitat in dike areas;
- material placed in construction of NCRP-WRSA closure cover;
- waste produced by rock type;
- surface inventory of waste rock and till by rock type and re-mined for underground fill;
- waste rock and till area landscape from annual aerial photographs and surveying of "as-built" conditions relative to final closure design;
- seepage quality, thermal condition, slope stability of waste rock and till area;
- PKC performance with regard to pond water volumes, pore water chemistry, physical and thermal properties of PK over time;
- PKC landscape relative to closure design; and
- inventory of back hauls.

Information collected during monitoring of progressive reclamation will be reported through Annual Closure and Reclamation Plan Progress Reporting, Reclamation Completion Reporting and Performance Completion Reporting as appropriate.

Progressive reclamation maintenance activities have been identified for the NCRP-WRSA and are documented as part of the engineering design. Please see NCRP-WRSA Final Closure Plan V1.1 – Appendix X. Following construction of the cover, monitoring of the NCRP for deformation should continue to be completed by visual inspection and by aerial survey methods on an annual basis for 5 years, with results reviewed annually. After 5 years the frequency of inspections and survey should be revisited. Required maintenance works should be identified as part of the inspections and monitoring of the NCRP. Maintenance works may include, but not be limited to, re-grading of surfaces and maintenance of geotechnical instrumentation.

7 Temporary or Interim Closure Measures

In addition to planning for permanent closure, DDMI has prepared plans for an interim shutdown in accordance with the requirements of the Class “A” Water License and the MVLWB and AANDC *Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories (MVLWB 2013)*

7.1 Definition of Temporary/Interim Closure

Temporary or interim closure occurs when a mine ends operations with the intent to resume mining activities in the future. Temporary closure could be due to an unplanned closure or a planned closure of certain facilities (MVLWB 2013). Temporary closure can last for a period of weeks or for several years, based on economic, environmental and social factors. No defined period is proposed for the Diavik site.

7.2 Temporary Closure Goals, Objectives

The goal or objective of temporary or interim closure measures is to ensure the ongoing protection of people and the environment and regulatory compliance until the mining operations can resume. Measures necessary for this will depend upon the duration and extent of site activities/presence during the mine closure. MVLWB (2013) suggests the following be implemented or completed upon temporary mine closure:

- access to the site, buildings, and all other structures must be secured and restricted to authorized personnel only;
- all mine openings must be guarded or blocked and warning signs must be posted;
- all physical, chemical and biological treatment and monitoring programs must continue according to licenses, permits and leases in order to maintain compliance;
- all waste management systems must be secured;
- chemicals and reagents, petroleum products and other hazardous materials must be inventoried and secured appropriately or removed if required;
- fluid levels in all fuel tanks must be recorded and monitored regularly for leaks or removed from the site;
- all explosives must be relocated to the main powder magazine and secured, disposed of, or removed from the site;
- all waste rock piles, ore stockpiles, tailings, mine water and other impoundments structures must be stable and maintained in an appropriate manner (including regular geotechnical inspections);
- drainage ditches and spillways must be inspected and maintained regularly (e.g., seasonally depending on snow and ice accumulation and melting) during the closure period and included as part of geotechnical inspections;
- facilities and infrastructure must be inspected regularly; and

- the reclamation security deposit must be kept up to date.

7.3 Temporary Closure Activities

The following are anticipated closure activities that may be implemented if an interim shutdown occurs. The extent to which any of these actions will be implemented will be in part dependent upon the anticipated duration of the shutdown.

7.3.1 Open Pits, Underground and Dike Areas

7.3.1.1 Open Pits

The open pits will not be flooded until permanent closure. The extent to which the procedures listed below are implemented would depend on the anticipated length of the closure and the seasonal limitations on overland transport if any materials or equipment have to be removed from the site if an extended shutdown occurs:

- Dewatering of the open pits would continue as conducted during operations since flooding and subsequent dewatering may adversely impact stability of the pit walls and underground workings.
- Surface water and seepage control systems would continue as conducted during operations. Refer to water management facilities in Section 7.3.4.
- Block open pit access routes with boulder fences and/or berms.
- Post warning signs and fences or berms around pit perimeters.
- Geotechnical stability monitoring and maintenance would continue as per operations. The frequency may be adjusted based upon the duration of the shutdown and subject to Inspector approval. The open pit areas would be inspected to check for rock falls, changes to groundwater inflows and overall integrity.
- All mobile equipment except for small service equipment required for open pit inspections would be removed and prepared for on-site storage.
- Stationary and mobile surface equipment stored within the common parking areas would have drip/spill trays placed in appropriate locations to absorb fluids which could leak.
- Fuel, lubricants and hydraulic fluids would be removed from the open pit area and stored in designated areas.

7.3.1.2 Underground Mine Workings

The underground mine workings will not be flooded until permanent closure.
The underground mining plan involves the integral use of backfill. Therefore, only very limited excavations will be open at any one time within the kimberlite pipes and long-term stability of the pipes is assured independent of the timing of a shutdown.

The extent to which the procedures listed below are implemented would depend on the anticipated length of the closure and the seasonal limitations on overland transport if any materials or equipment have to be removed from the site if an extended shutdown occurs:

- Dewatering of the open pit and underground would continue as conducted during operation.

- Surface water and seepage control systems would continue as conducted during operations. Refer to water management facilities in Section 7.3.4.
- Operation of the primary fans, dewatering pumps and drainage sumps would be maintained.
- Airflow through the mine ventilations systems would be maintained. The raises would remain open and primary intake/exhaust fans would continue to operate in conjunction with underground ventilation controls (doors and seals), to ensure air flow through areas requiring ventilation, including sump and dewatering pump stations; the air would be heated during winter months.
- Underground electric power distribution system would be maintained.
- Underground access to the main decline would be blocked with boulder fences and/or berms, subject to leaving access for maintenance.
- Warning signs and fences or berms would be placed around perimeters of any access or surface opening for the underground workings.
- Geotechnical stability monitoring and maintenance would continue as per operations. The frequency may be adjusted based upon the duration of the shutdown and subject to Inspector approval. All underground facilities would be inspected to check for rock falls, changes to groundwater inflows and overall integrity.
- All mobile equipment except for small service equipment required for underground inspections would be removed to surface and prepared for on-site storage.
- Underground mobile equipment stored within the common parking areas would have drip/spill trays placed in appropriate locations to absorb fluids which could leak.
- Fuel, lubricants and hydraulic fluids would be removed from all underground locations and stored in designated on-surface areas.
- Explosives and accessories would be removed from the underground storage magazines to the surface magazines.

7.3.1.3 Enclosure Dikes

Dikes enclose both of the open pits. The dikes will not be breached until permanent closure to ensure that the open pits and the underground workings are not flooded. If there was an interim closure the following would be completed for the dikes:

- The dike seepage collection systems at the downstream toe of the dikes would remain active as in operations.
- Access to dike roads would be blocked with boulder fences and/or berms.
- Warning signs and fences or berms would be placed around the perimeters of the accesses to the dikes.
- Geotechnical stability monitoring and maintenance would continue as conducted during operations. Dikes would be inspected to check for slope stability, changes to inflows and overall integrity.

7.3.2 Waste Rock and Till Storage Areas

At the time of a temporary or interim closure the waste rock and till area could be in a state of active development or active re-mining for underground backfill. The action taken will depend on the anticipated duration of the closure but would include the following:

- Access to piles would be blocked with boulder fences and/or berms.
- Warning signs would be placed around the perimeters toes.
- Geotechnical stability monitoring and maintenance would continue as conducted during operations. Piles would be inspected to check for slope stability and seepage.

7.3.3 Processed Kimberlite Containment Area

During a shutdown the following would be completed at the PKC facility:

- the FPK pipe distribution system would be purged, flushed, and drained;
- providing water quality is sufficient to be treated by the NIWTP, the barge would be operated periodically to pump excess water to the NI as needed to maintain design flood storage criteria within the PKC pond; and
- geotechnical instrumentation would continue to be read.

7.3.4 Water Management Facilities

The water management plan would not change during an interim temporary shutdown. However, the inflow from the PKC pond would decrease since the plant would not be processing kimberlite. The following procedures would be followed:

- Water from the ponds, and the NI would continue to be pumped to the NIWTP as conducted during operations.
- Collection sumps and ditches around the site would be maintained to manage runoff from the PKC facility, the waste rock and till area, and the general site.
- The NIWTP would remain in operation to treat water pumped from the pits, underground workings and from the collection ponds.
- Operational daily monitoring of the water quality would be performed at the inlet of the treatment plant with regulatory sampling continuing on a six-day frequency and at the outfall monthly. Operational monitoring would include flow rates, pH, turbidity, conductivity, ammonia and temperature. Regulated sampling would continue as per the Water License.

If the short-term shutdown progresses into indefinite shutdown, then the runoff water from the site and the PKC pond would be redirected to the NI. The NIWTP would remain in operation to treat excess water from the NI before discharge to Lac de Gras.

7.3.5 Plant Site, Accommodation Complex and Fuel Storage

7.3.5.1 Processing Plant

Any stockpiled kimberlite ore remaining on surface at the start of a temporary shutdown would be processed before plant operations end. The plant would then be shut down in a planned and sequential manner to prevent damage to equipment, piping and instrumentation.

The following preparatory measures would be taken before plant shutdown:

- all rough diamonds would be removed from the diamond collection receptacles and shipped to Yellowknife;
- remaining C PK fractions would be transported by truck to either the North or South CPK Cells; and
- the FPK slurry pipelines would be flushed of solids using reclaim water pumped from the PKC facility.

Short-term shutdown strategies for the Processing Plant include:

- minimal heating would be maintained to the Processing Plant to prevent equipment freezing;
- the raw water supply to the Processing Plant would be turned off;
- power and process air supplies to the Processing Plant would be maintained;
- an inventory of all chemical reagents would be undertaken and maintained;
- all tank levels would be recorded and monitored;
- all major equipment would be run periodically to ensure lubrication and integrity of the rotating parts; and
- FeSi would be periodically re-circulated to prevent setting up in the circulating medium tanks.

In addition to the above short-term shutdown strategies, the following measures would be taken if a long-term shutdown of the Processing Plant occurred:

- equipment and gearboxes would be drained of lubricants and coolants, which would be stored in sealed drums in the Maintenance Complex, or removed from site;
- all tanks would be drained, and remaining FeSi would be transferred to the waste rock and till area;
- all reclaim water and FPK slurry pipelines would be flushed and drained;
- sensitive electronic devices such as instrumentation control cards, personal laptop computers and control system computers would be removed from the site or warehoused within the Maintenance Complex;
- all chemical reagents would be inventoried and transferred to warehouse storage within the Maintenance Complex, or would be removed from site;
- heavy rotating equipment would be lifted off bearings and safely supported;

- all heating and power would be turned off, and power lines to the Processing Plant would be discharged and left open; and
- the entire Processing Plant would be winterized and locked up with emergency access restricted to authorized personnel only.

7.3.5.2 Accommodation Complex

With the exception of accommodation facilities required for care-and-maintenance personnel, wings, common areas and offices within the Accommodation Complex would be closed off to reduce power, heating and ventilation requirements during temporary shutdown.

All care-and–maintenance personnel would be housed within one wing of the complex and would be serviced by a single cafeteria, common area and laundry room. Recreational facilities located within the gymnasium would also remain available to on-site personnel during the shutdown periods.

Any hazardous materials located within closed off areas of the Accommodation Complex would be collected, inventoried and stored in the Maintenance Complex warehouse. All closed off areas would be securely locked with access restricted to authorized care-and-maintenance personnel only.

7.3.5.3 Administration/Maintenance Complex

Non-essential areas and offices within the Administration/Maintenance Complex would be closed off during temporary shutdown so that heating and ventilation could be reduced to minimum levels. All necessary support facilities and services for care-and-maintenance personnel would remain in operation, including workshops, the Emergency Response Vehicle garage, and the warehouse.

Any hazardous materials located within closed off areas would be collected, inventoried and stored in the warehouse. All closed off areas would be securely locked with access restricted to authorized care-and-maintenance personnel only.

7.3.5.4 Fuel Storage

The fuel storage areas would remain functional during short-term and long-term shutdown periods in support of care-and-maintenance activities. All tank levels would be monitored throughout the shutdown period, and the tanks would be regularly inspected for potential fuel leaks.

7.3.5.5 Power Plant

The power plant and waste heat recovery would remain functional during temporary shutdown periods to supply power and heating requirements for care-and-maintenance personnel. All non-essential power lines would be discharged and left open during long-term shutdown when power and heating supplies to non-critical plant and infrastructure would be turned off. The power plant would be configured to operate at maximum efficiency under the reduced loading condition.

7.3.5.6 Boiler Plant

The Boiler Plant would remain functional during short-term and long-term shutdown periods to supply minimal heating requirements in the event of a failure within the main power plant. All non-essential glycol lines would be flushed and drained during long-term shutdown when heating supplies to non-critical plant and infrastructure would be turned off. Excess glycol would be placed in sealed drums, which would be stored in the Boiler Plant or sent to warehousing within the Maintenance Complex.

7.3.6 Infrastructure

During temporary shutdown, the site infrastructure would be placed into a care-and-maintenance mode to minimize operating costs and ensure environmental stability while maintaining conditions that would permit the safe mechanical resumption of operations at reasonable cost and schedule.

Temporary shutdown strategies for the site infrastructure include the following:

- All support infrastructures necessary for care-and-maintenance activities would remain in operation during shutdown periods. This would include select arctic corridors, the communication system, the airstrip and roads, the raw water intake, the potable water treatment plant, the sewage treatment plant, the WTA and inert landfill.
- Minimal heating to critical facilities would be maintained to prevent equipment freezing.
- Water supplies would be turned off in specific areas that are not in use or are at a lower risk of fire.
- All non-critical facilities and equipment requiring power and/or heating would be shutdown. Computing facilities including networks and databases would be backed-up. Equipment and gearboxes would be drained of lubricants and coolants, which would be stored in sealed drums in the Maintenance Complex, or removed from site. Heavy rotating equipment would be lifted off bearings and safely supported. All heating and power would be turned off, and power lines to the plants would be discharged and left open.
- Remaining equipment would be adjusted or modified to operate at lower capacity and consume less power. All major equipment would be run periodically to ensure lubrication and integrity of the rotating parts.
- Excess chemical reagents and hazardous materials stored within the site buildings would be collected, inventoried and warehoused within designated areas, or transferred off site.
- All non-essential tanks would be drained, and remaining materials would be transferred to the waste rock and till area for storage. All remaining tank levels would be recorded and monitored.
- Explosive materials would be inventoried and stored within the Ammonia Nitrate Storage or Caps/Explosives Storage, or transferred off site.
- The Ammonia Nitrate Storage, Caps/Explosive Storage and Emulsion Plants, and the Batch and Crusher plants would be locked up securely with emergency access restricted to authorized care-and-maintenance personnel only.

- Most surface mobile equipment would be relocated to a secured, common parking area and inspected for any potential oil or other fluid leaks. Emergency response vehicles would be kept in the garage located within the Maintenance Complex, available for use as required.
- Stationary surface and underground mobile equipment stored within the common parking areas would have drip/spill trays placed in appropriate locations to absorb fluids which could leak.

7.4 Monitoring, Maintenance and Reporting

The required monitoring and reporting during interim closure will be the same as the required monitoring procedures carried out during operations as described in Water License, Fisheries Authorization, Land Use Permits and Environmental Agreement. Any changes in monitoring and reporting that may be appropriate during interim closure would be submitted to the WLWB and Inspector for approval before implementation.

7.4.1 Open Pits, Underground and Dike Areas

7.4.1.1 Open Pits

Geotechnical and water quality monitoring of the open pits during interim closure will occur as in operations. The geotechnical instrumentation installed throughout the open pit includes the following:

- piezometers;
- thermistors;
- inclinometers;
- extensometers;
- survey pins; and
- seismographs.

Visual inspections will also be conducted routinely to check for signs of instability, rockfall and overall integrity.

Water quality samples of pit sump water located at the base of the open pits will be obtained at approved locations in accordance with the Water License SNP. The samples will be tested for physical parameters (i.e., pH, TDS, TSS and conductivity), major ions, nutrients, oil and grease, and metals. In addition, the flows will be measured using flowmeters installed at the NIWTP.

7.4.1.2 Underground Mine Workings

Geotechnical and water quality monitoring of the underground mine workings during interim closure will occur as in operations. The geotechnical instrumentation for the underground workings will be integrated with the open-pit monitoring and may include the following:

- piezometers;
- thermistors;
- extensometers; and
- survey pins.

Water quality samples will be obtained from water pumped from the underground workings in accordance with the Water License SNP. The samples will be tested for physical parameters (i.e., pH, TDS, TSS and conductivity), major ions, nutrients and metals. In addition, flows to the underground workings will be measured using flowmeters installed at designated locations.

7.4.1.3 Enclosure Dikes

Geotechnical and water quality monitoring of the enclosure dikes during interim closure will occur as in operations. The geotechnical instrumentation installed within the dikes and near the fish habitat areas include the following:

- piezometers;
- thermistors;
- inclinometers;
- extensometers; and
- survey pins.

Visual inspections will also be conducted to check for signs of instability, including bulging, slumping or the development of tension cracks.

Water quality samples will be obtained from the dike seepage collection system located between the dike toe and the open pit rim in accordance to the Water License SNP. The samples will be tested for physical parameters (i.e., pH, TDS, TSS and conductivity), major ions, nutrients and metals. In addition, the flows will be measured using flowmeters installed at the NIWTP.

7.4.2 Waste Rock and Till Areas

Geotechnical monitoring of the waste rock and till area will be through regular inspections. Visual inspections will also be conducted to check for signs of instability.

Water quality and quantity monitoring of seepage and runoff from the waste rock and till area will occur as in operations as defined in the Water License. Water quality samples will be taken directly from the collection ponds. The water quality samples will be tested for physical parameters (i.e., pH, TDS, TSS and conductivity), major ions, nutrients and metals.

The water collected in the collection ponds will be monitored (quantity and quality) and discharged to Lac de Gras if the quality meets Water License effluent criteria. If the discharge criteria are not satisfied, the water will be pumped to the PKC Facility.

7.4.3 Processed Kimberlite Containment Area

Geotechnical monitoring within the PKC area during interim closure will occur as in operations. The geotechnical instrumentation may include the following:

- piezometers;
- thermistors;
- inclinometers; and
- survey pins.

Visual inspections will also be conducted to check for signs of instability.

Water quality and quantity monitoring of the PKC pond will occur as in operations but at a reduced frequency since the plant will not be processing kimberlite. Inflow to the ponds will be reduced to surface flow and limited treated sewage water. Pond water volume will be monitored by changes in water elevation. Water quality samples taken from the pond will be tested for physical parameters (i.e., pH, TDS, TSS and conductivity), major ions, nutrients and metals. Actual dissolved metals concentrations will be monitored and trended to evaluate the need for additional water treatment.

Excess water collected within the PKC pond will be pumped to the NI for treatment at the NIWTP.

7.4.4 Water Management Facilities

Operational monitoring protocols and procedures will continue at the water management facilities during interim closure. Monitoring of the water quality will be performed at the inlet of the NIWTP and at the outfall as per the SNP requirements. Monitoring will include tests for physical parameters (i.e., pH, TDS, TSS and conductivity), major ions, nutrients and metals. Samples will also be obtained and tested per the Water License.

In addition to monitoring at the NIWTP, water quality samples will be taken from locations indicated in the SNP.

7.4.5 Plant Site, Accommodation Complex and Fuel Storage

The plant site, Accommodation Complex and fuel storage areas will be inspected and maintained regularly during interim closure. In addition, all tank levels and fuel tanks, will be monitored as in operations.

7.4.6 Infrastructure

Infrastructure will be inspected and maintained regularly during interim closure.

7.5 Contingency Program

A core staff with access to external consultants and advisors would be maintained during any temporary closure. This team would be available to resolve any unforeseen events or conditions identified through the monitoring program. Many of the contingency options and plans that could be implemented during a temporary closure would be the same as those employed during operations and are defined in the most recent version of DDMI’s *Operations Phase Contingency Plan*.

7.6 Schedule

As temporary shutdown is commonly an uncertain condition, the schedule would be necessarily progressive as each week, month, season or year passes. Specific schedules would need to be developed before any temporary shutdown. The following includes typical schedule considerations.

During periods of short-term shutdown (usually less than one year), mining activities other than maintenance, monitoring, intermittent testing, periodic operation of equipment and appropriate facilities, would generally stop. Compliance with all permits and licenses will continue. A sufficient number of care and maintenance staff would be present on-site, and an appropriate level of security would be implemented at selected facilities. Activities related to ensuring public and wildlife safety would be a priority. Such activities would focus upon maintenance and monitoring of all facilities, equipment and stores to maintain physical and chemical stability. Access to temporarily inactive facilities would be restricted to authorized personnel. Fences and signposts to deny access would be erected as appropriate (e.g., underground portal).

Dewatering would continue at the open pit and underground workings to maintain stability. Underground areas would continue to be ventilated. Site-wide surface water, sediment and seepage control systems would be inspected regularly and would be maintained. Access to the PKC area would be restricted. Routine geotechnical stability monitoring and maintenance of the waste rock and till area, other material stockpiles, the PKC and other mine water impoundment structures would continue.

All facilities and infrastructure would be inspected regularly. Infrastructure, equipment, tools and utilities would remain in serviceable and safe condition. Non-emergency and non-essential vehicles would be parked in a secured common area, and when necessary, winterized. Non-essential buildings would be locked, and non-essential power lines would be discharged and locked open. All equipment would be maintained in a no-load condition. If necessary, selected equipment would be drained and stored. All tank levels, including fuel tanks, would be recorded and monitored, and chemical reagents, explosive materials and solvents would be inventoried.

8 Integrated Schedule of Activities to Permanent Closure

The integrated schedule of activities currently envisaged for advancing and implementing the preferred closure plan for the mine site is shown in Figure 8-1. The schedule as presented is highly uncertain. A refined schedule will only be possible once final designs and decommissioning plans have been completed. All schedules are subject to changes in mine plans. Market conditions could slow activities. Exploration or improved economics could extend the mine life beyond 2025.

The schedule in Figure 8-1 is a composite of the area-specific schedules presented in Section 5.2. Common activities have been combined. A brief description of each activity follows:

- *Mining Activities A154/A418/A21* – The mine areas are currently expected to be active until 2025 limiting the closure activities.
- *Dump Development* – The waste rock area is an active facility. It will continue to receive waste rock from open-pit mining through to 2023.
- *Re-Mining for Backfill* – Waste Rock will be re-mined for underground backfill through until 2025.
- *PK Deposition* – The PKC is an active facility and will be active until the last day of diamond production (currently 2025). Closure activities and associated works must remain mindful of this fact.
- *Mine Water Treatment* – The NIWTP would continue to treat mine water until the completion of underground mining and will then be required during the closure and reclamation activities up to 2029.
- *Accommodation/Power/Transportation Required* – Infrastructure will be required at one level to support mining operations (currently ending 2025) and then at a lesser level for closure activities (currently ending 2032).
- *Community and Regulatory Engagement* – Continued engagement is anticipated to refine the closure plans for the mine area. In particular, engagement is envisaged to strengthen Traditional Knowledge review Final engagement is anticipated around 2032 to confirm final closure performance.
- *Final Engineering* – Engineering to prepare final design drawings and construction specifications for closure activities would be completed for inclusion with the Final CRP
- *NCRP Cover Construction* – DDMI plans to execute the NCRP-WRSA Closure Plan starting in 2017 with expected completion of the cover by 2022.

- *Inventory of Assets* – A detailed inventory of assets for sale/reuse, salvage, and recycling will be begin three years before the final closure work begins to initiate external marketing.
- *Commercial Arrangements – Sale/Transfer of Assets* – Specific arrangements would be made for sale, reuse, salvage or recycle of equipment and materials in advance of decommissioning.
- *Complete Fish Habitat Construction* – Any final fish habitat construction work not completed during operations will be completed before back flooding.
- *Targeted Re-Vegetation* – Targeted re-vegetation will be conducted as series of campaigns starting in 2026 with available areas and finishing in 2031 after the final buildings are removed.
- *Decommissioning of Collection Ponds 1, 2 and 3* – Once runoff and seepage water quality/quantity have been confirmed, decommission collection ponds including removal of any pumping/piping infrastructure.
- *PKC Outlet Preparation* – Deconstruction of a section of PKC liner and preparation of an engineered drainage outlet.
- *Placement of Final Surface and Wildlife Access - PKC* – Rock placement will be required to prepare final PK surface, construct access routes around the PKC and re-slope access ramps.
- *Decommissioning of Surface Mine Infrastructure* –Mining equipment and associated infrastructure for A418A154/A21 open pits will be removed.
- *Decommissioning of Underground Mine Infrastructure* –A418/A154 underground mining equipment and associated infrastructure will be removed, and surface access locations will be sealed in preparation for flooding.
- *Decommissioning of Process and Paste Plants* – All activities associated with decommissioning this facility will occur.
- *Decommissioning of Explosives Plant and Storage* – All activities associated with decommissioning these facilities will occur.
- *Flood Mine Areas – Clarify Water* –The open pit and underground mine areas will be flooded. Water quality of A154/A418 and A21 pool areas will be monitored. Two years has been allocated to provide time for settling of particulate material.
- *Decommissioning of Accommodations and Other Buildings* – All activities associated with decommissioning these facilities will occur.
- *Decommissioning of Fuel Storage and Power* – All activities associated with decommissioning these facilities will occur.
- *Decommissioning of Collection Ponds 4, 5 and 7* – Once outlet and seepage water quality/quantity have been confirmed, decommission collection ponds.
- *Decommissioning of Dikes* –Breaches in the dikes will be excavated to re-connect Lac de Gras with mine area.

- *PKC Infrastructure Decommissioning* – Removal of reclaim barge, water and slurry pipelines, power and any associated surface infrastructure.
- *Decommissioning of Waste Transfer* – Activities associated with decommissioning this facility.
- *Decommissioning of Collection Ponds, and Pipelines 10, 11 and 12* – Activities associated with decommissioning these facilities.
- *Final NI Sediment Investigation* – A final sediment investigation is planned for as a final check to determine if hydrocarbon contamination has been sufficiently improved to enable fish use of the NI.
- *Treat and Discharge NI Water* – NIWTP will be used to treat the final water in the NI and discharge the water to Lac de Gras. Lac de Gras water will be allowed to seep into the NI through the decommissioned NI west dam to replace the volumes removed for treatment
- *Decommissioning North Inlet Dams* – When NI water and sediment quality have been confirmed, the east and west dams will be decommissioned.
- *Decommissioning Airstrip and Landfill* – All activities associated with decommissioning these facilities.
- *Performance Monitoring* – Performance monitoring will be conducted starting in 2017.
- *Engineering Inspections* – Inspections would be conducted during construction and decommissioning activities and in the years immediately following to review the closure performance.
- *Environmental Effects Monitoring* – In addition to specific performance monitoring, environmental effects monitoring would be conducted on a three-year cycle as a continuation of the Wildlife and Aquatics Effects Monitoring Programs. The frequency of specific elements and the completion date for monitoring would change based on results. Monitoring will continue from operational monitoring but will emphasise closure effects.
- *Reclamation Completion Reporting* – Report detailing the work completed, any deviations from the approved design and CRP, “as-built” reports and description of any monitoring still required.
- *Performance Assessment Reporting* – Reports providing a detailed comparison of conditions at site against closure objectives and criteria, identify any residual risk, describe monitoring and maintenance activities and update the security estimate.

9 Post-Closure Site Assessment

Residual environmental impacts of the post-closure mine site were first assessed during the EA for the Project (DDMI 1998c). In the 1998 EA, environmental impacts were assessed for the construction, operation, closure and post-closure phases of development (DDMI 1998c). The assessment was based the closure concepts at the time and predicted environmental changes. Specifics of the closure plan have evolved since 1998 EA (see Section 5).

Expected post-closure residual effects will become better defined over time. When the closure concepts are finalized, closure performance will be predicted and the predictions will be used to assess residual environmental impacts. After closure activities are complete actual results from performance and environmental effects monitoring will be used to assess environmental impacts.

The assessment results from the 1998 EA remain relevant as a preliminary assessment of residual environmental impacts. The development has proceeded largely as described in 1998 and with only a few exceptions (dust deposition and wildlife zone of effects), environmental conditions remain within the EA predictions. DDMI plans to use the same approach that was developed for the 1998 EA to assess residual environmental impacts at closure. These methods remain valid and relevant and a continuity in methodology from development assessment to post-closure assessment will provide helpful contrasts. The main difference in evaluating post-closure residual effects for the post-closure assessment will be that predictions of post-closure site and environmental conditions will be largely based measured environmental conditions rather than predictions. However, in some cases forecasts of environmental conditions will still be required and will be based on both measured post-closure conditions and information collected over the life of the mine operations.

Information and data collection is ongoing (see Appendix VIII), and will be used to update predictions of environmental conditions at closure. Closure designs will also evolve from initial concepts to final design concepts. DDMI will update the residual environmental impacts when the final closure design concepts are complete.

This section summarizes the approach used in the 1998 EA to assess environmental effects, as well as the results of the original assessment by key ecosystem component for the post-closure phase. Any differences based on current understanding of residual effects post-closure or changes to operational impacts as a result of environmental effects monitoring conducted to date are noted.

9.1 Assessment Approach

The 1998 EA focused on issues of ecological importance and importance to the people who would be affected by the mine development. The EA was structured to provide focused, understandable and relevant information about the type, extent and magnitude of potential environmental effects. The following general approach was used to assess potential environmental effects in the EA:

- identify important issues relevant to the assessment of the mine;
- discuss the physical, biological, socio-economic and socio-cultural environments in which the mine would be introduced;
- explain the potential effects of the mine on those environments; and
- provide an assessment of the nature and, where possible, the magnitude and severity of these potential effects.

Potential environmental effects of the mine development were originally predicted for four phases: construction, operation, closure and post-closure. The post-closure phase will be discussed here.

In conducting the *Comprehensive Study Review* for the Project the Responsible Authorities required sufficient information to determine if the proposed project would have significant adverse environmental effects. To address this information requirement, the EA described potential effects according to their magnitude, duration and geographic extent.

Potential effects on the environment were analyzed at the local, regional and cumulative scales. The size of each of these study area scales varied with the potential effect being assessed in order to capture the context necessary to best understand and quantify the potential effect. In general, the potential effects in the immediate vicinity of the mine were assessed with respect to the local scale, which was typically the East Island and adjacent water. For the regional scale the study area sizes were more varied. For example, the drainage basin of Lac de Gras (3,559 km^2) was considered to be sufficiently large to examine the potential regional effects of the mine on fish and water. However, to adequately assess potential regional effects on wildlife, a much larger area (approximately 11,500 km^2) was used.

The geographic extent is the spatial area that is affected by an activity. For the purposes of the environmental effects assessment, potential effects that were restricted to the LSAs were assessed as local in geographic extent. If an effect extended beyond the LSA, it was considered to be a regional effect. In some cases, effects have the potential to extend even farther and were considered “beyond regional.” Typically the cumulative effects were assessed using the RSA or the beyond RSA.

Magnitude describes the amount of change in a measurable parameter or variable relative to baseline conditions (e.g., 1996 conditions). The specific criteria used to determine the magnitude of an effect are related to the characteristic being investigated (e.g., fish populations, archaeological sites), the methods available to measure the effect, and the accepted practice in different scientific disciplines.

A brief description of the local, regional and cumulative study scales used, as well as the rationale for selection of the study scales is provided in Table 9-1. The criteria used to define the magnitude of each characteristic is defined in Table 9-2.

Table 9-1 Brief Descriptions of the Local, Regional and Cumulative Study Areas Used for Assessing Potential Effects in Each Discipline

Local Study Area	Regional/Cumulative Study Area	Rationale for Selection of Study Areas
Air Quality		
The East Island and adjacent waters of Lac de Gras.	An area 25 km east-west by 35 km north-south centred around East Island.	The LSA was selected as the area where ambient particulate concentrations and deposition rates would likely be the greatest. The RSA encompasses the entire area within which ambient concentrations are likely above the thresholds commonly used to define the distance from the emissions sources to locations where modelling is no longer necessary.
Vegetation and Terrain		
The East Island.	The drainage basin of Lac de Gras.	The study areas were selected because they are representative of the areas that could be affected by the proposed Project. The LSA was selected for assessing direct effects from the Project, while the RSA provides the context for understanding effects at the regional level.
Wildlife		
The East and West Islands; small islands in the east half of Lac de Gras; and the mainland along the south, east and north shores of Lac de Gras.	North to Yamba Lake; west to Desteffany Lake; south to MacKay; and east to Glowworm and Afridi Lakes.	These study areas were selected to effectively represent and assess the diversity in patterns of use by wildlife. The LSA provides a framework for assessing effects on sedentary species with small seasonal ranges, and the RSA provides a framework for assessing effects on species that have large seasonal ranges. Migratory species which use an area seasonally are also considered using these study areas.
Fish and Water		
The East Island and the surrounding water, within 1 km of the East Island shoreline.	The drainage basin of Lac de Gras.	The LSA was selected as a framework for presenting the effects on the aquatic environment that are likely to occur in the immediate vicinity of the proposed Project (e.g., fish habitat alterations on the East Island, alterations to water quality directly adjacent to the dikes). The RSA was selected to present effects in a regional context which is most appropriate for assessing effects on fish populations in Lac de Gras and water quality in Lac de Gras as a whole.

Table 9-1 Brief Descriptions of the Local, Regional and Cumulative Study Areas Used for Assessing Potential Effects in Each Discipline (continued)

Local Study Area	Regional/Cumulative Study Area	Rationale for Selection of Study Areas
Heritage Resources		
The East Island.	The East and West Islands and adjacent mainland to the north and east.	The LSA corresponds to the area potentially affected by the footprint of the Project. The RSA corresponds to the initial baseline studies, which encompasses the widest geographic area in which the Project facilities could have been situated.
Socio-Economics		
Communities of Gameti, Wekweètì, Dettah, N'dilo, Rae-Edzo, Wha Ti, and Lutsel K'e. Yellowknife was included for economic analysis.	The Western NWT; emphasis on 20 study area communities.	The LSA encompasses the communities that would likely experience changes to traditional land use and occupancy, wage-based employment and community infrastructure, as a result of the proposed Project. The RSA includes communities that may experience employment and business changes by virtue of their location and accessibility.

Table 9-2 Definitions for Magnitude and Duration

CLIMATE AND AIR QUALITY

Magnitude	Duration
Magnitude was determined by comparing to ambient air quality objectives	Duration was determined by the averaging period defined by the objectives used to determine magnitude

VEGETATION

Magnitude		Duration	
Negligible	Less than 1% changes to measurement endpoint	Short-term	Less than 1 year
Low	1% to 5% change	Mid-term	1 to 25 years
Moderate	6% to 30% change	Long-term	Greater than 25 years
High	Greater than 30% change		

WILDLIFE

Magnitude		Duration	
Low	Less than 1% change from baseline conditions	Short-term	Less than 3 years
Moderate	1% to 10% change	Mid-term	Between 3 and 30 years
High	Greater than 10% change	Long-term	Greater than 30 years

HERITAGE RESOURCES

Magnitude		Duration	
Low	Lost resource has limited scientific value with limited potential to contribute to public awareness and appreciation	Short-term	Not applicable
Moderate	Lost site has local and regional scientific interpretive values and has good potential to contribute to public awareness and appreciation	Mid-term	Not applicable
High	Lost site has regional scientific interpretive values with excellent potential to contribute to public awareness and appreciation	Long-term	Heritage resources are permanently altered

Table 9-2 Definitions for Magnitude and Duration (continued)

FISH AND WATER - MAGNITUDE

Sub-Section	Magnitude	
Water Quality		
Suspended Sediment	Low	Severity classes 0 (representing no effect) to less than 9 (representing short-term behavioural, feeding and physiological effects)
	High	Severity classes 9 (representing short-term behavioural, feeding and physiological effects) to 14 (representing 80 to 100% mortality)
• Pore water Release; • Dike Leaching; • Mine Water Discharge; and • East Island Runoff	Negligible	Concentration less than the drinking water and/or aquatic life guideline
	Low	Concentration exceeds the drinking water and/or the aquatic life guideline by 10% or less
	Moderate	Concentration exceeds the drinking water and/or the aquatic life guideline by 10% to 20%
	High	Concentration exceeds the drinking water and/or the aquatic life guideline by more than 20%
Sedimentation and Dust; and Air Emissions	High	Sedimentation exceeds 1 mm for any spawning and nursery habitat
Groundwater Quality	Negligible	Concentrations less than or equal to drinking water guidelines
	High	Concentrations greater than drinking water guidelines
Water Supply		
Lac de Gras Water Balance	Negligible	Less than or equal to 5% change
	Low	Greater than 5% and less than or equal to 10% change
	Moderate	Greater than 10% and less than or equal to 20% change
	High	Greater than 20% change
Groundwater Quantity	Low	Groundwater heads reduced but rock remains saturated
	High	Rock is completely dewatered and becomes unsaturated
Fish		
Angling	Low	Harvest rate below the sustainable yield
	High	Harvest rate above the sustainable yield
Blasting	Negligible	Peak particle velocity and instantaneous pressure change below threshold
	High	Peak particle velocity and instantaneous pressure change above threshold

Table 9-2 Definitions for Magnitude and Duration (continued)

FISH AND WATER – MAGNITUDE (CONTINUED)

Sub-Section	Magnitude	
Fish (continued)		
Dike Closure and Dewatering	Negligible	Less than or equal to 1% change in fish populations
	Low	Greater than 1% and less than or equal to 10% change in fish populations
	Moderate	Greater than 10% and less than or equal to 20% change in fish populations
	High	Greater than 20% change in fish populations
Habitat Change	Negligible	Less than or equal to 1% loss of fish habitat
	Low	Greater than 1% and less than or equal to 10% loss of fish habitat
	Moderate	Greater than 10% and less than or equal to 20% loss of fish habitat
	High	Greater than 20% loss of fish habitat
Fish Quality	Negligible	Predicted metal concentration in fish tissue is equal to or less than the consumption threshold
	High	Predicted metal concentration in fish exceeds threshold

FISH AND WATER – DURATION

Duration	
Short-term	Less than 3 years
Mid-term	3 to 30 years
Long-term	Greater than 30 years

The regional and local study scales are visually presented in Figures 9-1 and 9-2. The RSAs are shown in Figure 9-1 and the LSAs for wildlife, vegetation and terrain, fish and water, heritage resources and air quality are shown in Figure 9-2.

The duration of potential environmental effects were broadly divided into following three classifications:

- **Short-term effects** lasting for less than three years (i.e., effects generally associated with the period of intense construction activity before the start of operations, but may also occur during other phases);
- **Mid-term effects** lasting from 3 to 30 years (i.e., effects generally related to mine operations and closure, and extending from the beginning of operations to the beginning of post-closure); and

- **Long-term effects** lasting longer than 30 years (i.e., effects which persist beyond closure of the mine).

The long-term effects or those that last beyond closure that are of specific interest here.

In addition to the three main effect classifications of magnitude, duration and geographic extent, additional classifications were frequently considered, including ecological context and reversibility.

Ecological context is a measure of the relative ecological importance of a component of the environment. It indicates the degree to which an effect on the component would substantially affect the functioning of the ecosystem within the local or RSA. Ecological context was occasionally used to modify the magnitude classification assigned to an effect (i.e., the magnitude of an effect may be lowered or raised in accordance with the ecological context of the environmental component being assessed). In many cases, ecological context is explicit in the selection of the resource component being addressed. For example, caribou were chosen as a wildlife species for the assessment because they are the primary herbivore in the ecosystem and important for hunting.

Reversibility is also a factor related to duration. Loss of heritage sites, for example, is not reversible because the site is not replaceable. Plant reclamation of disturbed sites is not reversible in the short-term, but natural processes would eventually result in vegetation recovery.

Because environmental effects assessments deal with predictions of future circumstances, or must predict how complex environmental systems could respond to disturbances, effects assessments vary in their level of certainty. In some cases, predictions can be made with a high degree of confidence. For example, archaeological sites within the mine footprint are highly likely to be affected. Conversely, predictions of how fish populations would respond to the effects of increased productivity can be made with less certainty. Each environmental effects report addresses issues of certainty when it is an important factor in judging the potential effects of the mine.

With information on geographic extent, magnitude and duration an effect is assigned an effect level classification, as illustrated in Figure 9-3. Effects classifications with a level designation of “IV” are all long-term duration and Level IV effects are considered post-closure residual effects. Level IV effects are further defined by geographic extent as follows:

- Level IV Local Effect;
- Level IV Regional Effect; and
- Level IV Beyond Regional Effect.

The Responsible Authorities furthered this classification system in the Comprehensive Study Report to define a “significant adverse effect”. A significant adverse effect is an effect that has a high probability of a permanent or long-term effect of high magnitude, within the regional area that cannot be technically or economically mitigated (Canada 1999).

9.2 Post-Closure Effects Assessment

This section provides a summary of the effects assessment results from the 1998 EA with an emphasis on residual post-closure results. This assessment remains as a reasonable preliminary assessment of residual impacts.

Following is a summary of material presented in the Diavik Diamonds Project EER:

- Air and Climate (Cirrus 1998);
- Vegetation and Terrain (Golder 1998a);
- Wildlife (Axys Environmental Consulting and Penner and Associates 1998);
- Fish and Water (Golder 1998b); and
- Heritage Resources (Fedirchuk McCullough & Associates 1998).

These documents provide specific information.

9.2.1 Air Quality

Effects on local and regional air quality are linked to mine emissions. The EA focused on maximum periods of emissions during operations and concluded that the predicted ambient air quality would not lead to identified adverse environmental effects. Post-closure mine emission sources will be removed, which will result in improved local and regional air quality relative to operations. No long-term effects were identified.

Dust deposition is associated with potential effects to aquatic, vegetation and wildlife resources and was calculated based on information about the release of particulates into the air. The sources of the particulate material were all from mine-related activities (e.g., rock hauling, blasting, dumping, crushing) that would not exist post-closure. Some particulate would continue to be generated from wind erosion of rock surfaces but these would be substantially less than assessed for the operations phase. Dust deposition rates during operations have been measured by DDMI to be higher than predicted in the EA. Environmental impacts of dust on ecosystem components (aquatic, vegetation or wildlife) are discussed in the relevant sections below.

The mine has been designed for very efficient use of energy and energy recovery, which minimizes greenhouse gas emissions. Nevertheless, mine operations emit greenhouse gases through fuel use on site and transportation of personnel and materials to the site. Emissions would primarily consist of carbon dioxide, with much smaller amounts of methane and nitrous oxide. The mine operation is a very minor emission contributor to Canada's total greenhouse gas emissions and would have no emissions post-closure.

9.2.2 Vegetation and Terrain

Disturbed vegetation recovers slowly in conditions typical of arctic environments. Even with re-vegetation efforts, effects of the mine development on vegetation are expected to remain as residual effects post-closure.

The main effect on vegetation resulting from mine development is the reduction in the aerial extent of all VLC types (Figure 9-4). The VLC and water types within the LSA directly affected by the mine development are listed in Table 9-3. Locally, the magnitude of this effect would be high. Within the RSA this direct loss of VLC from the mine development would be less than 1% and considered negligible. Additionally, because no uncommon plant species or plant communities were identified within the mine development footprint, vegetation loss would be low in the ecological context.

Table 9-3 Direct Losses to Vegetation/Land Cover Due to Development of the Diavik Diamonds Mine, Year 2018

Vegetation/Land Cover Type	Local Study Area - Baseline		Regional Study Area - Baseline		Total Disturbance (Diavik Project)		
	km^2	%	km^2	%	km^2	%loss of Vegetation Land Cover Type in LSA	% loss of Vegetation Land Cover Type in RSA
Heath Tundra	8.70	38	1,674.77	38	3.38	39	0
Heath Tundra 30 to 80% Bedrock	1.65	7	83.51	2	0.75	45	1
Heath Tundra 30 to 80% Boulders	3.84	17	530.82	12	1.70	44	0
Tussock/Hummock	2.70	12	382.12	9	1.48	55	0
Sedge Wetland	0.46	2	134.06	3	0.24	52	0
Riparian Tall Shrub	0.05	<1	3.27	<1	0.03	56	1
Birch Seep and Riparian Shoreline Shrub	0.34	1	55.88	1	0.10	28	0
Boulder Complex	0.22	1	17.05	<1	0.05	23	0
Bedrock Complex	0.10	<1	4.29	<1	0.07	72	2
Shallow Water	0.98	4	172.22	4	0.46	47	0
Deep Water	3.49	15	1,304.04	30	3.12	90	0
Human Disturbance	0.06	<1	0.26	<1	0.06	100	22
Esker	0.25	1	39.95	1	0.14	55	0
Unclassified	0	0	1.08	<1	-	-	-
Total	**22.84**	**100**	**4,403.32**	**100**	**11.57**	**51**	**<1**

LSA = Local Study Area; RSA = Regional Study Area; km^2 = square kilometre; % = percent; <= less than.

Localized changes in plant community composition is expected to occur outside the mine footprint in response to dust deposition and changes in drainage conditions. The effects of dust would be concentrated within 10 m of Project facilities, and mostly limited to within 50 m. Incremental losses (over losses due to the mine footprint) were calculated as being 1% and 9% for each zone of impact, respectively. Effects on vegetation due to changes in drainage were estimated to affect 10% of the LSA. The geographic extent of these changes would be restricted to the LSA, and effects would be up to a moderate magnitude. Effects on vegetation outside the mine footprint are expected to reverse in time but could last more than 25 years and therefore are classified as local residual effects post-closure.

No plant species, vegetation types or terrain type would be eliminated by the mine development. At the landscape level, the number of naturally occurring terrain units may drop, but man-made units would increase, such that a low magnitude local increase in terrain diversity would result. At the community level, the richness (number) of VLC units would decrease by 14%, which represents an effect of moderate magnitude. Introduction of disturbed types could result in an increase, although artificial, in the diversity of community types. The size and range of patches for most VLC types would decrease due to the mine footprint. These changes would have moderate to high magnitude local effects on community structure. At the species level, a reduction of some 44% of species diversity and richness units is expected at the local level. This represents a local loss of high magnitude. However, no rare or endangered species would be affected.

All changes to vegetation and/or terrain biodiversity are expected to have a local geographic extent and be long-term in duration and therefore are classified as local residual effects post-closure.

9.2.3 Wildlife

9.2.3.1 Grizzly Bear

At full mine development, existing grizzly bear habitat availability would be expected to be reduced (through reductions in habitat suitability and effectiveness) by greater than 1% within the LSA but by less than 1% within the RSA, resulting in a high local effect but a low regional effect. Effects are considered to be regional in extent because the zone of influence of sensory disturbances extends marginally beyond parts of the LSA.

At post-closure, the causes of reduced habitat effectiveness (sensory disturbance) would have been largely removed. Nevertheless, there could potentially be a holdover, regional-level effect for some time after the mining activities end due to the learned avoidance responses of individual bears. The impact extent would, therefore, continue to be classified as regional. The effects of reduced habitat suitability through direct habitat loss within the mine footprint would remain at post-closure. These effects directly affect much less than 1% of total grizzly bear habitat in the RSA, resulting in a low magnitude regional impact. Greater than 1% of the total bear habitat in the LSA are affected which is equivalent to a moderate magnitude, local impact. However, the percentage of habitat affected post-closure would be less than during full development.

9.2.3.2 Raptors

Cumulative effects to raptors at full development were anticipated to be moderate in magnitude, based on predicted impacts on areas currently providing high to very high raptor nest site potential. This assessment represents a worst-case scenario, and the actual magnitude of reduced nesting potential would likely be lower than the 1.8% loss estimated in the EA (DDMI 1998a). The magnitude of effects and overall impact rating would be reduced at post-closure because of the removal of sensory disturbances (i.e., zone of influences) and possible gains in habitat suitability from reclamation.

Based on this assessment, cumulative effects at full development would be mid-term in duration, resulting in Level III regional effects. In the worst-case scenario, assuming unsuccessful reclamation and some continuing sensory disturbance, post-closure cumulative effects would be classified as Level IV regional (i.e., moderate magnitude and long-term in duration). However, the removal of sensory disturbance and restoration of suitable nesting habitat post-closure would more reasonably be expected to reverse the direction of impacts to neutral, resulting in a post-closure assessment of no residual effects.

Reclaimed mine sites would likely provide more rugged terrain categories compared to predevelopment conditions. Steep slopes and variable aspects could result from waste rock piles and, with the implementation of proven nest site enhancement techniques at these sites (e.g., ledge creation), raptor nest site potential could potentially be improved. Reclamation could, therefore, result in an increase in area of high to very high nest site potential at post-closure, relative to predevelopment or baseline conditions.

9.2.3.3 Waterfowl

At full development, existing waterfowl staging and nesting habitat availability was expected to be reduced (through reductions in habitat suitability and effectiveness) by greater than 1% within the LSA but by less than 1% within the RSA, resulting in a high (Level IV) local effect but a low (Level I) regional effect on waterfowl. At post-closure, the causes of reduced habitat effectiveness (sensory disturbance) would have been largely removed, but physical impacts on habitat might remain even with successful reclamation. These remaining physical impacts may result in a long-term reduction in the ability of the East Island to support staging and nesting waterfowl. Thus, although the types and extent of impacts would be expected to be reduced at post-closure, the overall effects classification remains the same as at full development.

9.2.3.4 Caribou

9.2.3.4.1 Distribution

Long-term changes in the seasonal distribution of caribou are generally the result of long-term changes in habitat availability. Analysis of changes (direct and indirect) in caribou summer habitat availability from mine development and cumulative land use activities has been estimated at high (12.3%) and moderate (2.6%) reductions in the local and RSAs respectively, relative to 1996 baseline conditions. The area of direct habitat loss is within the original EA predictions but the measured zone of influence from monitoring studies is greater than predicted in the EA, resulting in larger habitat changes. Habitat effects would not extend beyond the RSA and would have no influence on the calving and over-wintering distributions of the Bathurst herd. Within the broad migratory corridor and summer range of the herd that encompasses the mine development, the level of measured habitat reduction shows localized shifts in habitat use but no measurable effect on broad seasonal distribution. The duration of this effect on caribou is expected to be mid-term (3 to 30 years) and limited to the operations phase. With the removal of the operations stressors of noise and smell the indirect changes to habitat use are expected to be significantly reduced and only direct habitat losses will remain post-closure.

9.2.3.4.2 Mortality
The likelihood of injuries to caribou was projected to be very low once the mine sites are closed and post-closure landscapes are finalized. Hunting will continue to be the main source of human-caused mortality under the post-closure scenario.

Based on experiences at other mines, the likelihood of injury or direct mortality from industrial activity in the RSA is anticipated to be low under all conditions. It was assumed that hunting will remain the only significant source of human-caused mortality in the RSA and that hunting mortality will not increase as a result of mine development and operation.

9.2.3.4.3 Energetics
Under the post-closure scenario, the predicted paths of least resistance for fall migration returned to the predevelopment route. In the model it was assumed that movement through altered terrain in the mine sites might involve traversing or going around difficult terrain. The magnitude of effects on fall migration was predicted to be slight in the RSA. The overall energy cost of migration for individual caribou encountering the post-closure mine site resulted in an increase of less than 1%.

9.2.3.5 Carnivores
Mine-related decreases in habitat availability for both prey species and denning sites would cause a long-term reduction in the ability of the East Island to support wolves, wolverine and foxes. These decreases in habitat availability would remain post-closure. During the operations phase of the mine, most carnivores would avoid East Island. Red foxes were expected to exhibit a high degree of tolerance to mining activities and might remain as residents on less disturbed portions of East Island, assuming that an adequate prey base also remained. Wolves and wolverine were expected to be less tolerant of mining activities, and might avoid the East Island more than foxes. In either case, these localized shifts in habitat use off the East Island during operations would not represent a measurable shift in the distribution of these species within the RSA. Post-closure the predicted and observed influence of the mine area as an attractant/deterrent to carnivores would be significantly reduced/eliminated.

The mine development would not be expected to have measurable effects on the wolf and fox populations in the RSA during operations. Habitat lost to the mine and its zone of influence would represent a loss of less than 1% of the available hunting habitat in the RSA. Similarly, although at least one and possibly two fox den sites might be abandoned as a result of mining activities, comparable denning areas are widely distributed within the RSA, and the loss of East Island sites would not measurably affect regional denning potential. Direct mortalities from vehicle kills and the relocation of animals were also expected to be minimal, given the environmental management strategies adopted for the mine development.

Mine-specific effects on wolves and foxes at the population level are predicted to be low and limited to the operations phase.

Due to uncertainty regarding the current status of wolverine populations and the effectiveness of mitigation, mine-specific effects on wolverines at the population level have been classified as low to moderate. Even moderate level mine-specific effects would not be expected to affect wolverine population parameters beyond regional scale (i.e., within the Slave Geological Province). These effects were also predicted to be limited to the operations phase.

The mine is not expected to contribute measurably to cumulative effects on carnivore populations during operations. Mine-related mortalities are not expected to occur post-closure.

9.2.4 Fish and Water

9.2.4.1 Water Quality

The effect on water quality in Lac de Gras from flooding and breaching the open pits at closure is classified as Level I local effect for both drinking water and the protection of aquatic life. The magnitude was predicted to be negligible to low at for the local geographic extent.

Flooding the open pits at closure is not expected to have an adverse effect on groundwater quality. As mining proceeds, the quality of groundwater improves locally due to an overall decrease in TDS. Concentrations of TDS are expected to be higher near the bottom of the pits, but lower at the sides of the pits resulting in an overall decrease in TDS in groundwater.

Treated mine water discharge during operations introduce higher levels of nutrients, particularly phosphorus from the natural groundwater, to Lac de Gras. Up to 20% of the surface area of Lac de Gras was expected to increase in trophic status during operations. This has also been confirmed by operational monitoring. Effects of increased trophic status include an increase in algal growth, and likely increases in fish growth rates, improvements in fish health. There is also the potential for an increase in the abundance of some aquatic species and a decline in the abundance of others but these effects have not been observed to date. Trophic levels are predicted to decline back to background levels post-closure when mine water discharge ceases.

Containment of runoff during operations effectively prevents any effects on water quality in Lac de Gras during operations. Post-closure, runoff from disturbed areas would be re-directed through East Island streams and lakes to Lac de Gras. Undiluted post-closure runoff water quality may locally exceed thresholds for the protection of aquatic life for total phosphorus and nine metals (copper, aluminum, cadmium, chromium, lead, mercury, nickel, silver and zinc). Therefore, post-closure runoff could have a long-term, high magnitude effect on East Island lakes which receive drainage from reclaimed areas. Aluminum, cadmium, chromium, copper, lead, mercury, nickel, silver and zinc concentrations in post-closure runoff could adversely affect sensitive aquatic organisms in East Island waterbodies. Phosphorus levels in the post-closure runoff could substantially increase the trophic status of affected East Island lakes. However, when runoff reaches Lac de Gras, water quality in Lac de Gras is expected to remain below thresholds for aquatic life for all parameters except total phosphorus, aluminum, cadmium and chromium at the smallest assessment boundary (0.01 km^2). The magnitude of effect would be high for total phosphorus, cadmium and chromium and low for aluminum. The magnitude of the effect from cadmium would remain high at the 1 km^2 assessment boundary, but would be negligible at the 5 km^2 assessment boundary. The geographic extent would be local.

Post-closure runoff water quality is predicted to be below drinking water thresholds for all parameters and so is not expected to impact on drinking water quality on the East Island or in Lac de Gras.

The potential for these effects would be evaluated further based on actual run off monitoring information collected during operations and in advance of final closure.

9.2.4.2 Water Supply

The potential effects of changes to Lac de Gras water levels and outflows on the Coppermine River as a result of flooding the pit and dike areas are expected to be negligible and would not extend beyond closure. No measurable effect (i.e., less than 1% change) is predicted for flow in the Coppermine River downstream from the outlet of Point Lake.

9.2.4.3 Fish Mortality

An effect from angling on fish mortality was the only effect of the mine development that was identified in the EA as lasting beyond closure. Subsequent to the EA, a no fishing policy was adopted at the mine site, eliminating this potential effect.

9.2.4.4 Fish Habitat

The analysis of potential effects of mine infrastructure development on fish-bearing lakes on the East Island predicted that the permanent loss of four fish-bearing lakes on East Island would be an effect of high magnitude and mid-term duration. Habitat enhancement efforts are expected to compensate these losses by providing an overall net gain in fish habitat post-closure. At post-closure, there would be a loss of burbot and longnose sucker habitat because these species were not targeted for habitat restoration in the current mitigation plan. There is also a small reduction in rearing habitat for lake trout. However, the overall amount of habitat created for the remainder of the target management species results in a net creation of inland lake habitat.

Post-closure there is expected to be a small reduction in stream migration corridor habitat on the East Island, a habitat type that only existed under very high flow conditions.

Fish habitat losses in Lac de Gras as a result of mine development and dewatering a portion of Lac de Gras represent a maximum of 1% loss of the available habitat from baseline conditions. Post-closure, habitat enhancements would compensate for these habitat losses, resulting in a net gain in habitat. The effect on fish habitat in Lac de Gras regionally at post-closure would either be no adverse effect, indicating no net reduction or a net gain of habitat, or a negligible effect. All habitat losses at post-closure (i.e., those with negligible effects remaining) would be habitat that is not considered limiting in Lac de Gras (i.e., no post-closure effects on rearing habitat).

9.2.4.5 Fish Quality

The EA analysis determined that the metal concentrations in the flesh of fish in Lac de Gras are not expected to exceed the guidelines for safe human consumption for any fish species examined during operation or post-closure. The analysis further indicated that tainting of fish flesh as a result of the mine development would not be likely. However, post-closure runoff to two lakes on the East Island was predicted to result in elevated metals concentrations in fish flesh in those two lakes. The potential of this effect would be evaluated further based on actual runoff monitoring information collected during operations.

9.2.5 Heritage Resources

Heritage resource sites are non-renewable; as such any effects identified for the mine development would be permanent and remain post-closure as residual effects. Effects on heritage resources include loss of artifacts and features, artifact distributions, and loss of site location and site context. These effects would occur at the site, local and regional level of archaeological data. At the 57 sites that fall within the footprint of the mine, the effect of the mine development is a loss of these aspects of heritage resource either through disturbance or burial. Although these adverse effects would be offset by mitigative studies, the physical location of the sites and context would still be lost.

Potential effects on heritage resources can also be positive in that the results of site inventories add to the regional database and contribute to our understanding of past lifestyles and landscape use. This is the case for 138 of the identified sites.

The magnitude of effects on individual sites was classified based primarily on the potential scientific interpretive value and the potential contribution to public awareness and appreciation of heritage resources. Specifically, the magnitude of effect on heritage resources was classified as low if the heritage resources potentially lost are associated with limited scientific interpretive value and with limited potential to contribute to public awareness and appreciation. Effects on heritage resources were classified as moderate if the loss is associated with local and regional scientific interpretive values and with good potential to contribute to public awareness and appreciation. The magnitude of an effect on heritage resources was classified as high if the loss of the heritage resources is associated with regional scientific interpretive values with excellent potential to contribute to public awareness and appreciation.

The magnitude of effect at the local level, for the 57 sites within the mine footprint, would be high. However, with the completion of mitigative studies, loss of data would be offset by information gained. Although at the local level, effects would occur at a high number of precontact quarries, the magnitude of effect would not be high when viewed from the context of regional level of data. Given the nature of heritage resources, the confidence placed in the likelihood of the predicted effects occurring is high.

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