Crown-Indigenous Relations and Northern Affairs Canada
Relations Couronne-Autochtones et Affaires du Nord Canada

GIANT MINE REMEDIATION PROJECT

Status of the Environment from June 2015 to June 2021

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

Canada

Land *Acknowledgement*

We acknowledge that the Giant Mine site is located in Chief Drygeese Territory. From time immemorial, it has been and is the traditional land of the Yellowknives Dene First Nation. The Giant Mine site is also within Mǫwhì Gogha Dè Nıı̨tłèè (Boundary from the Tłı̨chǫ Agreement) of the Tłı̨chǫ government and on the traditional homelands of the North Slave Métis Alliance. The Giant Mine Remediation Project respects the histories, languages, and cultures of First Nations, Metis, Inuit, and all First Peoples of Canada.

Message from *CIRNAC Project Leader*

ASSISTANT DEPUTY MINISTER, WAYNE WALSH NORTHERN AFFAIRS ORGANIZATION

On behalf of the entire Giant Mine Remediation Project (GMRP) Team, I am pleased to present the inaugural Status of the Environment report to the Giant Mine Oversight Board. Status of environment reporting can assist a project by providing an early warning of potential environmental problems; chart the achievement of the objectives set out in the Environmental Agreement; provide baseline information for environmental planning, assessment, and regulation; and help guide future decision-making.

This first report provides our Rights holders, stakeholders, and the public with a high-level overview of our progress on the GMRP over the last seven years (mid-June 2015 to mid-June 2021) as the project completed the regulatory process to obtain the Water Licence and Land Use Permit, which allows the remediation of the site to move forward. It also looks at any actions that have been taken to benefit the project and the environment and provides a summary of the project's planned key operational activities over the next three-year reporting period, from mid-June 2021 to mid-June 2024.

Consistent monitoring and evaluation are integral to ensuring activities at the Giant Mine site will not cause adverse effects to people or the environment. The monitoring that has occurred to date allows the project to understand the legacy effects of the former Giant Mine, track possible trends that could warrant early intervention, and ensure that we can continue to protect the workers and public, as well as the land, water, and air as the remediation of the site moves forward.

As we enter into this period of full-scale remediation for the GMRP, we remain committed to ongoing monitoring and management of the environment and will continue to provide information through ongoing engagement with Rights holders, stakeholders, the Annual Report to the Giant Mine Oversight Board, as well as future Status of the Environment reports. Our goal is to achieve an outcome we can all be proud of that addresses the legacy left behind by Giant Mine, ensures reconciliation and socio-economic benefits for Indigenous Peoples and Northerners, and benefits all Canadians through collaboration, open and sincere dialogue, and learning from each other in order to continually improve. We look forward to ongoing engagement and communication of the work that is being done at the Giant Mine site, and we welcome feedback on ways in which we can continue to improve and refine how we communicate our information.

Summary

Welcome to the first **Status of the Environment Report** for the Giant Mine Remediation Project. The report is a requirement of the Environmental Agreement, signed in June 2015. The first report is due 7 years after the agreement was signed, and then a report is due every 3 years afterwards for 15 years. After that 15-year period, a report is due every 5 years. This report provides a high-level overview of the Giant Mine Remediation Project's key activities and the status of the environment on the Giant Mine site (the site) for mid-June 2015 to mid-June 2021.

The report's purpose is to summarize:

- key operational activities
- methods and results from environmental monitoring
- actions taken if conditions on the site were not going as planned (adaptive management)
- whether the actions taken were effective
- effects of the remediation plus effects of other human activities (cumulative effects)
- planned key operational activities for the upcoming reporting period (2022 to 2024)

In the last seven years, the site has been in care and maintenance. Remediation had not yet begun during the mid-June 2015 to mid-June 2021 reporting period. However, major progress was made on "building blocks" for completing the Giant Mine Remediation Project, including extensive engagement, planning, regulatory authorizations, studies, investigations, and urgent site stabilization works (Figure 1).

FIGURE 1: Giant Mine Remediation Project Key Activities from 2015 to 2021

Environmental Components

The environment on the site is considered in the following components: climate change, air, water, fish, land, and wildlife. The components are all connected (Figure 2).

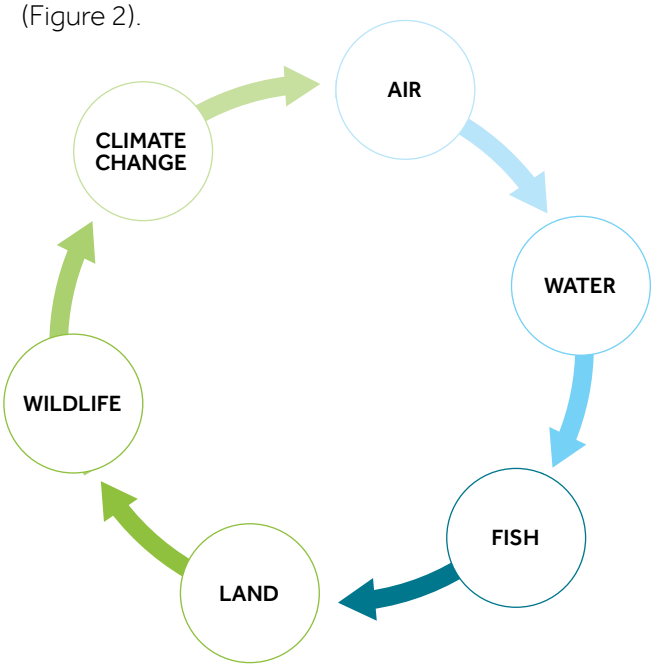

FIGURE 2: Environmental Components

Before mining activity, the land on which the site is now found was a valuable area for hunting, trapping, and collecting plants for food and medicine. The Giant Mine Remediation Project has worked with Indigenous Rights holders to document historical land use in the site area through archaeological and Traditional Knowledge studies. During mining operations, the land on site was changed. It now has extensive mining infrastructure like open pits and Tailings Containment Areas. The Giant Mine Remediation Project has included information about the features that remain from previous mining activities and how they are related to the environment in this report.

Did you know?

Before mining, Elders report the Giant Mine area was an abundant source for moose, caribou, bear, wolf, wolverine, beaver, lynx, fox, coyote, porcupine, otter, muskrat, fisher, marten, mink, and rabbit. Rabbit were so plentiful in an area near the Yellowknife River that it became known as "rabbit place." Aside from hunting and trapping, the area was preferred for harvesting berries, medicinal plants, and wood.

(YKDFN and Trailmark Systems 2019)

Environmental Monitoring

The Giant Mine Remediation Project has many environment-related monitoring plans and programs on site (Table 1). Many of these monitoring programs occur regularly. For some, the Giant Mine Remediation Project collected information, also called data, for many years in a row to understand environmental components and how they might change over time. For other programs, information was recorded during a short-term investigation only. The key results from the monitoring and investigations are summarized in this report.

Table 1: Environmental Monitoring and Investigations

SYMBOL	COMPONENT	MONITORING/INVESTIGATIONS
	**Climate Change**	• Weather station on site • Amount and flow rate of water (hydrology) in Baker creek on site and off
	**Air**	• Dust on site • Dust near communities • Wind on site
	**Water**	• Flow in Baker Creek • Mine water elevation • Effluent quality • Water quality in Baker Creek and Yellowknife Bay
	**Fish**	• Fish size, age, health in Baker Creek • Fish tissue quality in Baker Creek and Yellowknife Bay • Fish food (benthic invertebrates)
	**Land**	• Archaeology • Soil Quality • Underground stability • Open pit stability • Tailings Containment Areas / dams stability and seepage
	**Wildlife**	• Animal / bird observations, small mammal tissue quality

Summary of Monitoring of the Environment

The Giant Mine Remediation Project has collected a lot of information about the environment on site since 2015. The team summarized most of this information in documents submitted to the Mackenzie Valley Land and Water Board or the Giant Mine Oversight Board. These documents are available to the public. They include reports like the Closure and Reclamation Plan (Chapters 1-4, 5.0-5.4, 5.5, 5.6, 5.7-7.0) and annual Water Licence reports (2020, 2021). A summary of the monitoring programs and results is provided in this report. A brief summary of the key results is provided below:

Climate Change

The weather patterns (climate) in the Yellowknife area are changing. From 2015 to 2021, the Giant Mine Remediation Project saw minor increases in air temperature. Even more changes occurred in the amount of water at site (rain, snow) and water level in lakes and streams. Also, the timing of spring melt occurred earlier than in the past.
All these changes affect the environment on site and the care and maintenance of the site. In 2021, the site started measuring more information about factors that could influence climate change, including greenhouse gases.
The Giant Mine Remediation Project is making efforts to reduce greenhouse gases during remediation activities and after remediation is complete. The team is taking how to reduce greenhouse gases into consideration as it designs the elements that will operate over the long term, including the new water treatment plant and freeze program.

Air

Over the last seven years, the Giant Mine Remediation Project made efforts to control dust on the site. By improving which dust-suppressing products were used and how they were applied, the Project reduced the number of times visible dust occurred on site over the reporting period. Overall, on site and in the community air quality monitoring stations, dust particles and metals measured as low. Air quality monitoring results indicated the air quality of the local airshed was not significantly impacted by Project activities.

Water

Water in Baker Creek on site had arsenic concentrations similar to upstream. Treated water (effluent) met the discharge (release) limits. Total arsenic in Yellowknife Bay near the site was mostly less than 10 micrograms per litre, which is the current drinking water guideline, and was less than a site-specific water quality objective of 31 micrograms per litre which protects aquatic life.

Fish

Benthic invertebrates (fish food) were present in Baker Creek on site in similar amounts to a reference area (mouth of Yellowknife River). However, not all the same benthic invertebrate species were found on site compared to the reference area. Many fish species were present in Baker Creek on site. Fish body size of small-bodied fish was not the same as in the reference areas (Yellowknife River and Horseshoe Island Bay): one fish species was larger and the other one was smaller.

Small- and large-bodied fish have metals in their tissue. Eating a large-bodied fish like Arctic Grayling, a species the Yellowknives Dene First Nation identified as being of interest, from Baker Creek was found to not pose a risk to humans now and would not in the future.

Did you know?

The Wìlìdeh word for fox is nǫgèe and moose is dendì?

Land (including infrastructure)

Some areas on site have soils with higher amounts of total arsenic than the Government of the Northwest Territories industrial standard of 340 milligrams per kilogram and higher than the residential standard of 160 milligrams per kilogram. Annual dam inspections showed compliance with the Canadian Dam Association requirements; dams are stable. The Giant Mine Remediation Project inspected open pit walls and conducted some repairs. A buttress was placed within C1 Pit to protect the pit from inflows from Baker Creek. Inspections for the open pits required more consistent documentation. The existing Foreshore Tailings Area cover was stable, but erosion of the tailings submerged in Yellowknife Bay was seen past the cover.

Wildlife

The Giant Mine Remediation Project counted many species of wildlife in a winter survey, such as coyote, snowshoe hare, wolf, red fox, ermine, marten, least weasel, lynx, red squirrel, and various small mammals such as mice, voles, or shrews. The Giant Mine Remediation Project identified more than 50 types of birds on site in the last seven years. The site makes efforts to cover building openings like vents and windows; this prevents birds from nesting in areas needed for care and maintenance like the existing effluent treatment plant.

Adaptive Management

The Giant Mine Remediation Project has been able to adapt to changing site conditions during the care and maintenance period. The Giant Mine Remediation Project needed to conduct some additional works on site in this period for safety of the site. This included:

- freezing of the core of Dam 1 at the Polishing Pond to prevent further settlement
- stabilizing areas of the underground where risks to surface stability could have occurred

The Giant Mine Remediation Project Team learned numerous lessons that it will apply to remediation. These are described in this report and in Chapter 4 of the Closure and Reclamation Plan. Examples of key lessons learned include:

- Constant vigilance for dust is needed, and action needs to be taken to suppress dust.
- Planning for permafrost thawing and melting should be done now, while designing the remediation and during remediation activities.
- The project currently needs to maintain extra backup pumps for minewater on site in the event both existing submersible pumps fail.

Status of the Environment from 2015 to 2021

To provide a summary of the status of the environment, the Giant Mine Remediation Project rated the environmental components. Evidence such as data from years of monitoring and inspections (summarized above and thorough this report) were used to give a rating. Two components could not be rated: climate change and wildlife. For wildlife, observations of wildlife were made by site staff and surveys were done in various locations on site that changed over time. Wildlife presence on site is affected by the nearby city of Yellowknife and its Solid Waste Facility (landfill), the Ingraham Trail (Highway 4) which runs through the site, and by the nearby Great Slave Lake. The type of data is not appropriate to establish a meaningful indicator for the site distinct from the surrounding area. For climate change, the Giant Mine Remediation Project is reviewing information and possible ways to rate this component in future iterations of this report.

The Giant Mine Remediation Project ratings were set as:

- green, meaning the condition was stable or "okay"
- yellow, meaning the condition needed attention or was a concern
- red if the condition was a hazard or risk
- a combination of green/yellow, where some conditions were okay, but others were of concern, or
- yellow/red where some areas were of concern and others were a higher risk to the environment

These ratings provide a "snapshot" of the status of the environment for the period of this report (2015 to 2021).

Table 2: Summary of Status of Environment for 2015 to 2021

COMPONENT	RATING
Air	
Water	
Fish	
Land	

More details on the status of the environment and monitoring programs are found in the report.

What is next for the Giant Mine Remediation Project?

The main activities to occur on site in the next reporting period (mid-June 2021 to mid-June 2024) are:

- continuing care and maintenance
- ongoing site monitoring and remediation

The main remediation activities will be as follows:

- Stabilize/backfill underground.
- Construct the Area 1 freeze pad.
- Construct and operate the non-hazardous waste landfill.
- Take down Townsite buildings.
- Build the new water treatment plant and outfall.

More information on the schedule for remediation is provided in the GMRP Annual Water Licence Report (2020, 2021) submitted to the MVLWB.

The Giant Mine Remediation Project does not expect the overall status of the environment on site to change in the next three years. It is expected that some dust will occur from activities such as demolishing buildings and excavating contaminated soils and tailings to support new construction and underground stabilization activities. However, the Giant Mine Remediation Project will monitor the activities and take action to keep the amount of dust low. Improvements to the environment are not expected until more of the remediation is complete, such as covering the tailings ponds, which reduces dust and contaminated water, and operation of the new water treatment plant, which improves water quality.

Did you know?

Baker Pond on site was originally a local lake called Joe Lake?

The Giant Mine Remediation Project will continue monitoring on site and will follow the approved management and monitoring plans. The Giant Mine Remediation Project reports results from monitoring to the Mackenzie Valley Land and Water Board every year through its Annual Water Licence Report (2020, 2021). Results will also be summarized in the next Status of the Environment Report, submitted in June 2025.

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1.0

Purpose and *Overview of the Report*

Welcome to the first **Status of the Environment Report** for the Giant Mine Remediation Project (GMRP). The report is a requirement of the Environmental Agreement (Table 3), signed in June 2015. The first report is due 7 years after the agreement was signed, and then a report is due every 3 years after for 15 years. After that 15-year period, a report is due every 5 years. The report provides a high-level overview of the GMRP's key activities and the status of the environment on the Giant Mine site (the site; Figure 3) for mid-June 2015 to mid-June 2021.

The report's purpose is to summarize:

- key operational activities
- methods and results from environmental monitoring
- actions taken if conditions on site were not improving as planned (adaptive management)
- whether the actions taken were effective
- effects of the remediation plus effects of other human activities (cumulative effects)
- planned key operational activities for the upcoming reporting period (mid-2021 to mid-2024)

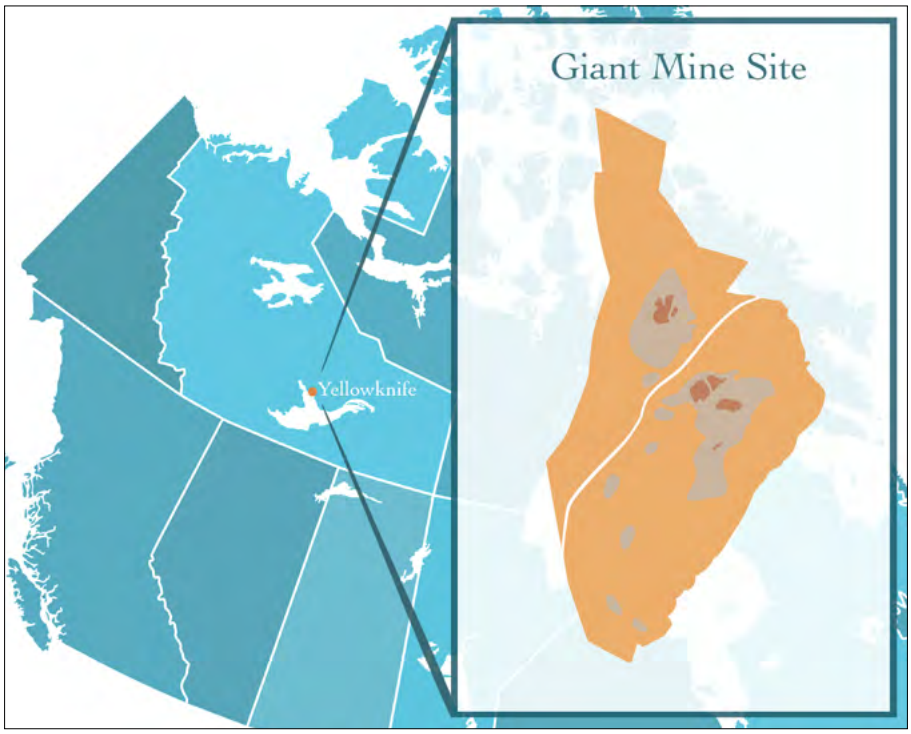


FIGURE 3: Location of the Giant Mine Site

[1] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada.

In the last seven years, the site has been in a period of care and maintenance. While remediation had not yet begun during the 2015 to 2021 reporting period, extensive engagement, planning, studies, and investigations were undertaken to help inform the final plan for remediation. Additionally, the Site Stabilization Program, which improved the stability of underground voids left by mining activities by adding support to the overlying rock mass, was conducted from 2013 to 2018. The GMRP resubmitted its Water Licence application and submitted its Land Use Permit application to the Mackenzie Valley Land and Water Board in April 2019. It received its Land Use Permit in August 2020 and Water Licence in September 2020. The final Closure and Reclamation Plan (Chapters 1-4, 5.0-5.4, 5.5, 5.6, 5.7-7.0)[1] was approved in January 2021.

Table 3: Environmental Agreement Requirements for Status of Environment Report

ARTICLE 6 STATUS OF THE ENVIRONMENT REPORTING
6.1 Status of the Environment Report - At the times identified in section 6.4 the Co-Proponents shall prepare, provide to the Oversight Body, and make available to the public a comprehensive report on the Project. Each report shall include in respect of each reporting period:
a) a summary of the Project's key operational activities;
b) an assessment of the long-term effects of the Project;
c) a summary of the methodology, and the results or findings, of all monitoring done for the Environmental Programs and Plans and a description of actions taken or planned to implement Adaptive Management;
d) a summary of any changes to the environmental impact prediction models, or other conceptual models used by the Co-Proponents to guide Project management, and of the rationale for the changes;
e) the identification of any cumulative effects of the Project on the environment, meaning any effects of the Project considered in the combination with the effects of other human activities;
f) a comparison of the results or findings of all environmental monitoring programs under the Environmental Programs and Plans to the results predicted in the Developer's Assessment Report submitted as part of the MVRMA environmental assessment;
g) an evaluation of the performance of Adaptive Management;
h) a summary of the Project's planned key operational activities for the upcoming reporting period;
i) references to all sources relied on by the Co-Proponents in coming to conclusions in the report; and
j) a plain-language summary of the report.

Remediation activities officially began in July 2021, just outside this reporting period. Given this, some of the requirements of the Environmental Agreement reporting do not yet apply. For example, a comparison of the results of monitoring during remediation to the predictions in the environmental assessment (Developer's Assessment Report[2]) required by Article 6.1(f) could not yet be done because remediation had not started. Also, assessment of the long-term effects of remediation and changes to predictions from the environmental assessment were provided in the Closure and Reclamation Plan (Chapters 1-4, 5.0-5.4, 5.5, 5.6, 5.7-7.0), Effluent Quality Report,[3] and the Human Health and Ecological Risk Assessment (Part 1, Part 2, Part 3, Part 4) [4] of the Water Licence Application in 2019, and the reader is referred to those documents for more information. In general, these reports noted the following:

- Section 5.11 and 5.12 of the Closure and Reclamation Plan outlined the long-term expected effects of remediation and the monitoring programs and management of these expected effects. No updates to these identified effects are planned unless remediation activities change.
- The Effluent Quality Report provided updated predictions for water quality from the proposed new water treatment plant; the new water treatment plant is required to remove arsenic to amounts less than those outlined in the environmental assessment; this report also provided site-specific water quality objectives for water in Yellowknife Bay near the site. Water quality in Yellowknife Bay after remediation is expected to be improved from what was expected in the environmental assessment.
- The Giant Mine site had assessments examining the risks of contamination from historical mining in 2006 and 2010 that were part of the environmental assessment. In 2014, the Mackenzie Valley Environmental Impact Review Board concluded that the public still had health concerns about contamination from Giant Mine. In 2018, a new Human Health and Ecological Assessment Report (Part 1, Part 2, Part 3, Part 4) was completed, and it concluded that after remediation, exposure to site would result in low risk to humans and reduced risk to wildlife and aquatic life. Additional health effects studies are underway, and the results will be provided in the next Status of the Environment Report.

Appendix A outlines the requirements of the Environmental Agreement and how they are addressed in this report.

1.1 COMPONENTS OF THE ENVIRONMENT

The main components of the environment at site are:

- climate change
- air
- water
- fish
- land (including infrastructure like tailings dams)
- wildlife (including birds)

Weather, such as the amount of rain or snow and air temperature, affects the environment on site (climate). The wind speed and wind direction effects combine with local activities on site and activities/events off site (e.g., a forest fire) to influence the air quality of the site. The site is made up of land with vegetation and rock, as well as industrial features from historical mining activities: two main Tailings Containment Areas containing a total of four tailings ponds with numerous dams, eight open pits, openings to the underground mine, a foreshore of Yellowknife Bay contaminated with tailings, and the effluent treatment plant. The soil in various areas of the site is contaminated (arsenic and hydrocarbon impacts) from historical mining practices. Another main feature is the creek running though the site, called Jackfish River by the Yellowknives Dene First Nation and now known as Baker Creek (The Giant Gold Mine – Our Story: Impact of the Yellowknife Giant Gold Mine on the Yellowknives Dene – A Traditional Knowledge Report)[5]. Baker Creek and local small lakes drain into Yellowknife Bay, part of Great Slave Lake. Much of the land on site is impacted because of historical mining. Figure 4 illustrates the site and how the various components interact.

[2] INAC and GNWT (Indian and Northern Affairs Canada and Government of the Northwest Territories). 2010. Giant Mine Remediation Project Developer's Assessment Report. EA0809-001. October 2010.

[3] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2019. Giant Mine Remediation Project Effluent Quality Criteria Report. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada. January 2019.

[4] CanNorth (Canada North Environmental Services). 2018. Giant Mine Human Health and Ecological Risk Assessment, Prepared for Public Services and Procurement Canada – Western Region, Environmental Services and Contaminated Sites Management. Edmonton, AB, Canada.

[5] YKDFNLEC (Yellowknives Dene First Nation Land and Environment Committee). 2005. The Giant Gold Mine – Our Story: Impact of the Yellowknife Giant Gold Mine on the Yellowknives Dene – A Traditional Knowledge Report. Prepared for the Department of Indian and Northern Affairs Giant Mine Remediation Project office. Yellowknife, Northwest Territories. 13 October 2005.

Note: not to scale, for illustrative purposes only. ETP = effluent treatment plant.

FIGURE 4: Conceptual Illustration of Giant Mine Site and Interaction of Environmental Components (climate change, air, water, fish, land, wildlife)

1.2 ENVIRONMENTAL PLANS AND MONITORING PROGRAMS

There are many environment-related monitoring plans and programs on site. The main programs for each environmental component and where to find more information are listed in Table 4. The key results from the monitoring are summarized in this report. Table 4 provides links to more detailed information on the monitoring programs.

Some monitoring programs occur regularly, and the site has information (data) for many years in a row to understand the environmental component and how it acts over time: Was it stable? Was it going up or down? For others, like soils, information is recorded during an investigation and data are recorded for the year of the investigation. It is normal for a remediation project to have some long-term monitoring programs as well as some short-term investigations. There are also data collected every day on site for operational purposes. Examples are inspections on foundations of bridges and buildings, health and safety inspections of facilities, or checks on vehicles for leaks. Operational data are not included in this report; if inspections indicate an issue, it is addressed by the main construction manager on site and reported to the relevant authorities having jurisdiction (e.g., Workers' Safety and Compensation Commission).

Table 4: Main Environment-Related Monitoring Programs at the Giant Mine Site

COMPONENT	MONITORING/INVESTIGATIONS	WHERE TO FIND MORE INFORMATION?
Climate	• Weather station on site • Amount and flow rate of water (hydrology) in Baker Creek on site and off site	Annual Water Licence Reports (2020, 2021)
Air	• Dust on site • Dust near communities • Wind on site	Dust Management and Monitoring Plan NWT Air Quality Monitoring Network
Water	• Flow rate (Baker Creek) • Minewater quality • Minewater elevation • Effluent quality • Water quality (Baker Creek, Yellowknife Bay)	Annual Water Licence Reports (2020, 2021) Water Management and Monitoring Plan AEMP Annual Reports - 2020 (Part 1, Part 2, Part 3), 2021 (Part 1, Part 2, Part 3)
Fish	• Fish size, age, health in Baker Creek • Fish tissue quality in Baker Creek and in Yellowknife Bay • Fish food (benthic invertebrates)	AEMP Annual Reports - 2020 (Part 1, Part 2, Part 3), 2021 (Part 1, Part 2, Part 3)
Land (including Infrastructure)	• Archaeology • Soil quality • Underground stability • Open pit stability • Tailings Containment Areas / dams stability and seepage	Underground Design Plan Tailings Management and Monitoring Plan Closure and Reclamation Plan & Appendices Operations, Maintenance and Surveillance Manual for Giant Mine Dams[6]
Wildlife	Animals/bird observations	Wildlife and Wildlife Habitat Management and Monitoring Plan Annual Water Licence Reports (2020, 2021)
General	Applicable to many of the components listed here	Giant Mine Remediation Project Annual Reports: 2015-16, 2016-17, 2017-18, 2018-19, 2019-20, and 2020-21.

[6] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2019. Operations, Maintenance and Surveillance Manual for Giant Mine Dams. Revision C. 4 September 2019.

1.3 ENVIRONMENTAL INDICATORS AND HOW THEY ARE RATED

A lot of information about the environment on site has been collected since 2015. Much of it was summarized in the Closure and Reclamation Plan (Chapter 2) and in annual reports to the Mackenzie Valley Land and Water Board or the Giant Mine Oversight Board. A summary of the monitoring is provided in the Chapters 3 through 8 of this report. To further simplify the large amount of information and summarize the status of the environment on site, indicators for each of the environmental components were developed (Table 5). These are provided as a "snapshot" of the status of the environment for the period of this report (2015 to 2021).

Table 5: List of Environmental Indicators for the Giant Mine Site for 2015 to 2021

ENVIRONMENTAL COMPONENT	INDICATOR	INFORMATION USED TO RATE STATUS OF ENVIRONMENT
Climate change	No indicator for this report, but under review to determine if one can be developed in future years	
Air	Dust on site [a]	Was there visual dust observed on site and/or due to activities on site? Was the total suspended particulate measured at or below the ambient air quality criteria[a] for site at the site perimeter air quality monitoring stations?
	Dust at community stations	Was visual dust observed at the community air quality monitoring stations due to site activities? Were the measurements at the community air quality monitoring stations at or below the ambient air quality criteria[a]?
Water	Water quality on site and in Baker Creek	Water in Baker Creek on site: Was arsenic on site greater than upstream? Was total arsenic less than the national regulation for metal mines (MDMER[7])? Treated effluent: Did it meet the licensed discharge criteria[b]?
	Water quality in Yellowknife Bay	Was arsenic in the water in Yellowknife Bay, near the site, below the drinking water quality standard and below the site-specific water quality objective?[b]
Fish	Fish food in Baker Creek	Were benthic invertebrates (fish food) present? Were they in similar amounts to a reference area? Did they have the same species as a reference area?
	Fish in Baker Creek	Were fish species present? Did they have high concentrations of metals in their bodies? Was the fish size the same as in a reference area?
Land (including Infrastructure)	Soil quality in developed areas	Did soils have total arsenic above the approved closure plan standard of 340 mg/kg for the site?
	Soil quality in bedrock, forest, wetland areas	Did soils have total arsenic above the approved closure plan standard of 340 mg/kg for the site?
	Soil quality in Townsite	Did soils have total arsenic above the approved closure plan standard of 160 mg/kg for the Townsite?
	Substrate quality in Baker Creek	What was quality of Baker Creek substrates at bottom of creek? Were they above the aquatic life guideline for total arsenic?
	Tailings Containment Area dam stability	Did the annual dam inspection show compliance with Canadian Dam Association requirements? Were dams stable? Were maintenance/repairs completed when required?
	Pit safety	Was maintenance/monitoring required? Were access controls in place?
	Foreshore Tailings Area in Yellowknife Bay	Was the existing foreshore cover stable? Were there local signs of erosion outside of the cover?
Wildlife	No indicator for wildlife was identified due to two concerns: 1) wildlife on site is influenced by the nearby developments (e.g., highway, City of Yellowknife and its Waste Transfer Area) and 2) data (e.g., observations of wildlife by workers on site) were intermittent and not collected in the same locations over time. It was not possible to develop a meaningful indicator of the status of wildlife on site independent of other influences and with the type of data available. However, a summary of the wildlife data is provided (Chapter 8).	

[a] Refer to the Air Quality Monitoring appendix of the Dust Management and Monitoring Plan;
[b] See Appendix B for more information.
MDMER = Metal and Diamond Mining Effluent Regulations; mg/L = milligrams per litre; mg/kg = milligrams per kilogram.

[7] Metal and Diamond Mining Effluent Regulations (justice.gc.ca)

For each indicator, information about the type and amount of monitoring data was reviewed (Table 5). For example, for the fish component, information on fish size, health, and what fish eat (fish food called benthic invertebrates) was available and could be used as evidence to provide a rating on the status of the environment. Each component was qualitatively rated based on the evidence from monitoring. Ratings were set as green, yellow, or red, as well as a combination of green/yellow or yellow/red (Table 6). Appendix B describes the indicators in more detail, explaining how they were chosen and what data were used to support the rating for each component. Appendix C provides a summary of rating for each component for 2015 to 2021.

Table 6: Proposed Rating Scheme for Status of Environment Report

SYMBOL	RATING	DESCRIPTION
	Good	Stable, "OK", acceptable for reporting period
	Medium	"Not so good," needs attention, concern
	Poor	Hazard/risk; "not good"
	Combination: Good to Medium or Medium to Poor	Combination rating of green/yellow or yellow/red. Used where monitoring program measures different areas around the site and they have different ratings. Combined to make one rating for the component.

1.4 REPORT ORGANIZATION

The report is organized to provide information on the key operational activities from mid-June 2015 to mid-June 2021 (Chapter 2), a summary of monitoring for each environmental component (Chapters 3 through 8), and an overview of cumulative effects (Chapter 9), as well as lessons learned during this period (Chapter 10). Chapter 11 gives a summary of the next steps for the GMRP until the next Status of the Environment Report in 2024.

2.0

Key Operational *Activities*

The GMRP had numerous activities ongoing from 2015 to 2021. These fit in three general categories: care and maintenance of site, planning for remediation, and engagement and Traditional Knowledge.

2.1 CARE AND MAINTENANCE ACTIVITIES

Key activities for the care and maintenance of the site, from 2015 to 2021 (Closure and Reclamation Plan Chapter 4[8]), included:

- rock pillar stabilization of various underground stope complexes
- contaminated water (effluent) treatment plant operations, inspections, and upgrades
- boiler evaluation and upgrades
- C1 Pit wall stabilization
- removal of contaminated materials
- removal and capping of underground arsenic delivery piping
- splitter dyke repairs
- electrical upgrades to substation and underground
- replacement of underground communication system
- UBC bridge foundation replacement
- fencing and signage
- underground chutes and head cover repairs
- backfill of Stope Complex C509
- roaster complex of buildings decontaminated and deconstructed
- A Shaft and C Shaft headframe deconstruction
- installation of new submersible pumps (Northwest Pumping System)
- stabilization of Dam 1

More details on the activities can be found in Chapters 3 and 4 of the Closure and Reclamation Plan[2], as well as the annual reports submitted to the Giant Mine Oversight Board (2015-16[9], 2016-17[10], 2017-18[11], 2018-19[12], 2019-20[13], 2020-21[14]). Chapters 7 and 10 of this report outline more information and lessons learned on key activities such as stabilizing the underground and installing the Northwest Pumping System.

[8] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada.

[9] INAC and GNWT (Indigenous and Northern Affairs Canada and the Government of the Northwest Territories). 2016. 2015-16 Annual Report of the Giant Mine Remediation Project: Remediating Giant Mine. Submitted to the Giant Mine Oversight Board. October 2016.

[10] INAC and GNWT (Indigenous and Northern Affairs Canada and the Government of the Northwest Territories). 2017. 2016-17 Annual Report of the Giant Mine Remediation Project: Remediating Giant Mine. Submitted to the Giant Mine Oversight Board. October 2017.

[11] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2018. 2017-18 Annual Report of the Giant Mine Remediation Project: Moving Toward Remediation. Submitted to the Giant Mine Oversight Board. October 2018.

[12] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2019. The 2018-19 Annual Report of the Giant Mine Remediation Project. Submitted to the Giant Mine Oversight Board. November 2019.

[13] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2020. Giant Mine Remediation Project Annual Report 2019-20. Submitted to the Giant Mine Oversight Board. October 2020.

[14] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Annual Report 2020-2021. Submitted to the Giant Mine Oversight Board. October 2021.

2.2 REMEDIATION PLANNING

A draft remediation plan was submitted with the Developer's Assessment Report in 2010 as part of the environmental assessment phase of the GMRP. The results of the environmental assessment process, as well as significant engagement in 2015 to 2021 (see Table 7), informed the planning of the final closure activities. Site investigations done during 2015 to 2021 also informed final engineering decisions. A final Closure and Reclamation Plan was submitted in 2019, and after edits through the Water Licence process, it was approved in 2021. The details of the planning that went into remediation are outlined in Sections 5.1 to 5.10 of the Closure and Reclamation Plan (Section 5.0-5.4, 5.5, 5.6, 5.7-5.10) [15].

2.3 ENGAGEMENT AND TRADITIONAL KNOWLEDGE

From 2015 to 2021, the GMRP had a strong focus on engagement. An overall summary is provided in Table 7; further details on the format and outcomes are provided in the appendices of the Engagement Plan[16]. During this period, engagement mechanisms and committees were developed including but not limited to:

- **Yellowknives Dene First Nation Giant Mine Advisory Committee:** in 2011/2012 the GMRP Team[17] worked with the Yellowknives Dene First Nation to establish a Community Liaison and Technical Advisor position responsible for effective Yellowknives Dene First Nation participation by ensuring all necessary arrangements are completed for consultations (e.g., public community hearings, site tours, evaluation meetings with Elders, briefings). Members formed a committee to allow the GMRP to seek input and guidance on various aspects of the project and broader community engagement initiatives.
- **Giant Mine Oversight Board:** developed after the signing of the Environmental Agreement to promote public awareness and engagement, provide independent advice to the GMRP Team, regulatory authorities, parties, and the public, and manage the research program for a permanent solution for on-site arsenic trioxide dust stored underground.
- **Health Effects Monitoring Program Advisory Committee and Hoèla Weteèts'eèdeè Understanding Community Well-Being Advisory and Technical Committee:** these committees include members with health expertise and knowledge of regional and community level issues and contribute to the development and implementation of the monitoring program and the well-being study.
- **Aquatic Advisory Committee:** a committee formed in 2020 to review aquatic-related topics such as remediation of Baker Creek and Yellowknife Bay, monitoring, and effects of activities on the environment (e.g., blasting). Rights holders, stakeholders, and regulators meet with the GMRP Team as needed each year.

[15] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada.

[16] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Engagement Plan. Version 2.1. March 2021.

[17] The GMRP Team consists of Crown-Indigenous Relations and Northern Affairs Canada and the Government of the Northwest Territories, supported by the federal department of Public Services and Procurement Canada.

Table 7: 2015 to 2021 Key Engagement Activities

ACTIVITY	DATE RANGE[a]	COMMENTS	OUTCOME
Site Stabilization Program	2013–2018	Input from Rights holders and stakeholders received throughout the process prior to submitting materials to the Mackenzie Valley Land and Water Board	Informed the air quality and medical monitoring programs for site workers, and emergency response plans
Surface design	2015–2017	Input into plans for remediation of the surface of the mine (i.e., Baker Creek, pits, tailings, contaminated soils, and land use); review of closure options and risks	Key decisions: • Fill in open pits and cover all tailings ponds. • Remove contaminated sediments from Baker Creek. • Relocate South Pond, consolidate North and Central ponds. • Excavate contaminated material from historical spill. • Remediate the Townsite and Marina to residential soil criteria of 160 mg/kg.
Outfall	2016–2017	Assessment of outfall location options for discharge from water treatment plant	Outfall location identified near the outlet of Baker Creek
Baker Creek alignment	2017	Detailed evaluation of diversion alternatives	Confirmed selection of on-site alignment
Non-hazardous landfill siting	2017	Sessions for the selection of the preferred landfill site	Confirmed identification of preferred site
Health Effects Monitoring Program	2017–2021	Consultation on the work began in 2017 with 2035 participants being sampled in 2018 from Yellowknife, Ndilǫ, and Dettah. Sample results were shared through personal letters and public meetings in 2019. The results of the study showed that residents of Yellowknife, Ndilǫ, and Dettah are within a similar range of exposure to arsenic as the rest of Canada	GMRP will ensure that exposure measured in 2018 does not increase from remediation activities.
Hoèla Weteèts'eèdeè Understanding Community Well-Being around Giant Mine	2020–2021	Ongoing Advisory and Technical Committee meetings where input was solicited on study design details	The study has been designed and will be implemented in 2022, COVID-19 regulations permitting.
Human Health and Ecological Risk Assessment	2015–2018	Significant input to better assess risks considering differences in traditional land use, food consumption, and lifestyles	January 2018 final report found low to very low risk from past activities, and that remediation will further reduce risk

Table 7: 2015 to 2021 Key Engagement Activities

ACTIVITY	DATE RANGE[a]	COMMENTS	OUTCOME
Archaeology	2018 and 2021	Archaeological Impact Assessment conducted in 2018 and 2021 with field assistance by members of the Yellowknives Dene First Nation (YKDFN), focusing on areas of high archaeological potential and areas of planned or potential remediation activities. The Archaeological Impact Assessment was also based on input from Traditional Knowledge holders including North Slave Métis Alliance (NSMA) members and from interested parties.	A total of 12 archaeology sites were recorded and revisited: six precontact Indigenous sites and six historical mineral prospecting sites. All of the documented sites were mapped, photographed, tested, and evaluated. Artifacts were collected and catalogued for submission to the Prince of Wales Northern Heritage Centre. The most significant sites will be avoided at the request of the GNWT, YKDFN, and as a GMRP commitment.
Closure and Reclamation Plan site tour	2018	Two site tours with Rights holders and stakeholders YKDFN and NSMA	Input was used to make adjustment to the Water Licence package, prior to submitting to the Mackenzie Valley Land and Water Board in April 2019.

Traditional Knowledge	2018–2021	• GNWT and YKDFN contracted Trailmark to complete a Traditional Knowledge Study (2018 to 2019)
		• NSMA completed a land-use study, focusing on the Yellowknife Bay area, by incorporating knowledge from Elders and reviewing relevant documents
			• The Trailmark study established YKDFN expectations and guidelines for the GMRP, allowing input to the project:
			  • Knowledge from YKDFN members and staff
			  • Strategic opportunities to incorporate YKDFN traditional and local knowledge
			  • Research and follow-up monitoring needs
			• Knowledge gathered from the traditional land use summary provided the GMRP with information on the traditional uses of the Yellowknife Bay area, including the Giant Mine site.

Quantitative Risk Assessment	2018–2020	Engagement completed in four phases: Phase 1 – Quantitative Risk Assessment introduction and the engagement process Phase 2 – risk scenarios and consequence categories Phase 3 – consequences of risk, thresholds, and analysis Phase 4 – review and discussion of Quantitative Risk Assessment results	Quantitative Risk Assessment found that the most significant risks are associated with the remaining contaminated soil on the site and the long-term care of the site—these will require a focus on communication and perpetual care. Quantitative Risk Assessment results will be used to improve changes to design and monitoring and management plans.
Review of Draft Closure Plan	2018	Presentation of main elements of draft Closure Plan	Edits made for the final submission to the Mackenzie Valley Land and Water Board
Perpetual Care Plan Workshop	2019–2021	Presentation and collaborative development of the Perpetual Care Plan draft framework. Initial meetings with the Perpetual Care Plan task force were held in 2021 to develop a plan for hiring a consultant to develop the plan	A series of workshops are being held in early 2022 with Rights holders and stakeholders to develop a statement of work so that a consultant can be hired to develop the Perpetual Care Plan.

Table 7: 2015 to 2021 Key Engagement Activities

ACTIVITY	DATE RANGE[a]	COMMENTS	OUTCOME
Borrow	2019–2021	Workshops were held in 2019 to share information on current borrow design and the decision process. Workshops were held in 2021 with the Aquatic Advisory Committee and the GMRP Working Group to share the updates to the design plan, details in the Borrow Materials and Explosives Management and Monitoring Plan and other items related to borrow (e.g., surface water runoff criteria)	Results helped inform the Borrow and Explosives Management and Monitoring Plan and move the design/location process forward.
Water Licence proceedings	2019–2020	Technical workshops with Rights holders and stakeholders, and community meetings with key topic areas allowing participants to ask questions	Proceedings informed final Closure Plan, Monitoring and Management Plan, and Water Licence and Land Use Permit for the GMRP.
Aquatic Advisory Committee	2020–2021	Workshops were held throughout 2020 and 2021 relating to a number of aquatic components including such as Baker Creek design, Aquatic Effects Monitoring Program, and Fisheries and Oceans Canada *Fisheries Act* Authorization requirements	Discussions and input from Rights holders and stakeholders helped inform the decisions around aquatic-related GMRP components (e.g., design elements, types of fish to sample in the monitoring program). Many items engaged on through the Aquatic Advisory Committee meetings will inform the *Fisheries Act* Authorization application that will be submitted in 2022.
Regulatory engagement – site-wide management and monitoring plans and action levels	2020–2021	The GMRP Team developed a process in the fall of 2020 with rights and stakeholders for pre-engaging on the GMRP site-wide management and monitoring plans for Phase 2: Active Remediation and Adaptive Management	Input from Rights holders and stakeholders was gathered at pre-engagement meetings and considered during the development of the management and monitoring plans for Mackenzie Valley Land and Water Board submittal.

a) The date ranges provided are intended to show the engagement activities within the timeframe of this report (mid-June 2015 to mid-June 2021); however, engagement for many of the listed activities may be on-going.

GMRP = Giant Mine Remediation Project; mg/kg = milligrams per kilogram; GNWT = Government of the Northwest Territories; YKDFN = Yellowknives Dene First Nation; NSMA = North Slave Métis Alliance.

3.0

Climate *Change*

The weather conditions on the site over a long period of time are called "the climate." As most people know, the climate is changing. The GMRP (plus other activities) can affect the climate by putting out gases, known as "greenhouse gases," into the air that can trap heat on Earth and make the weather different. The GMRP began to calculate how much greenhouse gas it puts out in 2021.

The climate can also affect the GMRP. Too little rain or snow can cause a drought with reduced water to use for GMRP activities and for fish spawning and survival. Too much rain or snow can cause a flood and prevent GMRP activities or be a risk to infrastructure. Air temperature can affect the rate of melting of snow or can affect the water temperature in Baker Creek, making it too warm for fish survival or too cool for fish growth. Both too much and too little water require extra management or inspections on site. The GMRP monitors water coming onto the site from rain, snow, and local streams very closely to prevent flooding on the site.

This chapter provides an overview of the greenhouse gases from the site, as well as a description of changing water conditions in the region that affected the site from 2015 to 2021, including water flows/water level and air temperature. Information on wind speed and direction is provided in Chapter 4.

3.1 GREENHOUSE GASES

What were the total emissions in 2021?

The GMRP monitors the amount of a key greenhouse gas: carbon dioxide gas, abbreviated as CO_2. Carbon dioxide gas comes naturally from around us, but it can also be emitted by cars and trucks and buildings. The GMRP calculated the total amount of carbon dioxide emitted in 2021, as well as the amount of two other greenhouse gases: methane gas, abbreviated as CH_4, and nitrous oxide gas, abbreviated as N_2O. Methane gas can be emitted by industrial activities including water treatment. Nitrous oxide gas can be emitted by burning fuel and treatment of water. The total amount for all three greenhouse gases is shown in Table 8. More details on the emissions are found in the Giant Mine Remediation Project Annual Report 2020-2021[18].

[18] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Annual Report 2020-2021. Submitted to the Giant Mine Oversight Board. October 2021

Table 8: Total Estimated Emissions of Three Greenhouse Gases from the Giant Mine Site in 2021

CARBON DIOXIDE	METHANE (KG CH_4)	NITROUS OXIDE (KG N_2O)
2,653,876 (kg CO_2) or 4,510,571 (kg CO_2e) or 4.5 kilotonnes CO_2e	356	94

kg = kilograms; kg CO2e = kilotonnes carbon dioxide equivalents.

As shown in Table 8, the total estimated emissions of carbon dioxide from the Giant Mine site in 2021 were 4.5 kilotonnes CO_2 equivalents (or 4,400 tonnes). For comparison, the total amount released by the Northwest Territories from April 2020 to March 2021 was approximately 988 kilotonnes CO2 equivalents (or 988,000 tonnes) (*Northwest Territories Carbon Tax Report 2020/21*[19]). The Northwest Territories has a Climate Change Strategic Framework and Climate Change Action Plan as well as a 2030 Energy Strategy and Action Plan (Climate Action and Energy Reports Released[20]) to help address climate change in the North.

What efforts are being undertaken to reduce greenhouse gases?

The remediation of the Giant Mine site will take approximately 15 years to complete. While the GMRP will result in improvements to the environment, the "earthworks" activities on site using heavy equipment will create greenhouse gases. The long-term infrastructure required on site after remediation, such as the water treatment plant and the freeze program (see below) can also create greenhouse gases. The GMRP is taking several steps to proactively reduce greenhouse gas emissions and implement federal climate action policies. The Closure and Reclamation Plan[21] outlined many design improvements and choices that were made to decrease greenhouse gas emissions (Figure 5), such as removing old buildings with inefficient heating systems and installing new, more efficient infrastructure. Also, the GMRP chose to source its borrow material (rock and gravel) from the Yellowknife area, including on-site sources, which reduces use of long-haul trucking to bring material to the site.

Did you know?

Industrial facilities that emit more than 10,000 tonnes of CO_2 are supposed to report their greenhouse gas emissions to Environment and Climate Change Canada's Greenhouse Gas Reporting Program? (A tonne is 1,000 kilograms.) This is part of Canada's commitment to publish a reliable, accurate, and timely greenhouse gas inventory. For more information, go to this website.

Water treatment plant: As required for all new federal buildings, the GMRP completed a greenhouse gas assessment of the design of the new water treatment plant to be constructed on site. This included a life cycle analysis of the heating system and all supporting equipment, as well as looking at the current proposed fuel oil heating design and a 100% electric heating system using electric boilers. Greenhouse gas emissions were calculated for each option over the 40-year lifespan of the facility to demonstrate the reduction in emissions (Figure 6). The option for biomass (pellets) and electric and propane and photovoltaic cells was chosen, which is estimated to reduce emissions by almost 90% over 40 years.

Freeze program: Arsenic trioxide dust that is stored underground in stopes and chambers (the spaces created by the removal of ore and waste rock during mining) will be frozen; this is called "the freeze." Passive heat pumps called thermosyphons, which do not require electrical power or energy, will be used to promote cooling of the subsurface. Over several years, they will develop a frozen shell in the surrounding bedrock that encloses the arsenic dust in the storage chambers, stopes, and other mine workings to prevent the release of arsenic. The choice to passively freeze the chambers instead of using electricity to create the frozen shell helps reduce the amount of greenhouse gases in comparison to an active pumping system.

[19] GNWT (Government of the Northwest Territories). 2021. Northwest Territories Carbon Tax Report 2020/21. March 2021.

[20] GNWT (Government of the Northwest Territories). 2021. Climate Action and Energy Reports Released. December 2021.

[21] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada.

Low-carbon cement: The process of creating cement releases carbon dioxide to the environment. Cement will be used in GMRP remediation activities including backfill of the underground for stability and the foundation of the water treatment plant. The GMRP Team will review low carbon cement options and will follow federal new building guidelines and outcomes of the upcoming cement working group. This may help reduce the total volume of cement needed, which helps reduce carbon dioxide.

The GMRP is also fully committed to looking for opportunities to reduce its greenhouse gas emissions during implementation (Giant Mine Remediation Project Annual Report 2020-2021[22]). The principal source of emissions from remediation will be through the operation of heavy construction equipment. Given that heavy construction equipment must be used for a remediation project of this nature, the principal tool available to minimize greenhouse gas emissions will be to minimize fuel use and reduce haul distances where possible.

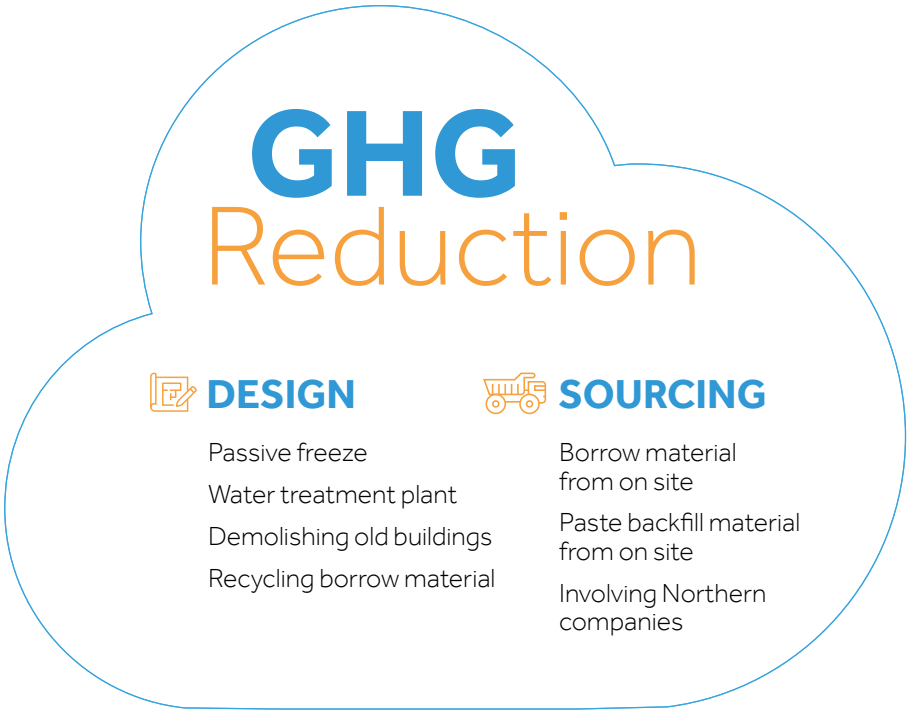


FIGURE 5: Ways the Giant Mine Remediation Project is Reducing Greenhouse Gases Due To Remediation

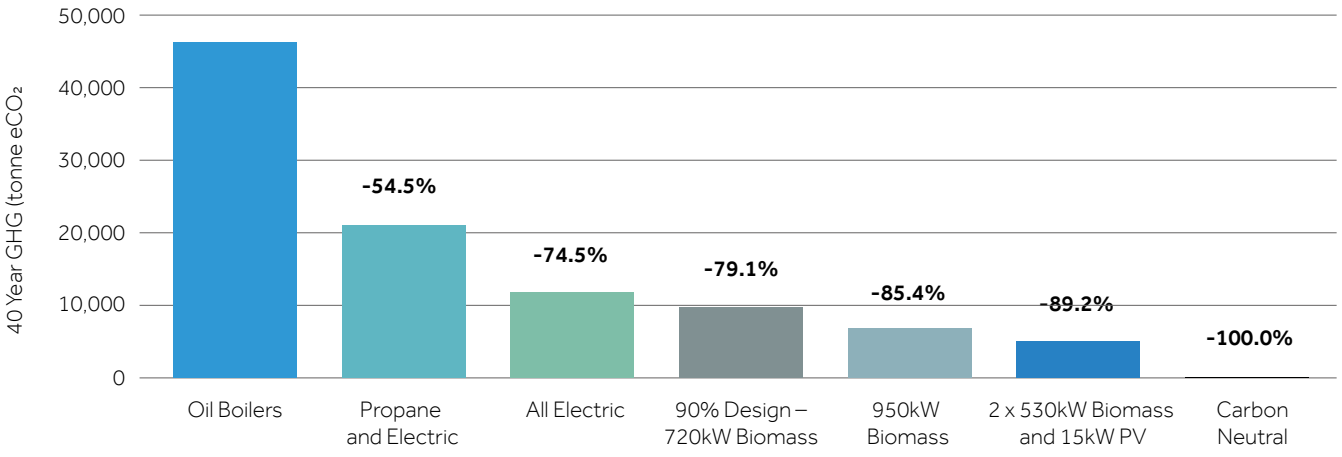


FIGURE 6: Comparison of Greenhouse Gases for Various Heating Options for New Water Treatment Plant

[22] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Annual Report 2020-2021. Submitted to the Giant Mine Oversight Board. October 2021.

3.2 CLIMATE

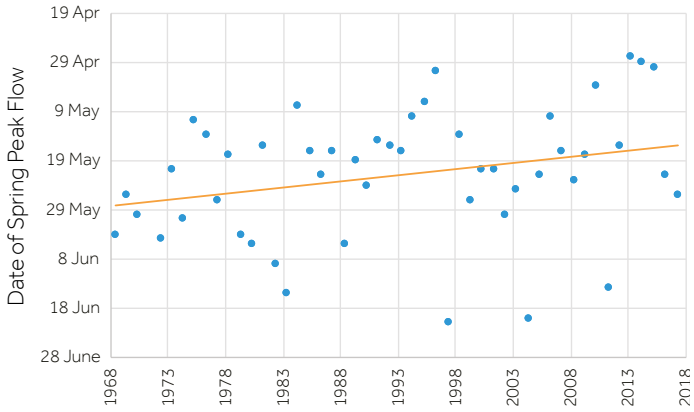
Background

The weather patterns (climate) in the Yellowknife area are changing. As most people know, the North is experiencing climate change faster than other areas. From 2015 to 2021, minor changes were seen in air temperature and larger changes in the amount of water (rain, snow, water level in lakes and streams) and timing of spring melt were observed. All these changes affect the environment on site and the care and maintenance of the site.

Air Temperature

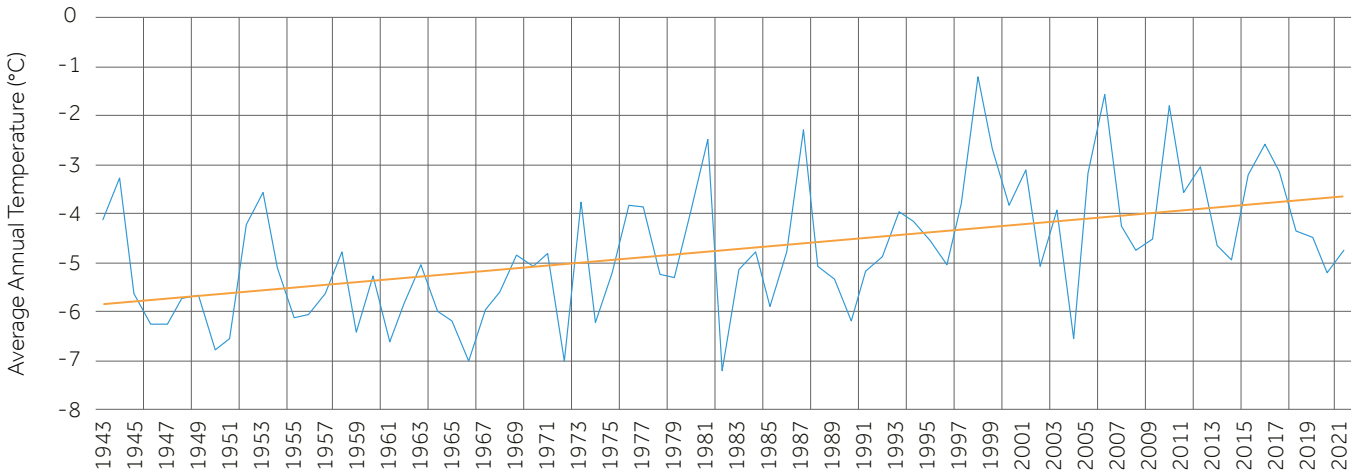
As outlined in the Closure and Reclamation Plan,[23] the annual average air temperatures in Yellowknife are going up (Figure 7). This shortens winters and lengthens summers. Warmer air temperature can mean warmer ground temperature. Some of the buildings and dams on site are settling, and this is thought to be in part due to the warmer ground. Frequent inspections and maintenance are carried out on site to manage settling until remediation when the buildings are demolished, and new infrastructure is built. The new water treatment plant will be built on bedrock so that it will not settle if the ground or permafrost settles or thaws. Section 10.1 provides more information about how the GMRP managed the settling of Dam 1.

The change in air temperature can change the timing of spring melt. Figure 8 shows the date of peak spring flows at Baker Creek above the site at the outlet of Lower Martin Lake. In general, the spring melt of Baker Creek is occurring earlier than in the past. The GMRP must monitor for ice jams and water levels in the creek to prevent flooding.



Source: Water Survey of Canada Stations Baker Creek near Yellowknife, and Baker Creek at Outlet of Lower Martin Lake

Figure 8: Date of Spring Peak Flow at Baker Creek, 1968 to 2017



Source: Environment and Climate Change Canada Yellowknife A station

FIGURE 7: Annual Average Temperature at Yellowknife, 1943 to 2021

[23] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada

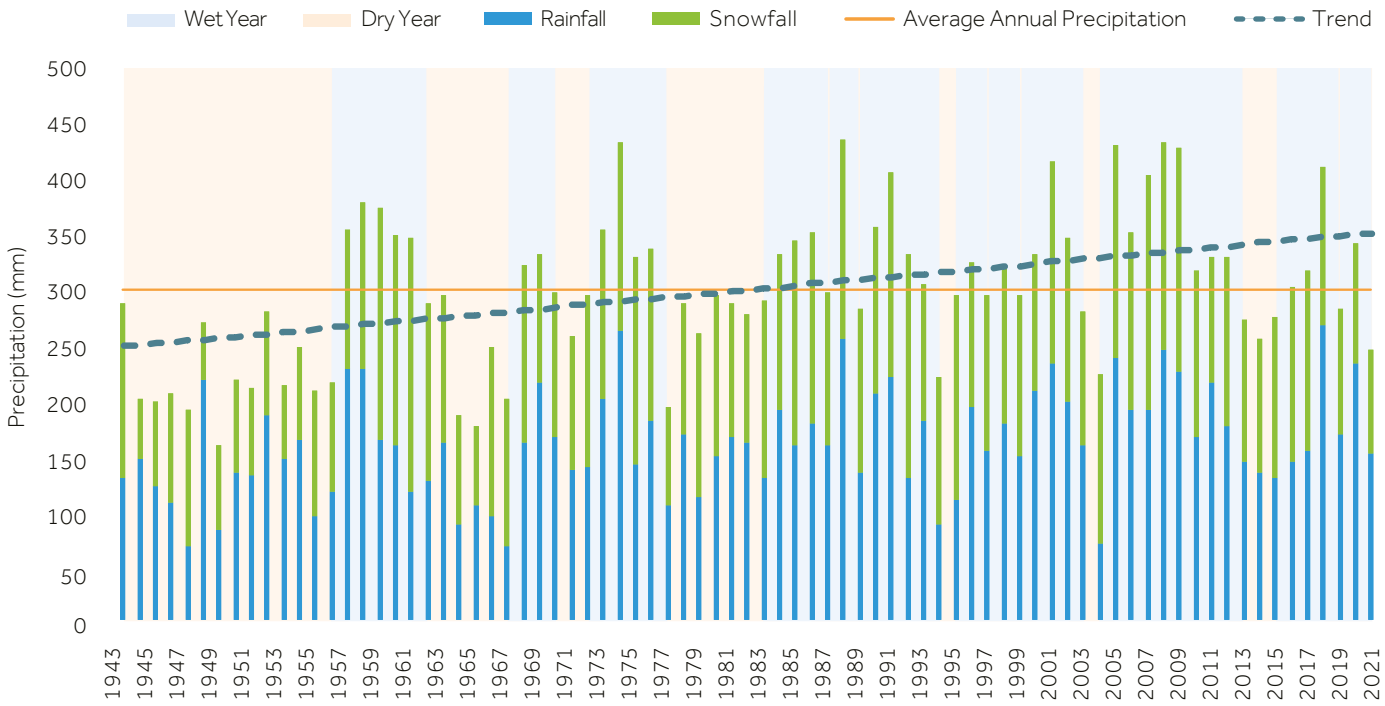
Precipitation (rainfall and snowfall)

Figure 9 shows information on snowfall and rainfall since 1943. It also indicates dry years, which are years with precipitation below average, and wet years, which are years with precipitation above average. From 2015 to 2021, very dry years and very wet years were observed. Overall, the amount of annual precipitation (snow and rain) in Yellowknife is increasing over time.

Dry years: From 2013 to 2015, the Yellowknife area experienced low water levels and drought conditions. Some local lakes went completely dry. Numerous forest fires occurred in the area. On the site, water quality data were looked at closely because sometimes water quality can worsen because of little water for dilution. This is discussed more in Chapter 2 of the Closure and Reclamation Plan [24]. Some monitoring stations in Baker Creek and Yellowknife Bay could not be sampled due to low amounts of water or high amounts of vegetation growing in shallow water.

Wet years: In 2018, Yellowknife experienced the most seasonal rain since 1943 when climate records were first maintained. In 2020, Great Slave Lake reached its highest water level since water level recording started in the 1930s. The water level went up because of record high summer rainfalls in Alberta that affected the Slave River entering Great Slave Lake and record August rainfall in the Northwest Territories[25]. For more information on the high water levels in Great Slave Lake, refer to Section 7 of the *Hydrological Analysis for Great Slave Lake 2020* report. Near the site, heavy rainfall resulted in Yellowknife Bay water overtopping the breakwater and entering the mouth of Baker Creek. Additional inspections were needed to be sure the road was safe in this area.

Water in Baker Creek is very dependent on lake levels of Martin Lake, which are affected by precipitation and other factors. Climate change can affect flow rates on



Source: Environment and Climate Change Canada Yellowknife A station.
Note: "Hydrological year" means the 12-month period of precipitation which turns into flow during open-water months. precipitation during the months of October to December of the previous year, and January to September of the current year, turn into flow during the current year.
mm = millimetre.

FIGURE 9: Annual Precipitation at Yellowknife, 1943 to 2021

[24] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada

[25] ECCC and GNWT (Environment and Climate Change Canada and Government of the Northwest Territories). 2021. Hydrological Analysis for Great Slave Lake 2020. December 2020.

the site. As noted in the Closure and Reclamation Plan (Chapters 1-4, 5.0-5.4, 5.5, 5.6, 5.7-7.0)[26], there has been a shift in the regional streamflow pattern where an increasing trend in September rainfall is seen. Peak flows historically occurred during spring freshet, with 76% of the Baker Creek annual streamflow in May and June compared to 8% between October and March. Since 1997, the proportion of annual streamflow has changed to 50% in spring and 20% in fall/winter[27, 28]. This shift in streamflow pattern is shown in Figure 10.

The remediation plan for Baker Creek includes realignment to accommodate a probable maximum flood and some ice. This was done to account for expected changes in climate in the future, including changes to precipitation and flows.

Summary

The consideration of climate change and climate and water level monitoring are essential to the safe and successful completion of the GMRP. Although annual trends can be identified, projecting the changes to precipitation due to climate change is uncertain, as the timing and intensity of precipitation can vary. The realignment of Baker Creek is designed to account for future uncertainty of precipitation.

3.3 STATUS OF ENVIRONMENT INDICATOR

The appropriateness of an indicator for climate change / greenhouse gases is under review. Additional work to understand reporting requirements and final designs of the remediation is underway.

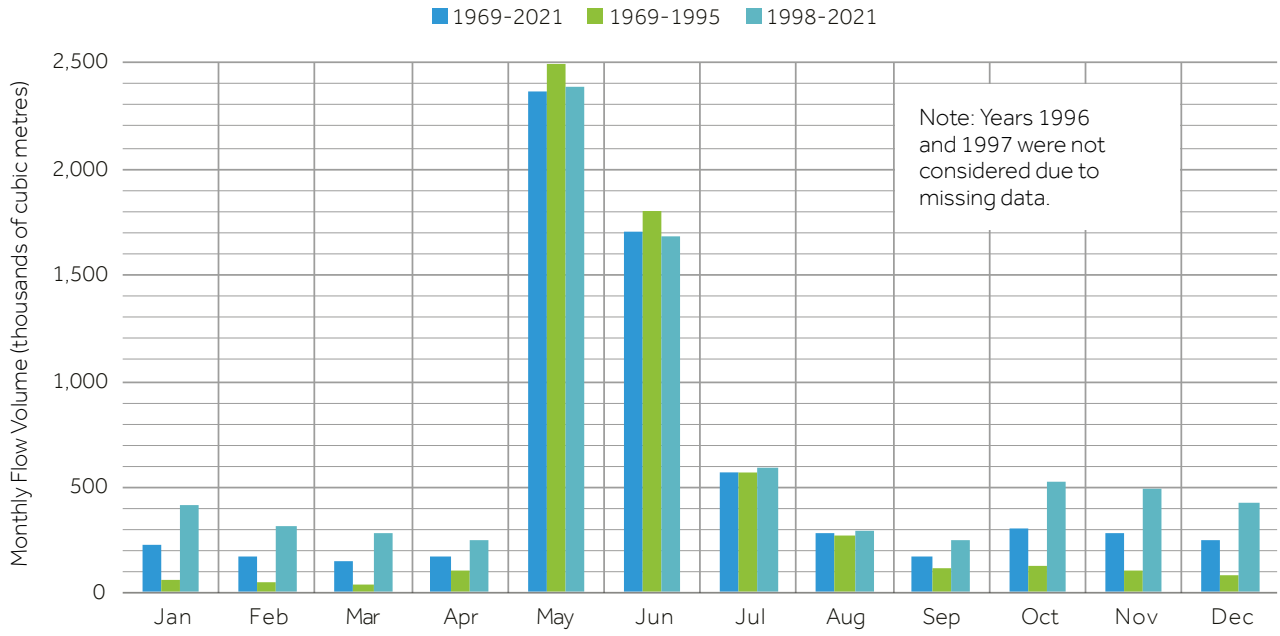


FIGURE 10: Monthly Flow Volumes at Baker Creek Upstream of the Giant Mine Site

[26] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada

[27] Kokelj SV, Spence C, Kokelj S. 2012. Changing Hydrological Regimes – Baker Creek: Results, implications and next steps. Submitted to the Giant Mine Team by Aboriginal Affairs and Northern Development Canada and Environment Canada.

[28] Spence C, Kokelj SV, Kokelj SA, McCluskie M, Hedstrom N. 2015. Evidence of a change in water chemistry in Canada's subarctic associated with enhanced winter streamflow, Journal of Geophysical Research: Biogeosciences, 120:113–127. doi:10.1002/2014JG002809.

4.0

Air

BACKGROUND

The GMRP could affect air quality, currently and over the next 15 years. This would occur primarily through release of dust and vehicle emissions on site.

An Air Quality Monitoring Plan was developed in 2013 for the GMRP. It was revised in 2019 following a review of the ambient air quality measurements collected from 2013 to 2017 and updated again in 2021. The Air Quality Monitoring Plan provides a description of the air monitoring that takes place for the GMRP and outlines methods for measuring, documenting, and responding to potential airborne contaminants on the site and in the community. The Air Quality Monitoring Plan was developed in consultation with Rights holders and stakeholders, including discussions on the locations of the community monitoring stations. This chapter describes the air quality monitoring that occurred from 2015 to 2021 (the period covered by this report).

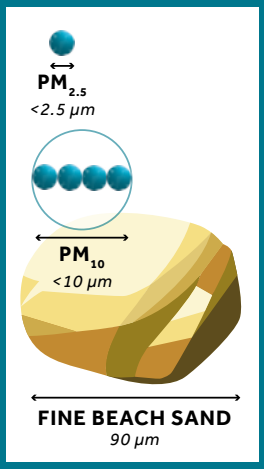
Dust is small particles in the air that settle on the land and water or can be breathed in (inhaled) by humans. Dust can come from forest fires, pollen from plants, or human activities such as blasting or construction. The amount and size of particles (particulate matter) in air is an indicator for human health. This is because dust that is very small can be inhaled by people.

Total suspended particulate (TSP) is the amount of airborne dust with particles measuring 100 microns or less in diameter. A micron measures one-millionth of a metre. Some amount of TSP in the air is normal. By determining the amount of airborne dust, TSP indicates overall air quality.

TSP includes both dust particles a person can inhale and larger dust particles that the body's protective systems can easily remove. Depending on its contents, TSP may not cause negative (adverse) health effects.

Did you know?

The naming of PM_{10} and $PM_{2.5}$ is a representation of their size, measured in microns (micrometres). A single micron of any substance is so small it is barely visible. The average grain of beach sand, for example, is about 90 microns wide.



If the TSP mostly contains larger particles, it is not considered a significant health risk. This is because the body's protective systems can remove the particles or keep them from getting into the lungs. For example, large particles can be trapped in the nose, preventing these from entering the lungs. However, if the TSP contains a large amount of small or fine particles that can be inhaled (called PM_{10} and $PM_{2.5}$, see below), it could cause adverse health effects. Particulates of concern include:

- fine particulate matter, such as that found in wood smoke or vehicle exhaust, that is smaller than 2.5 microns in diameter ($PM_{2.5}$);

- fine particulate matter smaller than 10 microns in diameter (PM_{10}), from landfills or construction or wildfires
- coarser particulate matter (larger than 10 microns), such as that found near unpaved roads and industrial activities

In summary, TSP provides an indication of overall air quality, and PM_{10} or $PM_{2.5}$ indicate the presence of particles that could cause adverse health effects. Monitoring of these is important to protect people and the land.

4.1 MONITORING

How is air and dust monitored for the Giant Mine Remediation Project?

The GMRP has a large monitoring program for dust that includes ambient air quality monitoring to protect the land and people. It provides information that helps protect people and the environment from work happening on site. If one of the air monitors detects an increase in airborne dust levels, site workers take action. This could mean watering the area to keep the dust down, or even stopping the work. While dust from the site may not contain harmful levels of contaminants, the GMRP still wants to make sure that dust does not reach communities near the site.

Air quality monitoring for the GMRP is conducted using two networks to track the effects of care and maintenance and remediation activities (Figure 11). The two networks measure different aspects about air quality:

1. On-site: network measures the air quality around the site to identify if dust and contaminants are released from the site. It provides information to site workers about activities that might be generating dust so site workers can manage these to reduce or prevent dust. There are fixed air monitor stations around the site (i.e., site perimeter monitoring stations), as well as monitoring around specific site activities as warranted.

2. Community: network provides information on potential dust heading toward communities near the site (Yellowknife, Ndilǫ) and the potential for health-related effects on people. The community stations make sure the on-site monitoring is effective and that dust does not release from the site. If the on-site monitors are within acceptable levels when the community monitors show spikes, the GMRP Team knows the source of dust is not the site and could be from regional forest fires or local road cleaning.

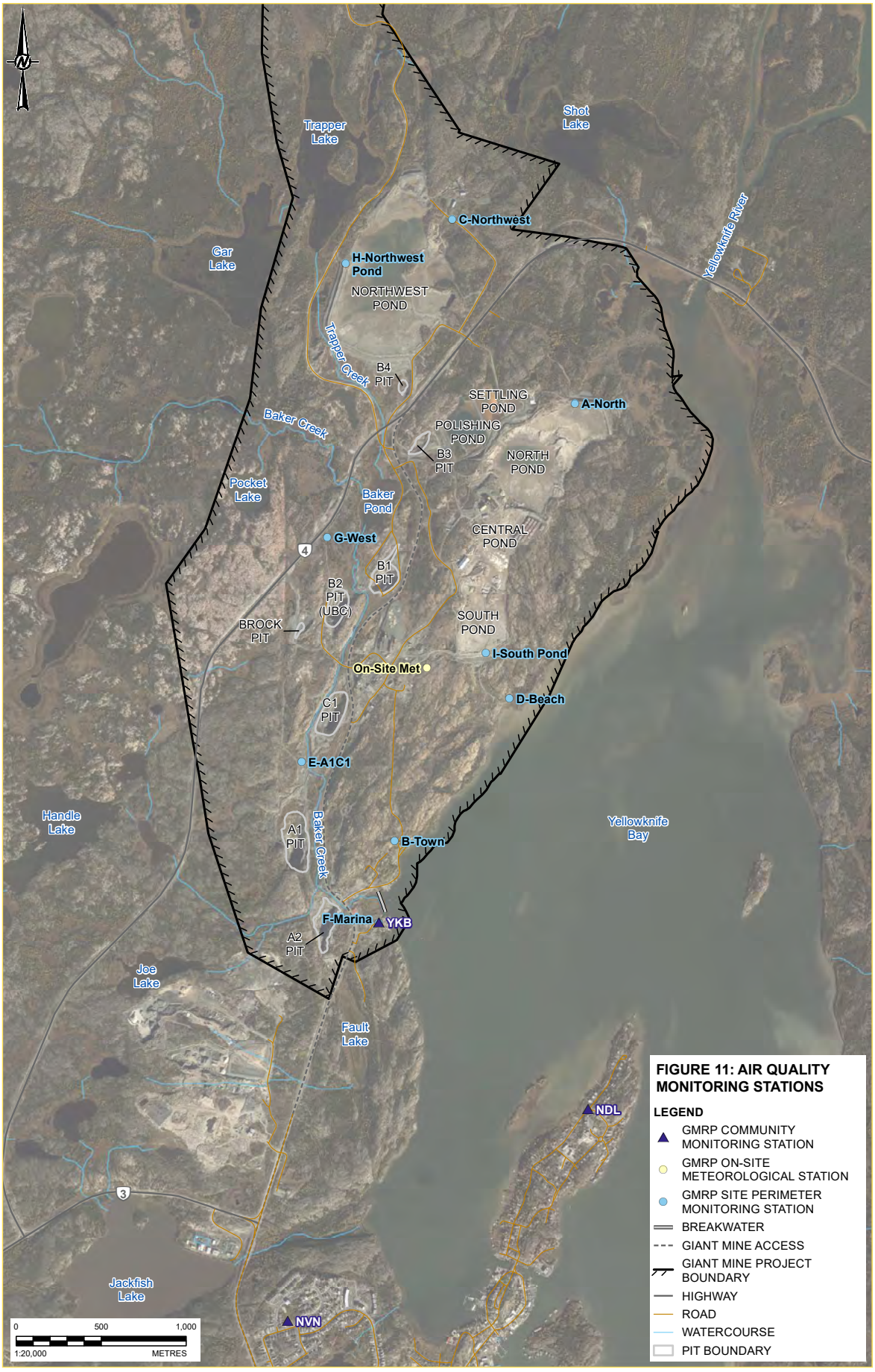


FIGURE 11: Air Quality Monitoring Stations

Where are the on-site stations and what do they monitor?

Dust is captured on filters at the nine site perimeter air quality monitoring stations (Figure 11). Continuous real-time monitoring of TSP and PM_{10} is done year-round, 24 hours a day. Filters from the air monitors are analyzed in a laboratory on a schedule partially determined by season and site activities. The amount of TSP and of fine particles at size PM_{10} are measured. They are reported as how much dust is in a volume of air (micrograms per cubic metre of air). Filters are also analyzed for metals (i.e., antimony, arsenic, lead, nickel, and iron). These are reported in how much of each metal is in a kilogram of dust (milligrams of metal per kilogram).

Did you know?

Dust from the Tailings Containment Areas on site contains arsenic but not arsenic trioxide, which is a more toxic form of arsenic. This is because the tailings with arsenic trioxide are located deeper in the Tailings Containment Areas.

Routine monitoring for signs of dust in the air (visible dust) is also done on site by all site workers. To help support dust monitoring, weather data such as wind speed and direction are collected at the on-site meteorological station (Photo 1) and at the Yellowknife airport. Table 9 summarizes the dust monitoring. More details on the monitoring can be found in the Dust Management and Monitoring Plan[29].

PHOTO 1: Meteorological Station on Site

[29] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Giant Mine Remediation Project Dust Management and Monitoring Plan. Version 2.1. June 2021.

Table 9: Summary of Dust Monitoring for the Giant Mine Site

NETWORK	TYPE OF MONITORING	WHERE?	WHAT STATIONS?	WHAT IS MONITORED?	HOW OFTEN?
On-site	Air quality / site-wide dust	9 stations	Stations A through I	Particulate (TSP, PM_{10}), arsenic, antimony, iron, lead, nickel	Continuous real-time data collection between May and November, and when site activities warrant during the winter, 24 hours a day; integrated 24-hour average filters for each of TSP and PM_{10} are collected daily between May and November and when site activities warrant during the winter. Filters from the air quality monitors are sent for gravimetric and inorganic trace element (metals) analysis on a schedule dependant on season and site activities, and whenever exceedances are found on site due to site activities (i.e., not the result of fog or inclement weather).
	Activity-specific dust	Near a specific site activity as needed	As needed	Particulate (PM_{10})	As needed
	Visible dust	Anywhere on site		Dust that is visible to the eye	Every day, multiple times per day, continuous
	Weather	Meteorological station	Located west of the mobile equipment garage	Horizontal wind speed, horizontal wind direction, temperature, precipitation, relative humidity, barometric pressure, solar radiation	Continuous real-time data
Community	Air quality / dust	3 stations	1) Yellowknife Bay 2) Ndilǫ 3) Niven Lake, subdivision near downtown Yellowknife	Particulate (TSP, PM_{10}, $PM_{2.5}$), arsenic, antimony, iron, lead, nickel, asbestos (as warranted by site activities), nitrogen dioxide (NO_2) (Niven Lake only)	Continuously monitor hourly average; collection will operate year-round, 24 hours a day. Monitoring of NO_2 is measured on a continuous basis and recorded hourly and averaged over a 24-hour period.

Where are the community stations and what do they monitor?

Three air quality monitoring stations, at locations selected with input from Rights holders and stakeholders, make up the community network. The stations are:

- Near Yellowknife Bay (station YKB)
- in Ndilǫ (station NDL)
- in Niven Lake subdivision near downtown Yellowknife (station NVN).

The community network monitors (Figure 11) fine particles ($PM_{2.5}$ and PM_{10}) that are mostly the result of combustion (from vehicles and heating) but also from possible dust generation on the site. On a fixed schedule dependent on season and site activities, filters are analyzed in a laboratory, as with the site samples (Photo 2). Each filter provides two types of data: weighed for the TSP and PM_{10} and then analyzed for metals (e.g., arsenic) (Table 9). One station (NVN) also continuously monitors nitrogen dioxide (NO_2) that is emitted from things such as vehicles and building heating.

PHOTO 2: Air Monitor Filter and Station

What do we do with the data?

1. The amount of PM_{10} and TSP at site perimeter monitoring stations is compared to air quality criteria limits set for the site in the Air Quality Monitoring Plan, which is an appendix to the Dust Management and Monitoring Plan[30]. These limits were set to be protective of human health. If there are any exceedances, they are investigated to determine if the site is the cause. If the site is found to be the cause of the dust, then action is taken on site to reduce or stop the dust (e.g., watering roads).
2. Metals in dust are compared to the established air quality monitoring criteria (as outlined in the Air Quality Monitoring Plan) as results are received from the laboratory (typically three weeks after submitting the filters). The amount of nitrogen dioxide at the Niven Lake station is compared to the Northwest Territories Ambient Air Quality Guideline[31].
3. The amount of PM_{10} and $PM_{2.5}$ at the community monitoring stations is reviewed to determine if there are any patterns or if it exceeds the established air quality monitoring criteria (as outlined in the Air Quality Monitoring Plan). This will be used to help improve the types and duration of dust mitigation strategies.

4) The GMRP uses information on wind speed and direction to guide the timing of activities on site, as well as the need for additional dust control.

Should the results show a concern about dust, site workers investigate the cause. They determine if something on site caused an issue by doing the following:

- doing visual checks for dust
- reviewing activities happening on site
- looking at how strong the wind is blowing
- looking at what the direction the wind is blowing
- checking other environmental factors like forest fires that could impact air quality
- if work on site causes the dust readings, taking action to address it right away

[30] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Giant Mine Remediation Project Dust Management and Monitoring Plan. Version 2.1. June 2021.

[31] GNWT (Government of the Northwest Territories). 2014.Guideline for Ambient Air Quality Standards in the Northwest Territories. Northwest Territories Environmental Protection Act.

4.2 KEY RESULTS

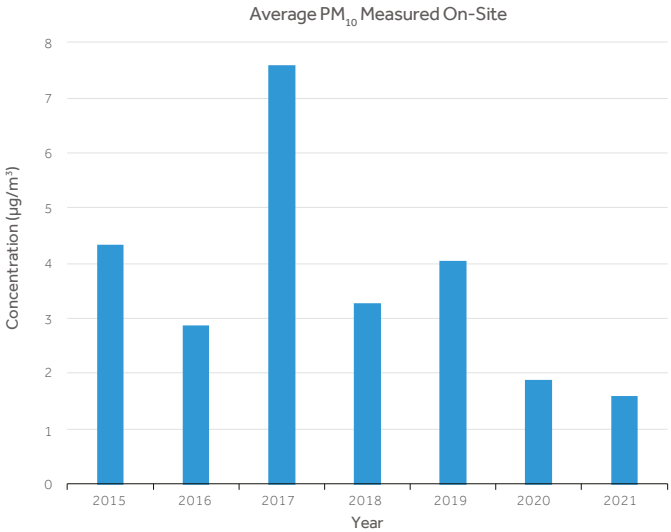
What are the results of the monitoring program from 2015 to 2021?

Results of dust and air quality monitoring are available to the public. Weekly air quality monitoring reports are sent via email to Rights holders and stakeholders; weekly reports are also uploaded to the Mackenzie Valley Land and Water Board Public Registry[32] and Government of the Northwest Territories Ambient Air Quality Network Website[33,34]. A summary of three key results (PM_{10}, visible dust, and wind) is provided below.

Dust

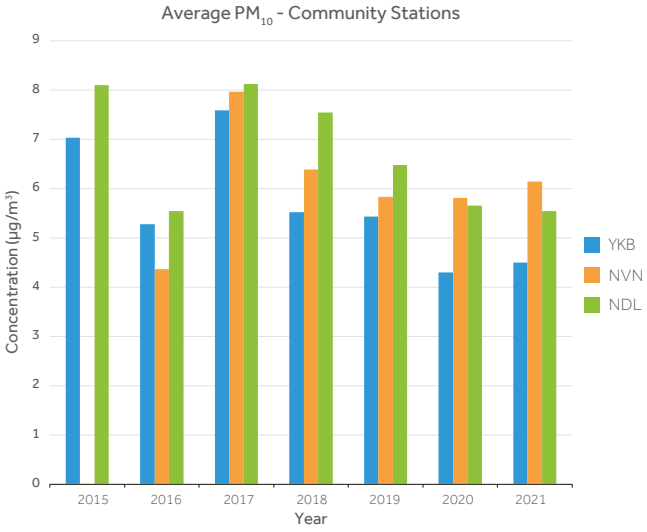
PM_{10} dust measured at the site perimeter and community stations had steady, low concentrations except for in 2017 when regional forest fires occurred (Figure 12). In fact, the measurements are slightly lower on site than in communities (Figure 13). This is because communities have more road traffic and heating emissions closer to the monitoring stations. Overall, dust in the PM_{10} size range measured in community stations shows a similar pattern of the influence of the forest fires (Figure 13). Based on data review, spring road cleaning, vehicles parked near the stations, and/or forest fires are often responsible for elevated values at community monitoring stations. Overall, PM_{10} levels of about 5 micrograms per cubic metre would be considered low in any part of the country, so both on-site and the community stations were below or close to this.

On occasion though, dust was visible on site. On 15 May 2015, there was a short time where dust was above the air quality criteria due to dust generated from tailings work happening in the South Pond. From 13 to 16 October 2020, dust could be seen blowing off two tailings ponds (see Section 10.1 for more information), but measured dust remained below the air quality criteria. The GMRP took action to water the area and place dust suppressant on the tailings ponds to stop the dust. Water and approved dust suppressant are applied to the tailings ponds and other areas of the site as needed to help reduce the chance of blowing dust. The GMRP recognizes that the potential for dust generation remains until remediation activities are complete and areas such as the tailings ponds are covered.



PM_{10} = particulate matter with a mean diameter less than 10 microns or smaller; µg/m³ = micrograms per cubic metre. Note: the 15 minute average air quality criteria for on site stations is 159 micrograms per cubic metre.

FIGURE 12: Dust (PM_{10}) at On-Site Stations



PM_{10} = particulate matter with a mean diameter less than 10 microns or smaller; µg/m³ = micrograms per cubic metre; YKB = station near Yellowknife Bay; NVN = station in Moyle Park, Niven Lake subdivision; NDL = station in Ndilǫ. Note: the air quality criteria for community stations is 50 µg/m³ for a 24 hour period.

FIGURE 13: Dust (PM_{10}) at Community Stations

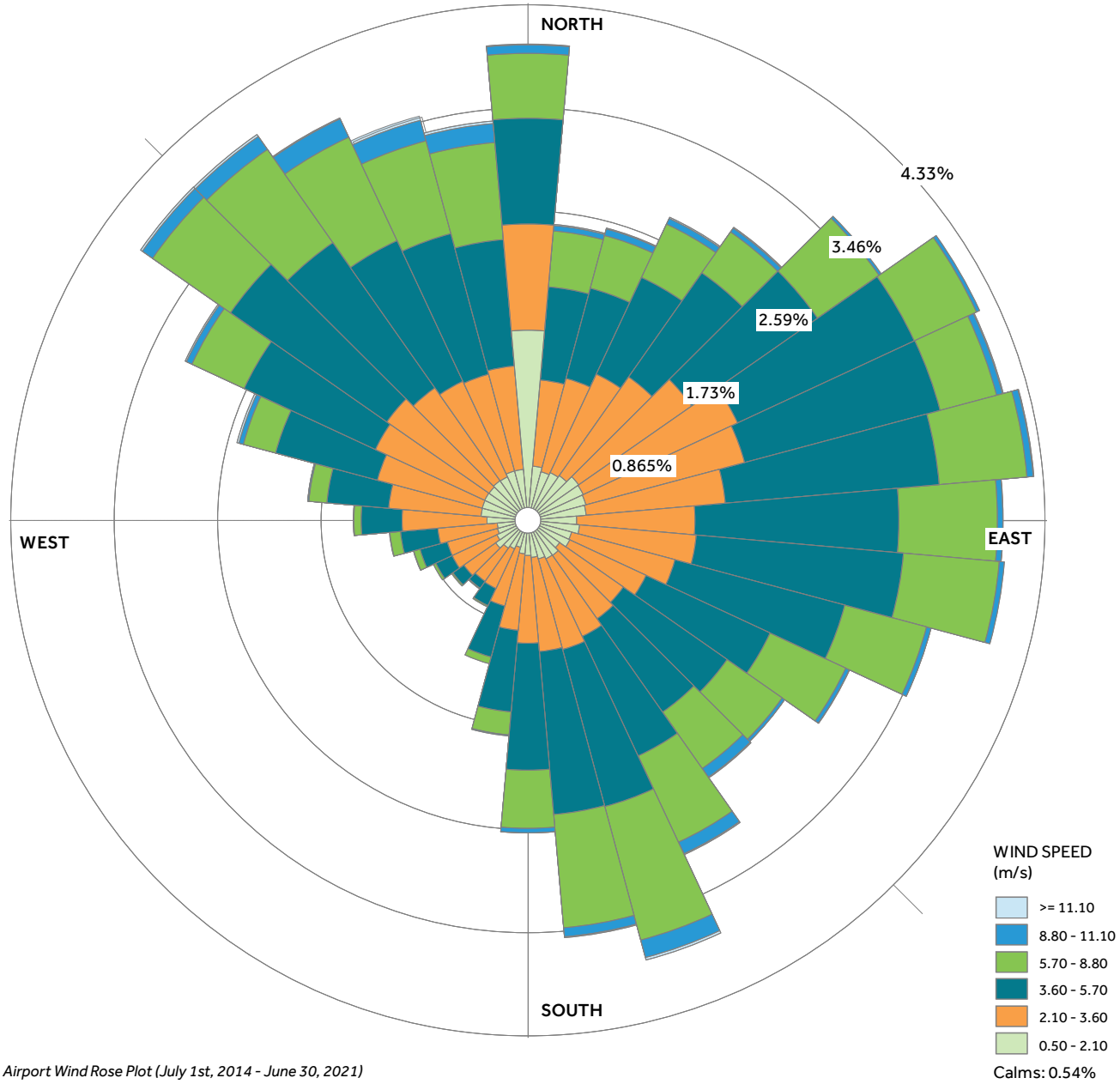
[32] Public Registry | Mackenzie Valley Land and Water Board (mvlwb.com)

[33] Envista - Air Resources Manager (gov.nt.ca)

[34] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Giant Mine Remediation Project Dust Management and Monitoring Plan. Version 2.1. June 2021.

Wind

Wind forecasts and real-time wind measurements are important as they help site workers plan site activities and have extra protection measures in place where needed (e.g., water trucks on stand-by). Wind direction is also an important aspect of wind measurements on site. Winds from the north have the potential to blow dust from the site toward communities. During this reporting period, this direction of wind occurred often (Figure 14). It is expected to occur as often in the near future. When dust is expected, extra monitoring is planned, as well as extra mitigation to reduce dust, such as watering a road before vehicles drive on it. If dust is seen, dust control can be started right away.



Yellowknife Airport Wind Rose Plot (July 1st, 2014 - June 30, 2021)

FIGURE 14: Wind Frequency

4.3 AIR STATUS OF THE ENVIRONMENT INDICATOR

The status of air was rated as "green." This is because the dust concentrations measured during the reporting period remained low despite having a few occasions where dust was visible on site and over the air quality criteria (Table 10).

The current rating is not expected to stay the same in the next three years. In future, more dust (PM_{10} emissions and larger dust particles) is expected on site with expanded remediation activities. Forest fires will occur, and some days will be windy and generate additional dust in the air. The Dust Management and Monitoring Plan[35] will be followed. Dust control measures in place are expected to be effective and continue to safeguard the communities in future years.

Table 10: Air Status of the Environment Indicator

COMPONENT	INDICATOR	EVIDENCE	STATUS FOR 2015–2021
Air	Dust on site	Dust was observed on Site in a few cases and action needed to be taken; overall dust was limited to site and rare exceedances of the air quality criteria occurred[a]. Measured dust particles were overall low on Site except in 2017 during regional forest fires.	●
	Dust at community stations	Measured dust particles were low at community stations except in 2017 during regional forest fires. Community air quality monitoring stations were below the ambient air quality criteria[a]	●

[a] Refer to the Air Quality Monitoring appendix of the Dust Management and Monitoring Plan
TSP = total suspended particulate; PM10 = particulate matter with a mean diameter less than 10 microns or smaller.

[35] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Giant Mine Remediation Project Dust Management and Monitoring Plan. Version 2.1. June 2021.

5.0

Water

The GMRP could affect water quality in the reporting period and over the next 15 years. This is due to historical mining contamination on the land entering the water, the operation of an aging effluent treatment plant, site stabilization activities and upcoming remediation including a new water treatment plant.

BACKGROUND

Water monitoring has occurred on site for decades, with data from the 1970s and 1980s showing that water underground and in Baker Creek was highly contaminated from the mining and roasting processes. The primary contaminant was arsenic, but levels of other metals and ammonia were also high. In the 1980s and 1990s, environmental controls and effluent treatment were implemented and water quality began to improve. In 2002, the Government of Canada established the Metal Mining and Effluent Regulations, which provided limits on the amount and quality of the effluent being released. These regulations became the Metal and Diamond Mining Effluent Regulations in 2018. Currently, the water quality at the site is still contaminated from historical mining operations, but concentrations are stable and meet current federal and territorial requirements. Water monitoring will continue in the long term, something Rights holders, stakeholders, and the GMRP Team all agree is important.

5.1 MONITORING PROGRAMS

How was water monitored?

The purpose of current water monitoring programs is two-fold: to understand what the water on and below the surface of the land is like now, and to check that the remediation is going as planned. The types of water monitoring completed each year include (Table 11):

- measuring water levels in lakes and measuring stream flows in the creeks on or near the site (**hydrology**)
- collecting water below the ground surface using shallow wells and deep wells (**groundwater**; Photo 3)
- testing water that comes from the old underground workings (called the mine pool), either while it is underground or after it is pumped to surface, and measuring how high the water level is in the underground (**minewater**)

PHOTO 3: Groundwater Well Sampling at Station MW00-02

PHOTO 4: Water Quality Sampling at Baker Pond

- sampling water that has undergone treatment by the effluent treatment plant and is discharged (released) to Baker Creek (**treated effluent**)
- collecting water from various locations on site: runoff, water in sumps and ponds (**surface water**)
- sampling **Baker Creek** at several locations from near where it enters the site down to where it enters Yellowknife Bay (Photo 4)
- testing water quality in **Yellowknife Bay** at stations in Back Bay and in north and south Yellowknife Bay as far as Dettah

Baker Creek flows through the site from Lower Martin Lake down to the mouth of the creek where it enters Yellowknife Bay. The monitoring of water levels and stream flows is done as part of the hydrology monitoring program, which helps the GMRP Team understand whether flows in Baker Creek each year are higher or lower than normal and to track patterns over time. This program also identifies beaver dams or other activities around Baker Creek that could cause a higher risk of flooding.

A groundwater monitoring network evaluates groundwater elevation, flow, and quality across the site. Groundwater wells are installed in areas that will help the GMRP Team understand water levels under the ground surface and the quality of the water that is flowing near the mine workings. The wells are grouped mainly based on their purpose and location (i.e., near areas of potential source of contamination, near the major environmental receptors, or near the site boundary to evaluate if impacted groundwater is migrating off site). An example of an area that is monitored using groundwater wells is near the Foreshore Tailings Area.

Surface water, groundwater, and minewater quality are all monitored by collecting field measurements and samples for laboratory analysis. Sampling locations span a wide range of areas of the site. Minewater is pumped to the surface (Figure 15) then sampled using a device called an autosampler or by sending equipment through a shaft and collecting minewater samples at different levels underground. In past years, the GMRP has also collected water samples underground in areas around the underground mine pool or near the sealed chambers that store arsenic trioxide dust; however, some of the underground sampling has been discontinued now that areas are starting to be closed. How high the water level is underground (mine pool elevation) is measured using sensors that are attached to the pumps.

After water is treated at the effluent treatment plant, it is sampled to make sure concentrations are within allowable discharge limits before it is seasonally discharged to Baker Creek. Treated water is also tested to see if it is toxic to aquatic life such as fish, bugs (insects), algae, and aquatic plants.

Water quality across the site is also sampled to better develop the predictive models, support remediation design, and help the GMRP Team make water management decisions. These programs include sampling runoff from spring snowmelt and rainfall as it flows across the surface of the site (Photo 5), seepage from the dams around the Tailings Containment Areas,

PHOTO 5: View of Surface Runoff on Site

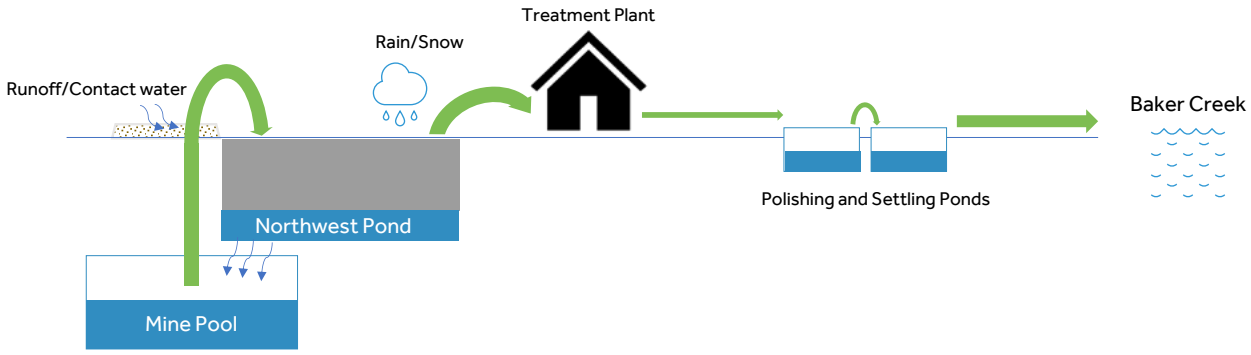


FIGURE 15: Pumping of Minewater to Treatment on Site

and in the small feeder creeks that drain into Baker Creek. These all help to understand the sources of metals and other parameters that could be linked to site activities such as construction or from off-site inputs.

Baker Creek monitoring provides information on how water quality changes over time, with distance downstream (mixing), and potential aquatic effects, including conditions for fish and insect communities that live in the water.

Most of the water sampling at the site happens from spring break-up each year (May) until freeze-up in fall (Table 11), although some such as minewater sampling occurs year-round. The water monitoring program is one of the most extensive monitoring programs on site. To help understand the program, results are organized below by four main questions: Did water flows change on site? How did the water quality compare on site, in Baker Creek, and in Yellowknife Bay? What have we learned so far about studying water quality in Yellowknife Bay? What was the water level in the underground?

5.2 KEY RESULTS

Key results from each of these monitoring programs are outlined below, along with some discussion of what the results mean. The results are summarized in reports that are sent to Environment and Climate Change Canada (for the Metal and Diamond Mining Effluent Regulations) and the Mackenzie Valley Land and Water Board (for the Water Licence).

5.2.1 Did Water Flows Change on Site (hydrology)?

Results from the hydrology monitoring program since 2017 show that flow in Baker Creek responds to changes in the timing of the spring melt, which depends on how quickly temperatures warm up in spring. The creek flows also depend on the timing and amount of rainfall that occurs in spring and summer. Graphs of the water levels are shown in Section 3.2.

Key results are:

- The largest annual volume of water flowing in Baker Creek since 2014 was recorded in 2020[36].
- Spring snowmelt and rainfall were normal in 2020, but heavy rains in summer and saturated ground conditions meant that flows remained high in Baker Creek right through the summer season and even into fall (Photo 6).

PHOTO 6: Mouth of Baker Creek, Flooded in 2020

Table 11: Water Monitoring Summary on Site, in Baker Creek, and in Yellowknife Bay

TYPE OF MONITORING	WHERE?	WHAT?	WHEN?
Hydrology	Baker Creek, Trapper Creek, nearby lakes	Water levels	Open-water (break-up to freeze-up)
		Stream flows	
Groundwater	Under the ground surface, on site	Groundwater quality	Spring and fall
		Water levels	
Minewater	In the underground workings, or from surface	Minewater quality	Year-round
		Minewater elevation	
Surface water	On site: ponds, sumps, runoff	Water quality	Freshet
		Pump volumes	
	Treated effluent	Water quality	During discharge
		Discharge volume	
	Baker Creek	Water quality	Open-water
	Yellowknife Bay	Water quality	Winter, spring, summer, fall

[36] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Giant Mine Remediation Project 2020 Annual Water Licence Report MV2007L8-0031. Version 1.1. July 2021.

- As discussed in Chapter 3, the water levels in Yellowknife Bay were also exceptionally high in 2020, with record high lake levels continuing through to freeze-up. This meant that the lake froze high in the winter of 2020 and 2021, and high water levels continued into spring of 2021 once the ice came off the lake.

5.2.2 How Did the Water Quality Compare on Site, in Baker Creek, and in Yellowknife Bay?

Water on the site is generally either 1) water that has been in contact with developed areas and is contaminated (contact water) or 2) relatively clean water sourced from undisturbed areas. The main source of contact water is the minewater that is in the old underground workings. Water seeps to the underground from the surface, is diverted there as part of water management, or is from groundwater that surrounds the underground workings. Water quality for the groundwater, minewater, treated effluent, and then in Baker Creek and Yellowknife Bay is discussed below.

Groundwater: Contaminants may migrate through groundwater where mine tailings were placed (e.g., Central Pond and South Pond, Foreshore Tailings Area) during mining operations or where contact water is stored (e.g., North Pond, Northwest Pond). Key results for groundwater quality are:

- Groundwater quality measurements near these sources typically show elevated arsenic, other metals, and dissolved anion (often refers to how "salty" the water is) concentrations.
- Arsenic concentrations in the shallow wells (Photo 7) have been generally highest when measured in tailings and lowest in the overburden or the bedrock. Arsenic concentrations in groundwater samples were typically the highest near the Tailings Containment Areas and the Calcine Pond and Mill Pond / Roaster Complex areas. The lowest dissolved arsenic concentrations were measured in the deep well samples collected in the eastern and western areas of the site, farthest from the influence of developed areas of the site and arsenic sources.
- Parameter concentrations in the wells have remained approximately the same throughout the reporting period.
- The groundwater elevations measured in the shallow wells and the shallowest ports of the deep multiport wells (Photo 8) suggest that the water table is typically within 20 metres of ground surface.
- Since mining and following the partial refilling of the underground workings in the early 2000s, minewater pumping has allowed the GMRP to have significant hydraulic control over groundwater flow conditions. The underground acts as a "sink" that collects infiltration, groundwater, and contaminated water.

For more information on groundwater monitoring methods and results, please refer to the 2020 and 2021 Annual Water Licence Reports for the Giant Mine site[37].

PHOTO 7: Conventional Shallow Well for Monitoring Groundwater (photo from ground surface)

PHOTO 8: Deep Multiport Well for Monitoring Groundwater

[37] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2022. Giant Mine Remediation Project 2021 Annual Water Licence Report. April 2022.

Minewater: The minewater is contaminated and must be treated before it can be discharged. It is pumped out of the underground workings year-round so that water levels remain below the arsenic storage chambers. Water is pumped to the surface using mostly the Northwest Shaft pumping system, but there are other backup pumps available in wet years (high snowmelt or heavy rainfall). Once minewater is pumped to the surface, it is stored in the Northwest Pond so that it can be seasonally treated and discharged. Water from other parts of the site, such as seepage from the Tailings Containment Areas or construction runoff, are also stored in North Pond or Northwest Pond until treatment.

Treated effluent: In spring each year, the site starts to operate the effluent treatment plant (Photo 9), and release of treated water (known as effluent) generally occurs between June and September. The treated effluent is released through a pipe into Baker Pond, where it mixes with water flowing in from Baker Creek upstream, and then flows directly into the lower part of Baker Creek.

How much effluent? The amount of effluent released to Baker Pond has steadily increased over time. The highest yearly release of effluent over the past decade was in 2020 (approximately 700,000 cubic metres). In 2021, the yearly amount decreased to around 600,000 cubic metres, but that was still higher than in previous years.

Quality of effluent? Minewater is treated using a chemical called ferric sulphate to remove a lot of the arsenic in the water. Once water has been treated at the plant, it is tested to confirm that it meets requirements before it is released to Baker Creek. The site almost always met the discharge limits for treated effluent with rare 'upset' conditions in the effluent treatment plant. The quality of

PHOTO 9: Giant Mine Effluent Treatment Plant

Did you know?

The Government of Canada regulations for discharges from metal and diamond mines changed in 2018? The amount of arsenic that can be discharged from mines went down from 0.5 to 0.3 milligrams per litre. The Giant Mine site effluent treatment plant was able to meet this lower limit for discharge to Baker Creek.

treated water from the site has been studied over many years of monitoring. Metals, such as arsenic, copper, lead, and zinc, are higher in treated effluent than in upstream Baker Creek. Levels of dissolved solids and anions (e.g., chloride, sulphate) are higher than in upstream Baker Creek due to the treatment processes used to remove arsenic and other contaminants.

A new water treatment plant will be built to replace the aging existing plant. The new plant will discharge directly to Yellowknife Bay, and arsenic concentrations in effluent discharge will be reduced to much lower than existing levels (from 0.3 to 0.01 milligrams per litre on average).

Baker Creek: In spring, Baker Creek is clear (low in suspended solids), and concentrations of most parameters are low, similar to water coming from above the site from Lower Martin Lake. Once effluent discharge begins in spring/summer, water quality in lower Baker Creek is characterized by concentrations of metals and anions elevated above background reference concentrations and above aquatic life guidelines for the receiving environment, but within allowable limits set by regulatory authorities. However, arsenic concentrations in effluent have decreased in recent years as treatment processes have improved. Arsenic is the main metal of concern on site. Although treatment removes much of the arsenic, there is still an increase downstream from Baker Pond after the treated effluent is released. This pattern is shown in Figure 16 by comparing arsenic concentrations over the past four years at the upstream Baker Creek sampling location (Station SNP 43-11) and at the sampling location downstream of the effluent treatment plant (Station "Baker Creek Exposure Point" in Baker Pond). The average concentration is about 3.5 times higher downstream of Baker Pond (0.11 milligrams per litre) compared to the upstream location (0.03 milligrams per litre).

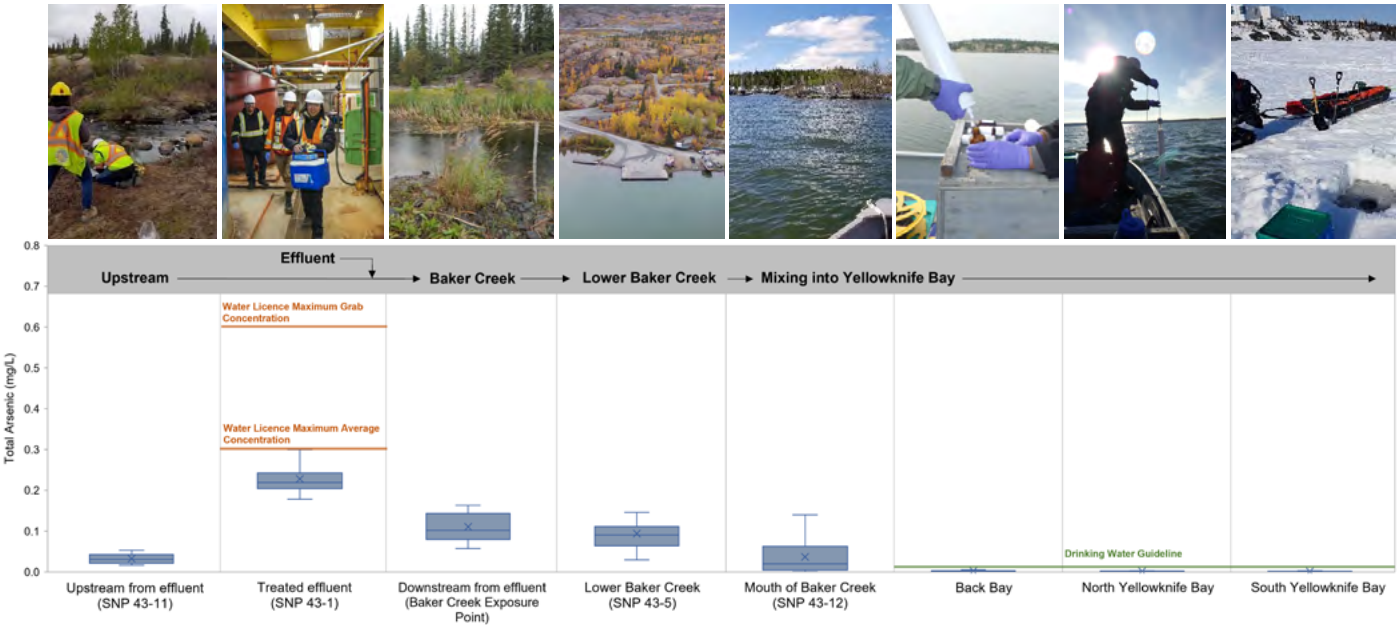
Farther downstream, inputs from runoff over the land surface and small feeder creeks enter Baker Creek. This water leads to lower average arsenic levels farther downstream (0.1 milligrams per litre at station SNP 43-5 in Figure 16). Once the water starts mixing farther into Yellowknife Bay (past the breakwater), arsenic levels decrease rapidly. The same pattern between upper and lower Baker Creek is seen for other metals, total dissolved solids, chloride, and sulphate.

Arsenic concentrations in Baker Creek have decreased over time with better environmental controls, improved treatment, and stricter regulations. For example, arsenic levels were around 12 milligrams per litre in the 1970s before the effluent treatment plant was built. As shown in Figure 17, the yearly mean arsenic levels in recent years decreased from around 0.30 milligrams per litre between 2015 and 2017 to 0.26 milligrams per litre in 2018, and to 0.23 or below between 2019 and 2021. The regulations for mine discharge in Canada changed from 0.5 to 0.3 milligrams per litre during the reporting period. While this decreasing pattern was observed for arsenic, not all parameters have seen this same decrease over time. Inputs from sediments or other local factors (e.g., changes in flows, climate, air patterns) may be cause some parameter levels to remain relatively consistent over time.

Did you know?

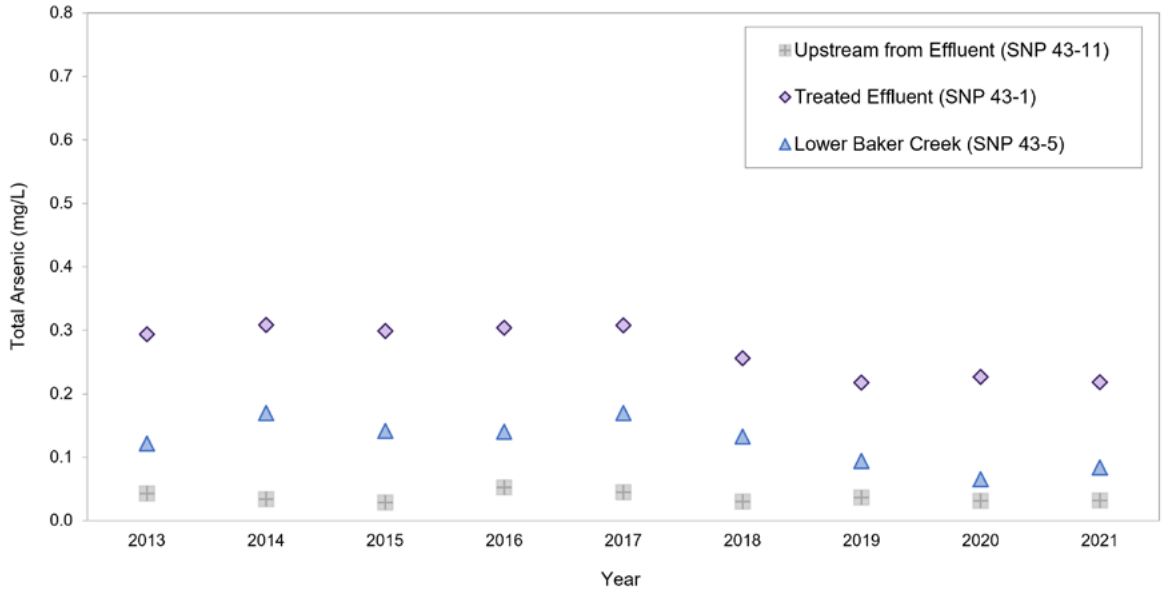
That arsenic concentrations in Yellowknife Bay near the mouth of Baker Creek have gone down since mining stopped and water treatment improved? Arsenic concentrations are close to or below the drinking water guidelines for Canada.

Yellowknife Bay: Sampling locations in Yellowknife Bay are grouped into three main areas (Figure 16): Back Bay, North Yellowknife Bay, and South Yellowknife Bay. These locations span the area from near the mouth of Baker Creek to around the Foreshore Tailings Area and farther to the north towards the mouth of Yellowknife River to as far south as Dettah. Based on recent samples collected in these areas, arsenic levels in Yellowknife Bay are close to, or below, the drinking water guidelines (Figures 16 and 18). With construction of the new water treatment plant later in remediation, it is expected that there will be a further lowering in arsenic levels in Yellowknife Bay, especially in areas near the mouth of Baker Creek that are currently affected by discharge from the existing plant.



*Notes: Data from 2018 to 2021 are used for statistical calculations. The bottom of the box indicates the first quartile, and the top of the box indicates the third quartile. The X indicates the average, and the horizontal line above of the box indicates the statistical maximum (i.e., Q3 + 1.5*IQR). mg/L = milligrams per litre; SNP = Surveillance Network Program; IQR = interquartile range.*

FIGURE 16: Pattern of Arsenic Concentrations in Treated Effluent and Baker Creek from Upstream to Downstream



mg/L = milligrams per litre; SNP = Surveillance Network Program.

FIGURE 17: Yearly Average Arsenic Levels over Time in Treated Effluent and Baker Creek

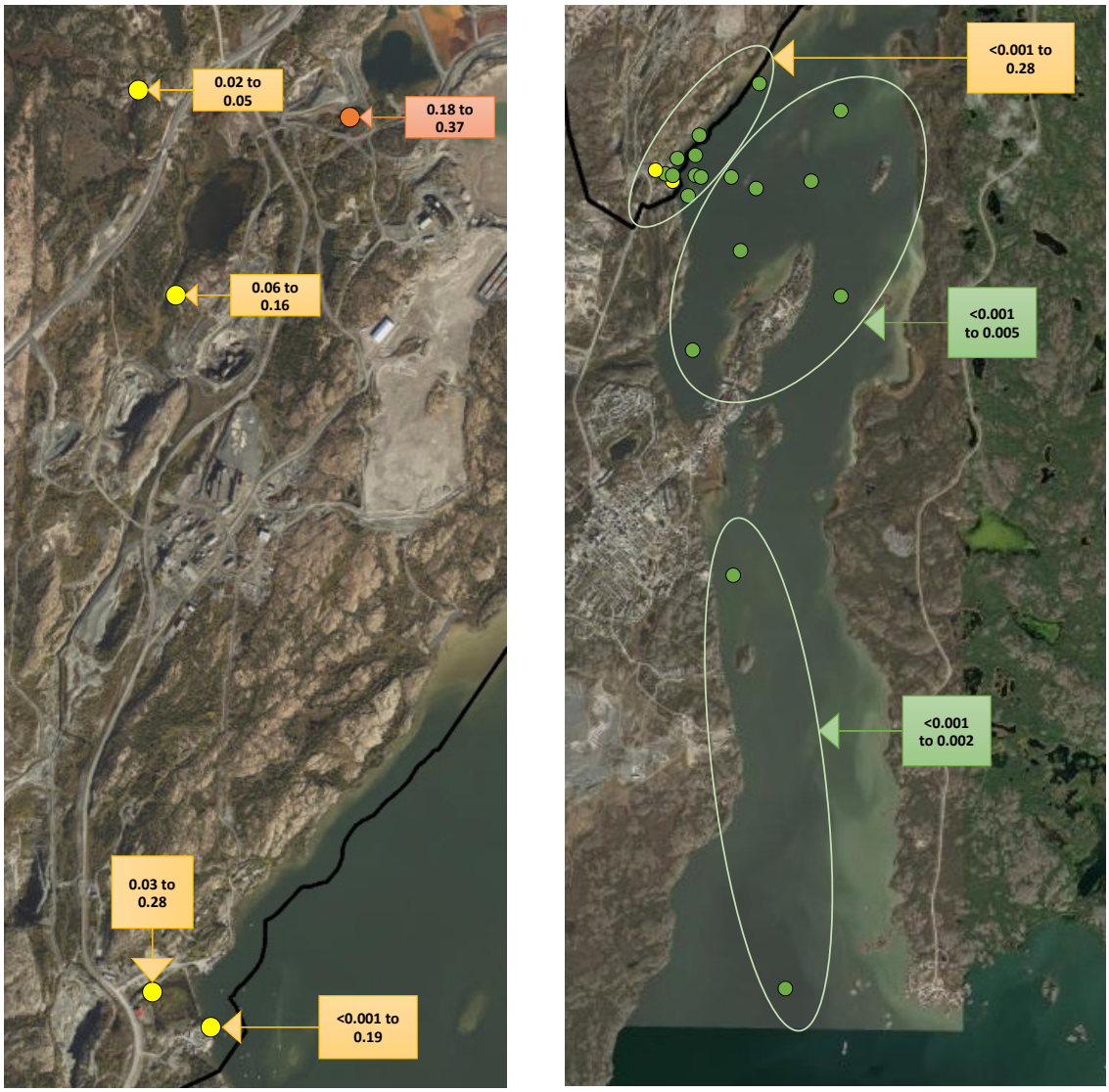


FIGURE 18: Pattern of Arsenic Concentrations in Baker Creek and Yellowknife Bay

For more information on water monitoring methods and results, please refer to the 2020 and 2021 Annual Water Licence Reports for the Giant Mine site as well as the annual aquatic effects monitoring plan reports[38,39,40].

5.2.3 What Have We Learned So Far about Studying Water Quality in Yellowknife Bay?

The GMRP started routinely collecting background information in Yellowknife Bay in 2018 as part of the Yellowknife Bay Special Study[41] (Photos 10 and 11). Many other researchers are also studying the impacts of historical mining on sediment and water quality in Yellowknife Bay. The studies agree that the sediments at the lake bottom continue to be a source of contaminants. However, because of high flows coming in from the Yellowknife River and other areas of Great Slave Lake, concentrations of contaminants in the water column are low.

Information collected as part of the Yellowknife Bay Special Study is used in two ways: 1) it shows whether there is an effect from treated effluent from the existing plant after the water leaves the mouth of Baker Creek and mixes into the bay, and 2) it establishes conditions before the new water treatment plant becomes operational.

PHOTO 10: Filling Water Bottles for Water Quality Sampling of Yellowknife Bay

PHOTO 11: Water Quality Sampling in Yellowknife Bay Using the Kemmerer Sampling Tube

[38] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Giant Mine Remediation Project 2020 Annual Water Licence Report MV2007L8-0031. Version 1.1. July 2021.

[39] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2022. Giant Mine Remediation Project 2021 Annual Water Licence Report. April 2022.

[40] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Aquatic Effects Monitoring Program Annual Reports - 2020 (Part 1, Part 2, Part 3), 2021 (Part 1, Part 2, Part 3)

[41] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Aquatic Effects Monitoring Program Annual Reports - 2020 (Part 1, Part 2, Part 3), 2021 (Part 1, Part 2, Part 3)

An example of the way that the Yellowknife Bay Special Study has helped understand conditions in Yellowknife Bay is illustrated in Figure 19. In summer (left of diagram), there is surface warming from the sun and there are cooler layers at deeper levels of the lake (shown in darker colours). By fall (right of diagram), these layers start to mix until lake turnover occurs, bringing nutrients up to the surface from deeper layers. At this stage, there is very little change in temperature with depth because the cooler layers have been mixed with the warmer surface layers. The different temperature layers affect fish food, fish growth, and type of organisms that can live in the bay.

Toxicity testing (a laboratory test that looks for negative [adverse] effect of a substance on animal health or the environment) was completed as part of the Yellowknife Bay Special Study for fish, bugs, algae, and aquatic plants using water from an area close to the site, as well as an area farther offshore in North Yellowknife Bay. In both cases, there have been effects on the organisms being tested, but results indicate that the water discharge from the site has not had a major effect on the aquatic organisms: they can still reproduce, feed, and grow.

5.2.4 What Was the Water Level in the Underground?

During the reporting period, the water level was very closely managed; pumps were turned on and off to keep the water level at approximately the same elevation. The water level was kept to the current level, which is 239 metres below ground surface (-77 average metres above sea level or in mining terms, approximately the 750 Level). On occasion, for example in spring 2021, the water level went up approximately 3 metres when more water came into the underground during spring melt. The water level was returned to its normal level a few weeks later.

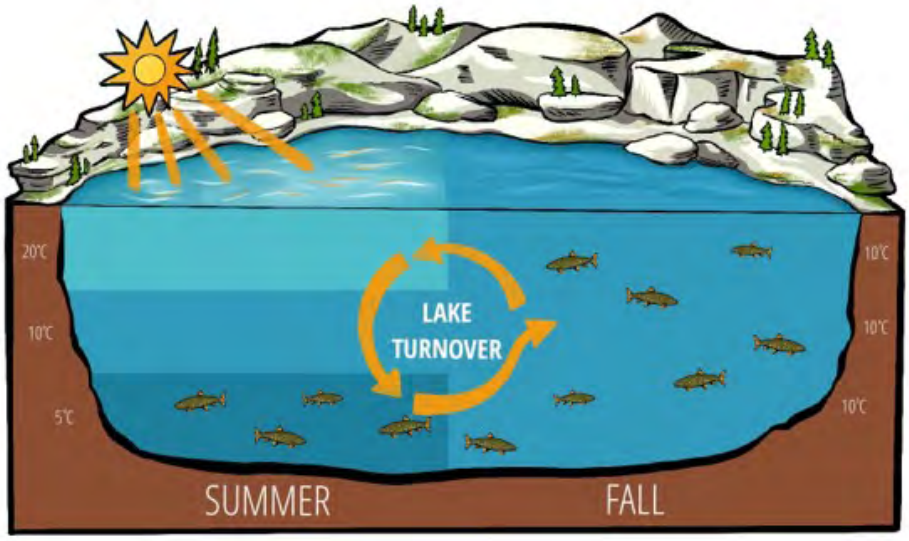


FIGURE 19: Lake Turnover in Yellowknife Bay between Summer and Fall

5.3 WATER STATUS OF ENVIRONMENT INDICATOR

The status of water was rated as shown below:

On-site / Baker Creek: The status of water was rated as "yellow" for water quality on site and in Baker Creek (Table 12). This is because Baker Creek had increased arsenic in the water when treated effluent was discharged but also had arsenic at amounts similar to upstream when effluent was not discharged to the stream. With effluent present in the creek, arsenic concentrations remained below the national regulation for metal mines (Metal and Diamond Mining Effluent Regulations).The quality of treated effluent from the site has improved over time. Few exceedances of licence limits were noted.

Yellowknife Bay: Yellowknife Bay water was rated as "green" (Table 12). This is because the arsenic concentrations were often less than current drinking water quality standard and always less than the site-specific water quality objective (Effluent Quality Criteria Report[42]).

These ratings are expected to stay the same as remediation progresses. Until there is a new water treatment plant for the site, water quality improvements are not expected

Table 12: Water Status of Environment Indicator

COMPONENT	INDICATOR	EVIDENCE	STATUS 2015–2021
Water	Water quality on site and in Baker Creek	***Water in Baker Creek on site***: had arsenic that was higher than upstream of the site when effluent was being discharged, but remained within the national regulation for metal mines (MDMER[43]). ***Treated effluent***: met licensed discharge criteria almost all of the time	
	Water quality in Yellowknife Bay	Arsenic was often less than current drinking water quality standard and always less than the site-specific water quality objective in Yellowknife Bay.	

** From 2015 to September 2020 of this report period, the GMRP operated the effluent treatment plant to meet the discharge limits (effluent quality criteria) of expired water licence #N1L2-0043. From September 2020 onward, the GMRP operated under a new water licence with updated effluent quality criteria (#MV2007L8-0031). MDMER = Metal and Diamond Mining Effluent Regulations.*

[42] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2019. Giant Mine Remediation Project Effluent Quality Criteria Report. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada. January 2019.

[43] Metal and Diamond Mining Effluent Regulations (justice.gc.ca)

6.0

Fish

The GMRP could affect fish in the reporting period, and over the next 15 years of remediation. This is due to historical mining contamination in the sediments and water, discharge of treated effluent from an aging effluent treatment plant, site stabilization activities, and upcoming remediation.

BACKGROUND

Baker Creek is a stream that flows through the Giant Mine site. Before mining, Baker Creek provided a place for fish to lay eggs (spawning habitat), as well as a passageway for fish moving between Yellowknife Bay and the lakes upstream. Baker Creek, within the Giant Mine site boundary, and the mouth of the Yellowknife River, were sources of trout and whitefish according to the Yellowknives Dene First Nation[44].

Data from the 1970s during mining activities showed that the health of Baker Creek was severely damaged; no fish, and very little fish food (crustaceans, aquatic insects, or benthic invertebrates), were found downstream of the Giant Mine site (Closure and Reclamation Plan Chapter 2[45]). During the 1990s, wastewater (treated effluent) quality and the timing of release to Baker Creek were improved to reduce the impact on fish in Baker Creek. In 2002, the Government of Canada established the Metal Mining Effluent Regulations (note that as of 2018, this is called the Metal and Diamond Mining Effluent Regulations), which provides effluent quality and quantity standards and requires frequent environmental monitoring in Baker Creek. Following these improvements, species of fish and fish food began to come back to (recolonize) Baker Creek. After the site began adopting better controls, and as the GMRP began work towards remediation, improvements in the Baker Creek aquatic life were observed. Currently, Baker Creek is described as contaminated and altered but showing signs of a system in recovery.

Did you know?

Traditional Knowledge says Arctic Grayling (ts'èt'ìa; Thymallus arcticus) and Walleye (Sander vitreus) both spawned in the creek. The Yellowknives Dene regularly picked berries and fished at the mouth of Baker Creek. The Yellowknives Dene called the creek "Jackfish River," suggesting Northern Pike (ihdaà; Esox lucius) were also in the creek.

[44] YKDFN (YKDFN Elders Advisory Council) and Trailmark Systems. 2019. Yellowknives Dene First Nation Knowledge and History of the Giant Mine: Concerns, Recommendations, and Closure. Prepared for the Giant Mine Remediation Plan. March 2019.

[45] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada.

Some facts about Baker Creek:

- A range of fish species have been found in Baker Creek since the 1990s, including Northern Pike (*Esox lucius*), Arctic Grayling (*Thymallus arcticus*), Lake Chub (*Couesius plumbeus*), Ninespine Stickleback (*Dahts'a; Pungitius pungitius*), Emerald Shiner (*Notropis atherinoides*), Spottail Shiner (*Notropis hudsonius*), Trout Perch (*Percopsis omiscomaycus*), White Sucker (*Catostomus commersonii*), Burbot (*Lota lota*), Longnose Sucker (*Catostomus catostomus*), Slimy Sculpin (*Cottus cognatus*), Lake Whitefish (*łi; Coregonus clupeaformis*), and Walleye (*Stizostedion vitreum*).
- The mouth of Baker Creek, which has been the focus of biological monitoring, is a marsh habitat with many aquatic plants, including cattails and reeds. It is the richest area of the creek in terms of fish species and is an important area for fish to gather before they migrate upstream. Young fish live at the mouth in summer to eat food and grow, hiding in the vegetation; thousands of fish of different types spend their summers there, including Northern Pike, Slimy Sculpin, Arctic Grayling, and Longnose Sucker, as well as many small-bodied fish.
- Large-bodied fish, such as Arctic Grayling, can travel through the culvert under the highway and go upstream to the part of the creek that flows through the site. Here, some fish lay eggs (spawn), and the eggs will hatch and young fish will feed and grow until the creek warms up and they travel to Yellowknife Bay.
- Over 40 species of benthic invertebrates have been found in Baker Creek. The main group of invertebrate species present are the flies/bloodworms (dipterans), with other groups also present such as mayflies and shrimps/scud (amphipods) (see Photo 12). For all, or at least part of their lives, benthic invertebrates in Baker Creek either live in the upper few centimetres of sediment, or on the sediment surface, or both. The numerous aquatic plants in Baker Creek in the summer also provide habitat for benthic invertebrates. Many of the young benthic invertebrates will hatch into adult flies/beetles. Both the young and the adults are food for fish.
- The mouth of Baker Creek is used for recreational catch and release fishing in summer. The creek is closed to fishing in spring.

PHOTO 12: Shrimp, Mayfly, and Bloodworm – Fish Food in Baker Creek

6.1 MONITORING PROGRAMS

What monitoring programs and investigations were done from 2015 to 2021?

In the last seven years, monitoring activities in Baker Creek have focused on the effects of the discharge of treated effluent on fish and fish food (benthic invertebrates). Monitoring has also provided insight on the amount of contaminants in fish muscle and organs ("tissue chemistry") in Baker Creek and Yellowknife Bay (Table 13). A Human Health and Ecological Risk Assessment Report (Part 1, Part 2, Part 3, Part 4) was done in 2018[46], using the data from the monitoring program to check if fish were healthy and safe for humans and other predators to eat (results presented in Section 6.2.3).

6.1.1 Biological Monitoring

Baker Creek benthic invertebrate and fish health monitoring (biological monitoring) started in 2002 as required by the Metal and Diamond Mining Effluent Regulations. The biological monitoring is referred to as the Giant Mine Environmental Effects Monitoring Program, which occurs every three years and lasts for a period of two to three years.

1. In the first year, a plan is submitted to Environment and Climate Change Canada that describes the monitoring.
2. In the second year, the field monitoring occurs.
3. In the third year, the data are analyzed and reported to Environment and Climate Change Canada.

To date, six reports have been submitted to Environment and Climate Change Canada.

Biological monitoring includes sampling benthic invertebrates and fish health. Sampling is done in two types of areas:

- **Exposure area:** where benthic invertebrates / fish live in or near the treated effluent. The exposure area in Baker Creek is close to the mouth of the creek, where treated effluent and creek water are mixed. This water also mixes with water from Yellowknife Bay at the mouth of the creek.
- **Reference area:** where benthic invertebrates or fish live in water that does not contain treated effluent. The reference areas for fish are the Yellowknife River and Horseshoe Island Bay, and the reference area for the benthic invertebrates is the mouth of the Yellowknife River as it enters Yellowknife Bay (Figure 20).

The biological data collected from these areas are compared to each other to determine how the benthic invertebrates and fish from the exposure area are performing (i.e., how healthy they are) when compared to benthic invertebrates and fish from the reference areas (Table 14).

Table 13: Types of Fish Monitoring in Baker Creek, the Yellowknife River, and Yellowknife Bay

TYPE OF MONITORING/ INVESTIGATIONS	WHERE?	WHAT?	HOW OFTEN?
Effects of treated effluent on fish (biological monitoring)	Baker Creek, Yellowknife River, Horseshoe Island Bay	Small-bodied fish length, weight, sex, age, number of parasites, tissue chemistry, liver size, and health of organs like liver and gonads (ovaries, testes); amount of fish food (benthic invertebrates) and types of fish food	Every two to three years, in spring and summer[(a)]
Concentrations of metals in fish (fish tissue chemistry)	Baker Creek	Arctic Grayling muscle, organs, eyes	Spring 2020
	Yellowknife Bay	Lake Whitefish, Northern Pike, Lake Trout muscle	Summer 2021

a) Monitoring was done in 2004, 2006, 2010, 2012, and 2019 based on the requirements of Environment and Climate Change Canada; a desktop monitoring review study was done in 2015.

[46] CanNorth (Canada North Environmental Services). 2018. Giant Mine Human Health and Ecological Risk Assessment, Prepared for Public Services and Procurement Canada – Western Region, Environmental Services and Contaminated Sites Management. Edmonton, AB, Canada.

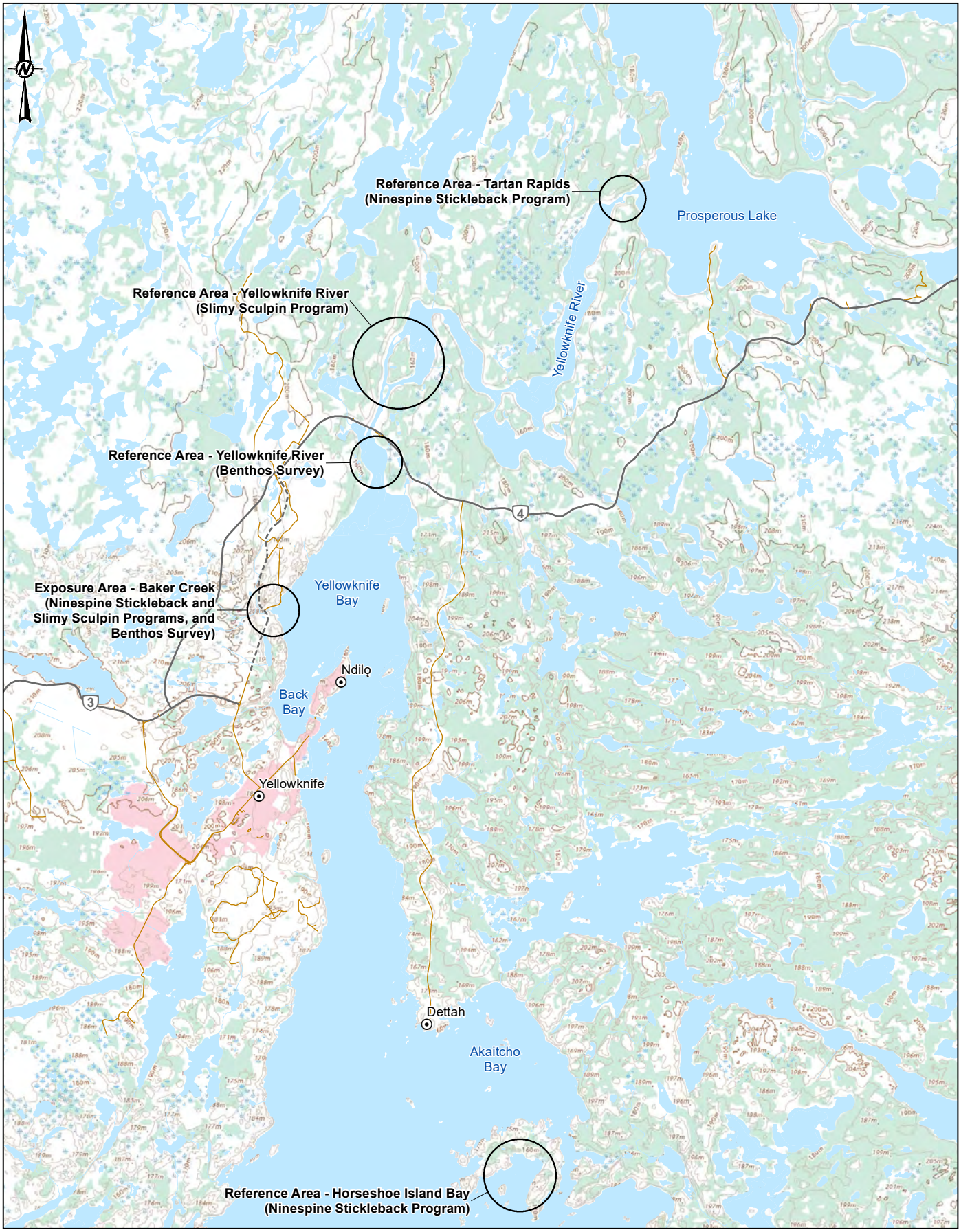


FIGURE 20: Environmental Effects Monitoring Exposure and Reference Areas Map

Table 14: Biological Monitoring Details for the Giant Mine Remediation Project

SAMPLING	SPECIES	EXPOSURE AREA	REFERENCE AREA	HOW ARE THEY MONITORED?	HOW OFTEN?
Benthic invertebrate	N/A	Weedy, soft areas of the mouth of Baker Creek	Weedy, soft areas of the mouth of Yellowknife River	On plates and in grabs of sediment from the bottom	Every three years
Fish health	Ninespine Stickleback	Mouth of Baker Creek in weedy areas	Weedy area of Horseshoe Island Bay and Tartan Rapids in Yellowknife River	Fish collected by seine nets	Every three years
	Slimy Sculpin	Rocky, shallow areas of mouth of Baker Creek	Rocky shore of island Yellowknife River	Fish collected by electrofishing	Every three years

N/A = not applicable.

Benthic Invertebrate Monitoring

The most common method for sampling of benthic invertebrates is to take a bottom sediment sample using a type of "grab sampler" (Photo 13), sieve out the sediment, and remove any benthic invertebrates and send them to a laboratory for identification. However, in Baker Creek the sediments are contaminated, and this makes it hard to know if the benthic invertebrates are affected by the treated effluent mixed with the creek water or by the sediment. Another difficulty is the differences in aquatic habitat where different types of bottom substrates or amounts of vegetation are found, which can affect the number and types of benthic invertebrates that live there.

To address these complicating factors, a different sampling method involving artificial substrates or plates (Photo 14), either on their own (2004 to 2012) or alongside the more traditional grab sampling of natural substrates (2019), was used. The invertebrates colonize the plates over the summer months. In fall, the artificial plates are taken out and the invertebrates are brushed off and sent to the laboratory for identification.

In 2015, an investigation into the probable cause or causes of the environmental effects detected at Baker Creek was completed in place of biological monitoring. This investigation involved a critical review of routine Environmental Effects Monitoring studies and other studies of fish and benthic invertebrates to determine the cause of confirmed effects observed in fish and benthic invertebrate communities during previous years of Environmental Effects Monitoring. The findings of the 2015 investigation helped inform remediation decision-making at the Giant Mine site and the design of the future monitoring programs under the GMRP Water Licence.

Fish Health Monitoring

Fish health monitoring is part of biological monitoring and it investigates size, reproduction, and growth of fish; it is looking at the ecology of the fish and is separate from eating fish and risks to human health (see Section 6.2.3). To help minimize the effects of monitoring on the fish community, small-bodied fish are used. At Baker Creek, Ninespine Stickleback (Photo 15) and Slimy Sculpin (Photo 16) are used for monitoring. These are usually found in greater numbers than larger species such as Northern Pike or Lake Trout. They also move around less than larger species, so it is easier to relate any differences observed in their health to the area where they were collected.

PHOTO 13: Grab Sampler

PHOTO 14: Artificial Sample Plates Deployed 2019

Source: photograph by Paul Vecsei

PHOTO 15: Ninespine Stickleback in Baker Creek

Source: photograph by Paul Vecsei.

PHOTO 16: Slimy Sculpin on Site

Fish are captured by nets and electrofishing (Photo 17). Every three years, these fish are collected from the exposure area in Baker Creek (Figure 20) and the reference areas and are weighed and measured. Approximately 90 Slimy Sculpin are killed to collect otoliths (i.e., small bones used to estimate the age of a fish) and organs (liver and gonads). These data are then used to evaluate the survival, growth, reproduction, and energy storage of these fish populations.

PHOTO 17: Baker Creek Electrofishing

6.1.2 Fish Tissue Monitoring

Sampling of fish tissue chemistry has been completed to monitor concentrations of metals in fish and has been done in Baker Creek for many years. Fish tissue monitoring is used to check whether fish are safe for humans and wildlife to eat, as well as find out if metals in fish tissue could be harmful to the fish themselves.

6.1.2.1 2018 Human Health and Ecological Risk Assessment

A large fish tissue study was done in 2011 that concluded that fish in Baker Creek had arsenic and other metals in their tissues (Closure and Reclamation Plan Chapter 2, Appendix 2B[47]). A Human Health and Ecological Risk Assessment (Part1, Part 2, Part 3, Part 4) was done with fish tissue from 2011 and 2015[48]. This study included using the measurements of potential contaminants in the tissue of fish to assess if there was a risk to humans or predators from eating fish now and after remediation:

- Fish from Baker Creek and Yellowknife Bay were analyzed for total arsenic and other metals (Closure and Reclamation Plan Chapter 2, Appendix 2E [Part 1, Part 2, Part 3, Part 4][49]). This included whole bodies for small fish like Slimy Sculpin, Ninespine Stickleback, and young Arctic Grayling. Muscle samples were taken from a variety of fish species in Yellowknife Bay: Lake Trout, Lake Whitefish, Northern Pike, Inconnu (*Stenodus leucichthys*), and Burbot. Tissue was taken from Lake Whitefish and Northern Pike fish livers.

6.1.2.2 2020 to 2021 Updates to Fish Tissue Chemistry

During the GMRP Water Licence engagement process, communities expressed interest in having more up-to-date fish tissue chemistry data at the start of remediation:

1. Fish tissue monitoring was completed in 2020 in Baker Creek; Arctic Grayling were collected by the Yellowknives Dene First Nation and the Government of the Northwest Territories. The Government of the Northwest Territories had the fish samples (muscle, organs, and eyes) analyzed and reviewed to determine if there would be human health issues with eating Arctic Grayling from the creek, as part of its overall Legacy Human Health Risk Assessment.
2. In summer 2021, fish tissue from large-bodied fish was collected from Yellowknife Bay (Table 13) after engagement with the Yellowknives Dene First Nation and North Slave Métis Alliance about fishing locations and species to capture in summer. The survey targeted 10 individuals each from three fish species: Northern Pike, Lake Trout, and Lake Whitefish. Fish were collected using gill nets and angling. After the fish were captured, fish muscle (fillet) was sent to the laboratory for metals analysis; organs and eyes were archived for future study if needed.
3. In addition to fish muscle, three other fish tissue types were collected in 2020 and 2021: scales, fins, and a small muscle plug. A muscle plug is a tiny piece of muscle collected with a needle (dermal punch). These three types of samples were sent to a laboratory to test for the presence of arsenic and determine if they were a viable option to represent arsenic concentrations in the fish. The aim was to reduce lethal methods for sample collection, as scales, fins, and muscle plugs may be collected without killing the fish. This was called a "non-lethal pilot study" since it is one of the first of its kind for these fish in the North.

[47] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2019. Giant Mine Remediation Project Closure and Reclamation Plan. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada.

[48] CanNorth (Canada North Environmental Services). 2018. Giant Mine Human Health and Ecological Risk Assessment, Prepared for Public Services and Procurement Canada – Western Region, Environmental Services and Contaminated Sites Management. Edmonton, AB, Canada.

[49] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2019. Giant Mine Remediation Project Closure and Reclamation Plan. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada.

6.2 KEY RESULTS

What were the results from the 2015 to 2021 monitoring programs?

6.2.1 Benthic Invertebrate Communities

Benthic invertebrate communities were sampled in 2004, 2006, and 2010 by the GMRP Environmental Effects Monitoring Program, and results were comparable across years (Closure and Reclamation Plan Chapter 2, Appendix 2B[50]). Some small differences were found in Baker Creek communities compared to the Yellowknife River communities. For example, there was a reduced proportion of pollution-sensitive mayflies in Baker Creek.

In 2015, an investigation of cause study looked at why there might be differences in Baker Creek benthic communities compared to the reference area[51]. The study found that exposure to metal contaminants was the most likely cause of the observed effects, through exposure to salts (total dissolved solids) in the treated effluent, historical arsenic sediment contamination, or a combination of both. This finding was still a little uncertain because of possible effects of aquatic habitat on the biological data collected (e.g., differences in the amount of plants in each area).

In 2019, benthic invertebrates were sampled using artificial plates and also by sampling the natural sediments directly[52]. Both showed that there were effects on the number of invertebrates, or the types of invertebrates found in the exposure area. The same species groups were not found in each area (dissimilar, measured with a scientific index called the Bray-Curtis Index) in either artificial or natural substrates. As also seen in previous years, there were proportionally fewer mayflies and caddisflies in the exposure area, but the overall community was diverse, with many different types of invertebrates collected. Exposure to treated effluent was responsible in part for these effects; however, habitat variation and historically contaminated sediments could still not be ruled out as having an influence.

In summary, the biological monitoring showed that while invertebrates were relatively plentiful at the mouth of Baker Creek, benthic invertebrate communities were different from those in the Yellowknife River reference area, which had habitat similar to the exposure areas and so was used to represent what might be expected with no treated effluent discharge. However, looking at the history of the Giant Mine, the effects confirmed by the GMRP Environmental Effects Monitoring Program were relatively minor compared to those observed decades ago when benthic invertebrate communities provided very little food for fish in Baker Creek. Benthic invertebrate communities in lower Baker Creek now provide different types of food for fish, which helps the creek support a variety of fish species and life-stages.

6.2.2 Fish Health

Based on data collected between 2006 and 2012, effects on fish growth were seen for both Slimy Sculpin and Ninespine Stickleback in Baker Creek (Closure and Reclamation Plan Chapter 2, Appendix 2B[53]). In the case of small fish that live on the bottom of the creek (Slimy Sculpin), body size was smaller in the exposure area than the reference area; also, their livers were larger, which could indicate the liver was "stressed" and trying to eliminate metals. In Ninespine Stickleback, body size was larger in the exposure areas than the reference area; this type of fish moves up and down in the water column (pelagic) and does not live on the bottom.

[50] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2019. Giant Mine Remediation Project Closure and Reclamation Plan. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada.

[51] Golder (Golder Associates Ltd.). 2017. Phase 5 Environmental Effects Monitoring Program - Giant Mine Investigation of Cause Study. Prepared for Indigenous and Northern Affairs Canada and Public Services and Procurement Canada - Giant Mine Remediation Project, by Golder Associates Ltd. Yellowknife, NWT, Canada.

[52] Golder (Golder Associates Ltd.). 2020. Final Interpretative Report, Phase 6 Environmental Effects Monitoring Program. Submitted to Environment and Climate Change Canada, June 2020. Prepared for AECOM and PSPC, Edmonton.

[53] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2019. Giant Mine Remediation Project Closure and Reclamation Plan. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada.

In 2015, an investigation of cause study was completed and no fish health monitoring was completed that year[54]. The results of the investigation found that historical arsenic contamination and differences in habitat between Baker Creek and the reference areas were most likely responsible for these effects seen in growth, and it was unlikely to be related to treated effluent released from the site.

In 2019, similar effects were seen in the growth of fish at Baker Creek when compared to other years:

- **Results for fish living near sediment:** Slimy Sculpin were abundant in Baker Creek; however, shorter males, and male and female fish with larger livers, were found in the area exposed to effluent than in the reference area. These effects were thought to be related to the historical arsenic contamination within the sediments in Baker Creek.
- **Results for fish living around creek and in vegetation:** Ninespine Stickleback showed the opposite results, with bigger fish (by weight and length) in the exposure area and more young of year fish in Baker Creek when compared to the reference area.
- Overall, more fish were captured in Baker Creek, and with a greater variety of species, than in the reference areas.

Differences in life history may explain the differing responses observed in Slimy Sculpin and Ninespine Stickleback. Ninespine Stickleback are pelagic and appear to use Baker Creek as temporary spawning and nursery habitat, emigrating into Great Slave Lake after the first year. Because they move up and down in the water column, Ninespine Stickleback have minimal consistent or direct interaction with sediment. In contrast, Slimy Sculpin inhabit small home range areas, and appear to live in Baker Creek for several years. During this time, they have consistent and direct physical exposure to the sediments, while also experiencing indirect exposure from feeding on benthic invertebrates within the sediment.

Did you know?

Every spring, fish, like these Longnose Sucker, come to Baker Creek on site and spawn. These fish and their young leave by early summer.

6.2.3 Fish Tissue

6.2.3.1 Human Health and Ecological Risk Assessment

A Human Health and Ecological Risk Assessment Report (Part 1, Part 2, Part 3, Part 4) was completed in 2018[55]:

- The results showed fish had detectable arsenic (see the Closure and Reclamation Plan Chapter 2, Appendix 2E [Part 1, Part 2, Part 3, Part 4[56]] for the full results). Different species had varying amounts of arsenic.
- The risks to humans from eating fish were found to be very low to low before remediation and the cleanup will further reduce these risks.
- It concluded that fish that enter and leave Baker Creek and are captured in Yellowknife Bay were safe for humans and wildlife to eat, as metal contamination levels remained below guidelines (Closure and Reclamation Plan Chapter 2, Appendix 2E [Part 1, 2, 3, and 4][57]).

[54] Golder (Golder Associates Ltd.). 2017. Phase 5 Environmental Effects Monitoring Program - Giant Mine Investigation of Cause Study. Prepared for Indigenous and Northern Affairs Canada and Public Services and Procurement Canada - Giant Mine Remediation Project, by Golder Associates Ltd. Yellowknife, NWT, Canada.

[55] CanNorth (Canada North Environmental Services). 2018. Giant Mine Human Health and Ecological Risk Assessment, Prepared for Public Services and Procurement Canada – Western Region, Environmental Services and Contaminated Sites Management. Edmonton, AB, Canada.

[56] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2019. Giant Mine Remediation Project Closure and Reclamation Plan. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada

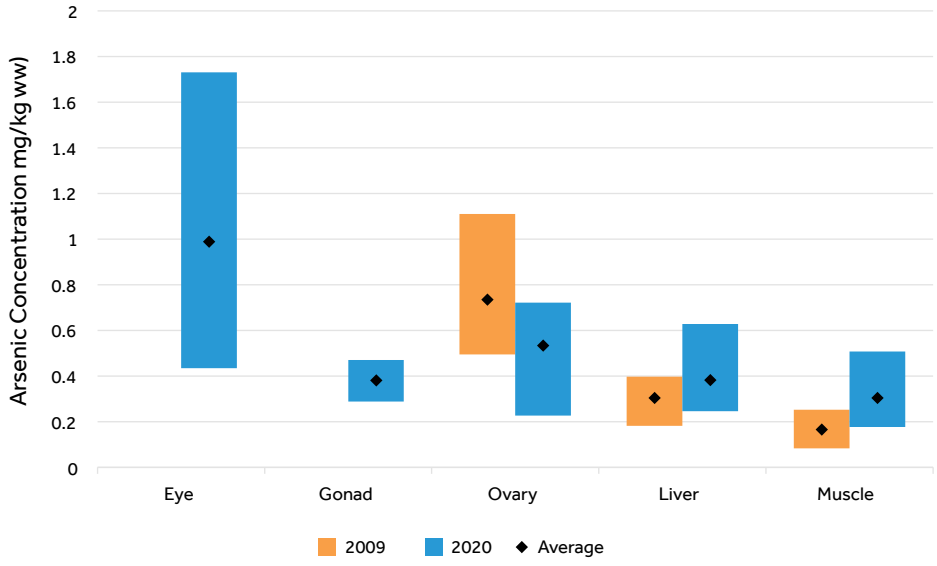
6.2.3.2 Updates to Fish Tissue Chemistry

Arctic Grayling in Baker Creek

As noted in Section 6.1.2.2, an investigation into Arctic Grayling in Baker Creek was completed in June 2020. Eight adult Arctic Grayling were captured in reaches of Baker Creek on site. The Arctic Grayling ranged in size from 397 to 451 mm and 706 to 1,127 g. Arctic Grayling body condition was in good shape. The average age of Arctic Grayling from Baker Creek was six years.

The total arsenic concentrations were analyzed in the ovary, liver, and muscle tissues of these fish and compared to the concentrations from fish captured in 2009 (Closure and Reclamation Plan Chapter 2[57]) (Figure 21). In 2020, arsenic concentrations were generally lower in the ovary tissue but tended to be higher in liver and muscle. Overall, tissues with the highest arsenic concentrations were eyes, followed by ovary tissue, with the lowest concentrations in liver and muscle.

A Human Health Risk Assessment update was completed in 2021 based on the Arctic Grayling captured on site in 2020. The assessment considered a person eating 10 or 27 Arctic Grayling a year from Baker Creek under various scenarios. These assumptions are likely to be conservative based on the relatively small numbers of adult fish observed in Baker Creek. The assessment concluded that eating Arctic Grayling from Baker Creek does not represent a health concern to people in Dettah and Ndilǫ[58].



Note: 2009 data are from fish from Reach 1. 2020 data are from fish from Reaches 3, 4, and 5
mg/kg ww = milligrams per kilogram wet weight.

FIGURE 21: Arsenic Concentrations in Arctic Grayling from Baker Creek

[57] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada.

[58] CanNorth (Canada North Environmental Services). 2021. Human Health Risk Assessment for Off-Site Legacy Arsenic Contamination from the Giant and Con Mines, Prepared for Government of Northwest Territories, Yellowknife, NT, Canada.

Large-Bodied Fish in Yellowknife Bay

As noted in Section 6.1.2.2, a fish tissue survey was conducted in summer 2021. A total of 83 fish were captured from nine species. Results were reported in the GMRP annual Aquatic Effects Monitoring Program report (Part 1, Part 2, Part 3) to the Mackenzie Valley Land and Water Board in spring 2022[59]. Of the fish captured, 32 were killed and tissue samples were collected.

Some key results from the lethal sampling program are summarized in Table 15 and below:

- The tissue chemistry results are similar to other studies from the region.
- Northern Pike appeared to have greater concentrations of arsenic in larger fish. This relationship has been observed in other studies in the region, and fish size should be considered when comparing arsenic concentrations among populations of Northern Pike.

The results of the non-lethal pilot study in 2021 showed:

- Arsenic concentrations in muscle plugs were similar to whole muscle (fillet) samples collected. As such, sampling of muscle plugs is an acceptable method to use when testing for arsenic in large-bodied fish and is preferable because it does not kill the fish. Arsenic was detectable in scales and fins. However, no relationship was found between the amount of arsenic found in a scale or fin and in the muscle. This is because the laboratory cannot yet detect arsenic at low levels in scales and fins. Until the laboratory can improve its methods, scale and fin sampling is not an acceptable method to sample for arsenic in large-bodied fish.
- These results can be used to improve future monitoring programs.

6.2.4 Summary

To date, six biological monitoring studies have been completed in Baker Creek under the GMRP Environmental Effects Monitoring Program. An abundance of fish exists in the creek downstream of the site. Based on risk assessments, it was concluded that eating fish from Baker Creek and Yellowknife Bay did not represent a health concern. There is a benthic community that provides a variety of food for both young and adult fish. Results of the monitoring confirm that the creek has shown signs of recovery since the 1970s when the aquatic ecosystem of Baker Creek was severely damaged. While this is a positive development, Baker Creek remains contaminated with arsenic from previous mining activities, which have contributed to effects seen in both fish populations and benthic invertebrate communities.

Table 15: Key Results for Large-Bodied Fish

FISH SPECIES	LENGTH RANGE (MM)	WEIGHT RANGE (G)	AGE (YEARS)	MEAN ARSENIC CONCENTRATION (MG/KG WW)	
				YELLOWKNIFE BAY	BACK BAY
Lake Whitefish	330 to 524	489 to 2,255	5 to 18	0.160	0.100
Northern Pike	493 to 867	520 to 4,700	3 to 9	0.146	0.243

mm = millimetre; g = gram; mg/kg ww = milligrams per kilogram wet weight.

[59] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Aquatic Effects Monitoring Program 2021 Annual Report. May 2022.

6.3 FISH STATUS OF ENVIRONMENT INDICATOR

The status of fish and fish food (benthic invertebrates) in Baker Creek was rated as "yellow." This is because fish are recovering in Baker Creek since mining stopped, overall they appear healthy, and eating the fish does not present a health concern. However, fish size in Baker Creek was different from that in the reference area. Benthic invertebrates were present in the creek, but populations were not as diverse as in reference areas. Continued fish and benthic invertebrate monitoring will be completed under the Aquatic Effects Monitoring Program for the Giant Mine site.

The current rating (Table 16) is expected to improve as remediation progresses. Specifically, remediating creek sediments and the end of treated effluent discharge to Baker Creek is expected to improve conditions for these indicators.

Table 16: Fish Status of Environment Indicator

COMPONENT	INDICATOR	EVIDENCE	STATUS FOR 2015–2021
Fish	Fish food in Baker Creek	Benthic invertebrates (fish food) were present, and creek had similar amounts but not all the species as reference area.	
	Fish in Baker Creek	Numerous fish species were present, but fish sizes were not the same as in reference area; eating fish from creek did not pose a risk to humans.	

7.0

Land

The GMRP could affect land in the reporting period and over the next 15 years. This is due to historical mining contamination on the land, care and maintenance of Tailings Containment Areas and open pits, site stabilization activities, and upcoming remediation.

OVERVIEW OF CHAPTER

While mining is a temporary use of the land, the changes mining activities make to the landscape can be permanent. Prior to mining activity, the land on which the Giant Mine site is now found was a valuable area for hunting, trapping, and collecting plants for food and medicine. Archaeological and Traditional Knowledge studies have helped to document the historical use of the land around the site. An update on archaeology assessments completed by the GMRP is provided to capture and communicate the cultural significance of the land on site. As discussed in Chapter 2, as a result of the historical mining activities, the land on site has contaminated soils, extensive underground mine workings that contain arsenic trioxide stopes/chambers, and open pits on surface, as well as large Tailings Containment Areas (and associated dams) storing mine waste and contaminated water.

A variety of considerations make up a discussion of land at the site, ranging from the assessing the presence of archaeological sites, to identifying the make-up of soils and sediment, to monitoring underground and pit stability, to performing maintenance on the Tailings Containment Areas. Because of this, Chapter 7 is not organized into "Monitoring" and "Key Results" sections like the previous chapters. Instead, the chapter is organized by area of consideration, and activities carried out during the reporting period are summarized within each of these sections.

7.1 ARCHAEOLOGY

Background

Archaeological sites are important for the understanding of the cultural history of the Northwest Territories and are valued by community members. As a result, they are protected by legislation and regulations. In the Northwest Territories, archaeological sites are defined as any physical evidence of human activity that is more than 50 years old and has been abandoned. This can range from Indigenous campsites that are thousands of years old to more recent prospecting camps from the early 1900s. Archaeological sites that have been identified at the site include such things as stone features (e.g., tent ring, hearth, cache), artifacts (e.g., worked stone, bone, or wood tools; historical glass, ceramics, or metal), and building/structure remains (e.g., log cabin, cellar depression).

Archaeologists and members of the Yellowknives Dene First Nation completed the first archaeological field visit to the site conducted specifically as part of the GMRP in 2012[60]. The goal of the field visit was to identify potential heritage sensitive areas as part of a Heritage Overview Assessment. Prior to the GMRP, limited archaeological studies had been completed in the 1940s and 1960s[61, 62].

[60] De Guzman M. Ball BF, Jankuta K. 2013. Heritage Overview Assessment Giant Mine Remediation Project: Northwest Territories Class 2 Archaeologists Permit # 2012-017. Report on file Prince of Wales Northern Heritage Centre, Yellowknife, NT.

[61] MacNeish R. 1951. An Archaeological Reconnaissance in the Northwest Territories. Annual Report for 1949-50. National Museum of Canada Bulletin 123:24-41. Ottawa, ON

[62] Noble WC. 1966 1969. Archaeological Sites in the Northwest Territories. Compiled Fieldnotes. Manuscript No. 615. on file Prince of Wales Northern Heritage Centre, Yellowknife, NT.

In 2018, an Archaeological Impact Assessment was completed for the GMRP[63]. The objective of this assessment was to evaluate previously documented archaeological and traditional use sites and to assess specific planned disturbance areas (e.g., borrow pits). The data were used to develop avoidance or mitigation measures where needed to assist with future remediation planning. A second supplemental Archaeological Impact Assessment was completed in 2021[64]. This second Archaeological Impact Assessment focused on areas of high archaeological potential that had not been previously assessed, as well as areas of the shoreline requested by members of the Yellowknives Dene First Nation. Both the 2018 and 2021 assessments involved members of Yellowknives Dene First Nation and the North Slave Métis Alliance who provided valuable insights and interpretations.

What were the results of the 2018 to 2021 work?

The results of the Archaeological Impact Assessments confirmed that much of the Giant Mine site was disturbed by activities related to historical mining and exploration. However, despite the previous disturbance, several areas within the site were identified to potentially contain undisturbed archaeological sites (i.e., high archaeological potential). These areas were explored by walking along landforms and visually examining the ground for evidence of features or artifacts and through shovel testing to search for buried sites. A total of 12 archaeological sites were ultimately revisited (having been previously identified) or were newly identified within the site boundary. This included six precontact (prior to European arrival) and six historical (after European arrival) sites.

Precontact sites: Four of the precontact sites are located adjacent to Baker Creek. They consist of lithic scatters containing small amounts of stone flaking debris and tools or tool fragments such as projectile points, scrapers, or knives (Photo 18). An arrowhead from one site was considered to date from approximately 1,300 to 200 years ago and belong to ancestral Dene.

The remaining two precontact sites were campsites found farther inland. One contained a single tent ring (a circle of anchor rocks used to hold down the edges of a hide tent), while the other was a large campsite/lookout containing multiple features including tent rings and linear stone features thought to be used as canoe rests (Photo 19). These precontact sites are consistent with Traditional Knowledge and oral histories collected by Yellowknives Dene, who identify Yellowknife Bay as a focal point for current members and their ancestors[65].

PHOTO 18: Fragment of Stone Knife from Baker Creek Area

PHOTO 19: Tent Ring at Giant Mine Site Observed during Archaeological Survey

[63] Golder (Golder Associates Ltd.). 2019. Giant Mine Remediation Project: 2018 Archaeological Impact Assessment. Permit No. 2018 002. Report on file with Prince of Wales Northern Heritage Centre, Yellowknife, NT.

[64] Golder (Golder Associates Ltd.). 2022. Giant Mine Remediation Project: 2021 Archaeological Impact Assessment. Permit No. 2021 002. Report on file with Prince of Wales Northern Heritage Centre, Yellowknife, NT.

[65] YKDFN (YKDFN Elders Advisory Council) and Trailmark Systems. 2019. Yellowknives Dene First Nation Knowledge and History of the Giant Mine: Concerns, Recommendations and Closure.

Historical sites: The documented historical sites relate to early mineral exploration and development activities. Evidence of 20th century mineral exploration was noted as surface debris throughout the property in the form of old claim stakes/cairns, drill boxes and core samples, drill holes and drill rods, blast pits, and various other refuse associated with these activities. Six sites with substantive features were documented as archaeological sites. These included the dilapidated remains of three exploration camps along the shore of Yellowknife Bay that date to the 1940s. Two of them were identified as the Atlas and Mate camps. Features consisted of log foundations for canvas tents, core racks, garbage middens containing tin cans and glass bottles (Photo 20), and pit depressions. The other sites included the remains of an exploration work shelter, a tin can refuse and wood debris dump feature likely related to former town housing, and a dilapidated wood structure known as the Brock Ore Bin (Photo 21). The latter structure was originally built in 1939 to stockpile and load ore mined from shafts for transport off site.

PHOTO 20: Can and Bottle Midden

PHOTO 21: Brock Ore Bin

How are the archaeological sites protected for remediation?

The combined archaeological assessments completed at the site were successful in identifying sites related to both Indigenous and Euro-Canadian history. These results were summarized in permit reports and submitted to the Government of the Northwest Territories Department of Education, Culture and Employment. Results were also presented to the GMRP Working Group, and to North Slave Métis Alliance members and Yellowknives Dene First Nation members. The documented sites were mapped, photographed, tested, and evaluated. Artifacts were collected and catalogued for submission to the Prince of Wales Northern Heritage Centre.

All of the archaeological sites will either be protected or mitigated, or they no longer exist. Out of the 12 identified in the reports, the GMRP has committed to avoiding two of the archaeological sites, as requested by the Government of the Northwest Territories and Yellowknives Dene First Nation. Two other archaeological sites fall outside the current area of remediation, and further discussions would take place if those plans change. All other archaeological sites either no longer exist (i.e., were archaeological sites identified during mine operations and were disturbed during previous mining activities) or have been sufficiently mitigated (i.e., documented and artifacts submitted to the Government of the Northwest Territories). Sites must follow their land use permit conditions and management and monitoring plans should any future potential archaeological areas or artifacts be found during remediation activities. If this occurs on the Giant Mine site, the GMRP Team would work with the Government of the Northwest Territories Department of Education, Culture and Employment and Rights holders on next steps.

7.2 SOIL

Background

Historical mine operations resulted in the widespread contamination of surface soils and sediments. The initial years of roaster operation (1940s to mid 1950s) were with minimal emission control. This operating practice led to the distribution of the roaster emissions throughout a 25 kilometre radius. Mineralized mine rock, tailings, and buried waste were placed throughout the site, with the distribution of these materials increasing as mine development progressed throughout the 1970s and 1980s.

Environmental management practices gradually evolved with the improvement of tailings containment through the 1960s and 1970s and reduction in roaster stack emissions from the 1950s and 1960s onwards. However, the environmental impairment resulting from the early years of mine operation to regional soil and sediment quality is present today.

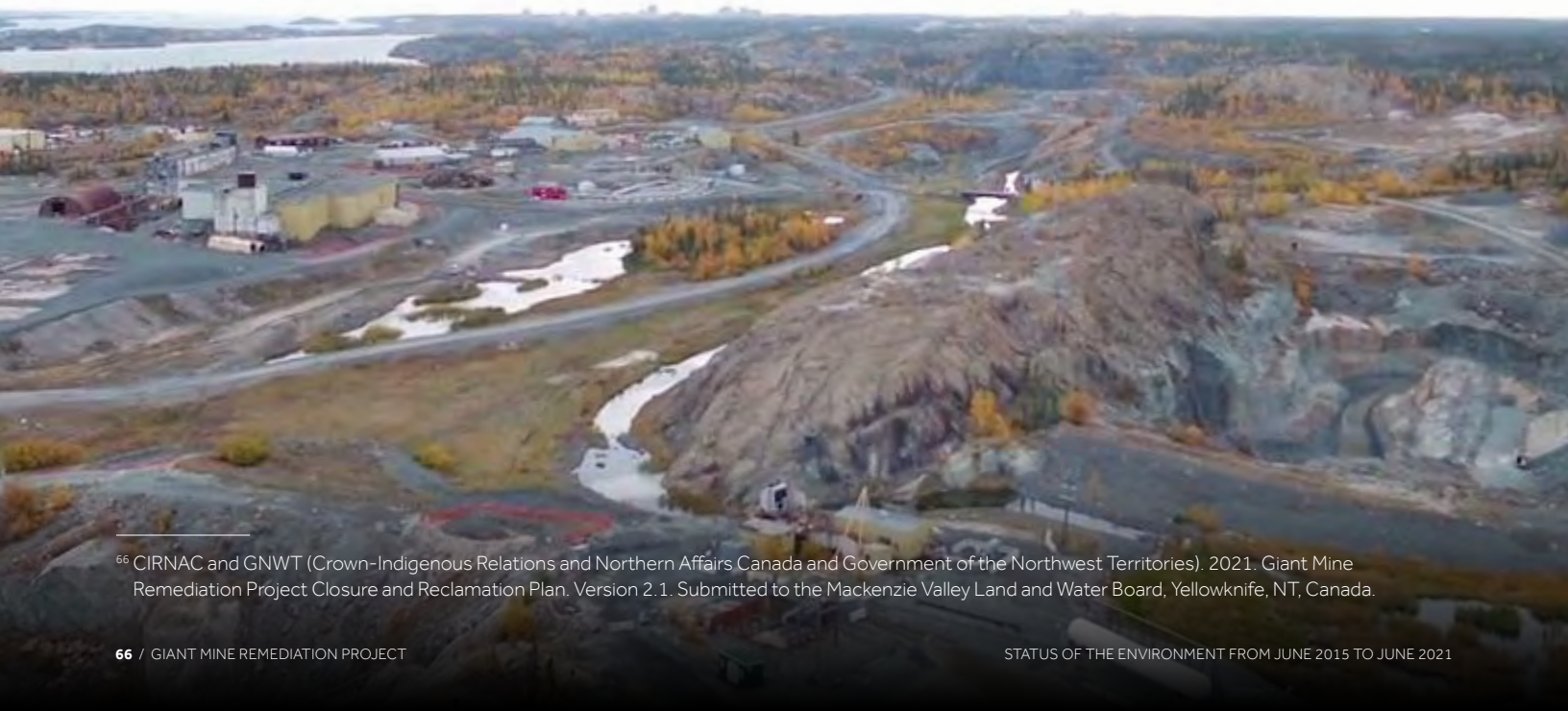
How were soil and sediment conditions on site characterized?

Early environmental investigations of soil and sediment quality were initiated in the 1990s, by 2021, multiple investigations were completed and over 2,000 samples collected (see Figure 22 for sampling locations). These data are used to identify (characterize) the conditions on site. Most of this information was summarized in the Closure and Reclamation Plan[66].

The early stages of soil and sediment quality investigations involved soil characterization and collection of soil/sediment samples for chemical analysis; sometimes samples were collected by hand tools and sometimes by digging deeper with an excavator (Photos 22 and 23). Field data collection was supported by interpretation of historical reports and aerial photographs. As the field programs advanced, specialized forensic laboratory techniques were used to confirm the sources of soil quality impacts (e.g., from the roaster or from a tailings spill).

PHOTO 22: Soil Sampling on Site Using Hand Tools

PHOTO 23: Soil Sampling on Site Using Heavy Equipment



[66] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada.

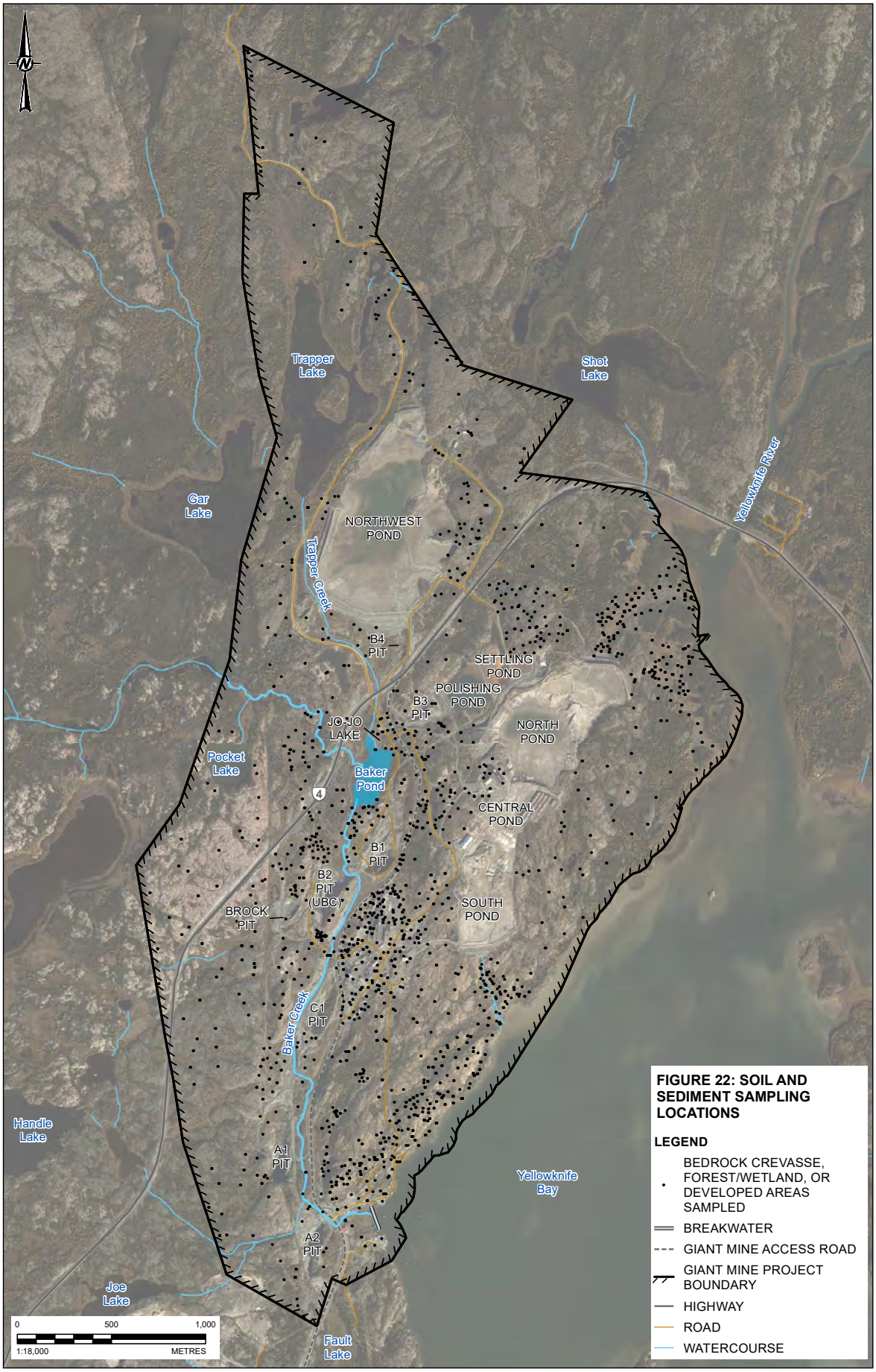


Figure 22: Soil and Sediment Sampling Locations

What are the results of the soil and sediment sampling?

Based on these investigations, the primary contaminant of concern in soil and sediment is arsenic. In some areas, there are also concerns with elevated concentrations of petroleum hydrocarbons in soil. Elevated concentrations of other metals (i.e., antimony, copper, lead, and zinc) are also present; however, these metals typically occur with elevated arsenic concentrations.

Was any new information about soils or sediment found in the investigations?

Sediment was sampled throughout Baker Creek in a large-scale investigation in 2011 and in Yellowknife Bay in 2013 and 2015; this was reported in the environmental assessment and Chapter 2 of the Closure and Reclamation Plan (Closure and Reclamation Plan Chapter 2, Appendix 2B[67]). Those investigations showed that sediment in Baker Creek and Yellowknife Bay near site was contaminated and had elevated concentrations of arsenic and other metals. Some areas of the creek had sediment that was toxic to aquatic life based on laboratory tests. Concentrations were higher in deeper layers of sediment.

Since that time, sediment was monitored in Baker Creek as part of the biological monitoring in 2019 (see Chapter 6 for more information on biological monitoring). Arsenic and other metals were elevated above guidelines for aquatic life and were higher than concentrations in reference areas. Yellowknife Bay sediment near the site was monitored in a special study from 2018 to 2021 (Part 1, Part 2, Part 3)[68]; Section 5.2.3 provides more information about this study. Arsenic, chromium, copper, lead, and zinc were above guidelines for aquatic life. This monitoring did not provide new information but confirmed the results of past investigations.

Did you know?

We can measure arsenic in soil right on site with a handheld machine called an XRF Metal Analyzer (see photo). Instruments like this provide fast results to minimize delays in the field and risk of over-excavation of an area.

In the 2018 to 2020 soil sampling programs, two additional soil-related concerns were investigated:

1. In an area of contaminated soil ("Area 4" near the North Pond), buried waste was found during a field survey. Waste materials (soil, wood, metal, and debris) contained elevated arsenic concentrations. These materials will be excavated and placed in the frozen zone of B1 Pit.
2. A large survey of the area downgradient of Dam 3 of the North Pond showed the spread of soil contamination was slightly wider than estimated in the Closure and Reclamation Plan. A historical tailings release occurred here consisting of both tailings and contaminated water; contaminated water was also released more than once during mining. To address this contamination, tailings in this area will be excavated and put back in a Tailings Containment Area. Areas where there was contaminated water were documented and found to have higher concentrations of arsenic in soil, sediment, and water than in undisturbed areas on site, but the concentrations were much lower than in the tailings release area. The areas where the water was released are heavily treed and have wetlands and forest and will be left in place. More information on this area will be available publicly as part of the Reclamation Research Plan results in the Contaminated Soils Design Plan.

[67] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2019. Giant Mine Remediation Project Closure and Reclamation Plan. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada.

[68] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Aquatic Effects Monitoring Program 2020 Annual Report. July 2021.

Where are these contaminants?

Based on these investigations, contaminated soil and sediment was grouped into three categories around the site: Developed Areas, Bedrock/Forest/Wetland Terrain, and Baker Creek (Table 17). Each of these areas has different types of soil/sediment with different concentrations of arsenic contamination.

A soil quality terrain model was developed to analyze soil samples collectively. This model was used to make a map that shows the distribution of arsenic contamination in soil (to approximately 0.5 metres deep) (Figure 23). Digital terrain mapping tools were used with soil quality data to show total arsenic concentrations in soil by colour gradation. This map shows that areas on the site are contaminated and are above the approved closure plan standard, which is the current Government of the Northwest Territories industrial arsenic soil criterion of 340 milligrams per kilogram[69]. As part of the site closure, approximately 1.5 million cubic metres of contaminated soil and sediment will be removed from the developed areas, Baker Creek, and a portion of the bedrock, forest, and wetland terrain. A fence will also be installed surrounding core area of the site including the mill area to restrict access to shallow soil within bedrock, forest, and wetland terrain with the highest recorded arsenic concentrations.

As noted above, sediment in Baker Creek and sediment along the shoreline of Yellowknife Bay shows elevated levels of arsenic and other metals when compared to reference areas. The creek sediment is very different along the length of the creek. In some areas, sediment deposits in the creek have very high concentrations of metals. In other areas where sediment is washed away by fast-flowing water, there are lower concentrations of metals. In general, the closure plan is to remove the contaminated sediments in Baker Creek and cover the sediments along the nearshore in Yellowknife Bay.

Table 17: Types of Areas on Site with Contaminated Soil and Sediment

DEVELOPED AREAS	• Includes Mill area, mine buildings, Townsite, roads, and other areas the miners developed. • Mostly sand and rock gravel contaminated with arsenic, hydrocarbons, and tailings.	
BEDROCK, FOREST, WETLAND TERRAIN	• Land around the site that has rock outcrops, forest, and wetlands. Includes parts of the Core Industrial Area, downgradient of Dam 3, and Shoreline Lands. • Fine-grained soil contaminated with arsenic and metals from the roaster emissions as well as tailings and tailings pond-water.	 
BAKER CREEK	• Baker Creek through the site including Baker Pond and the former Jo-Jo Lake (now called Jo-Jo tailings area). • Areas of soft sediment contaminated by metals from untreated mine water releases, spills, and roaster emissions.	 

[69] GNWT ENR (Government of the Northwest Territories – Environment and Natural Resources). 2003. Environmental Guideline for Contaminated Site Remediation. November 2003.

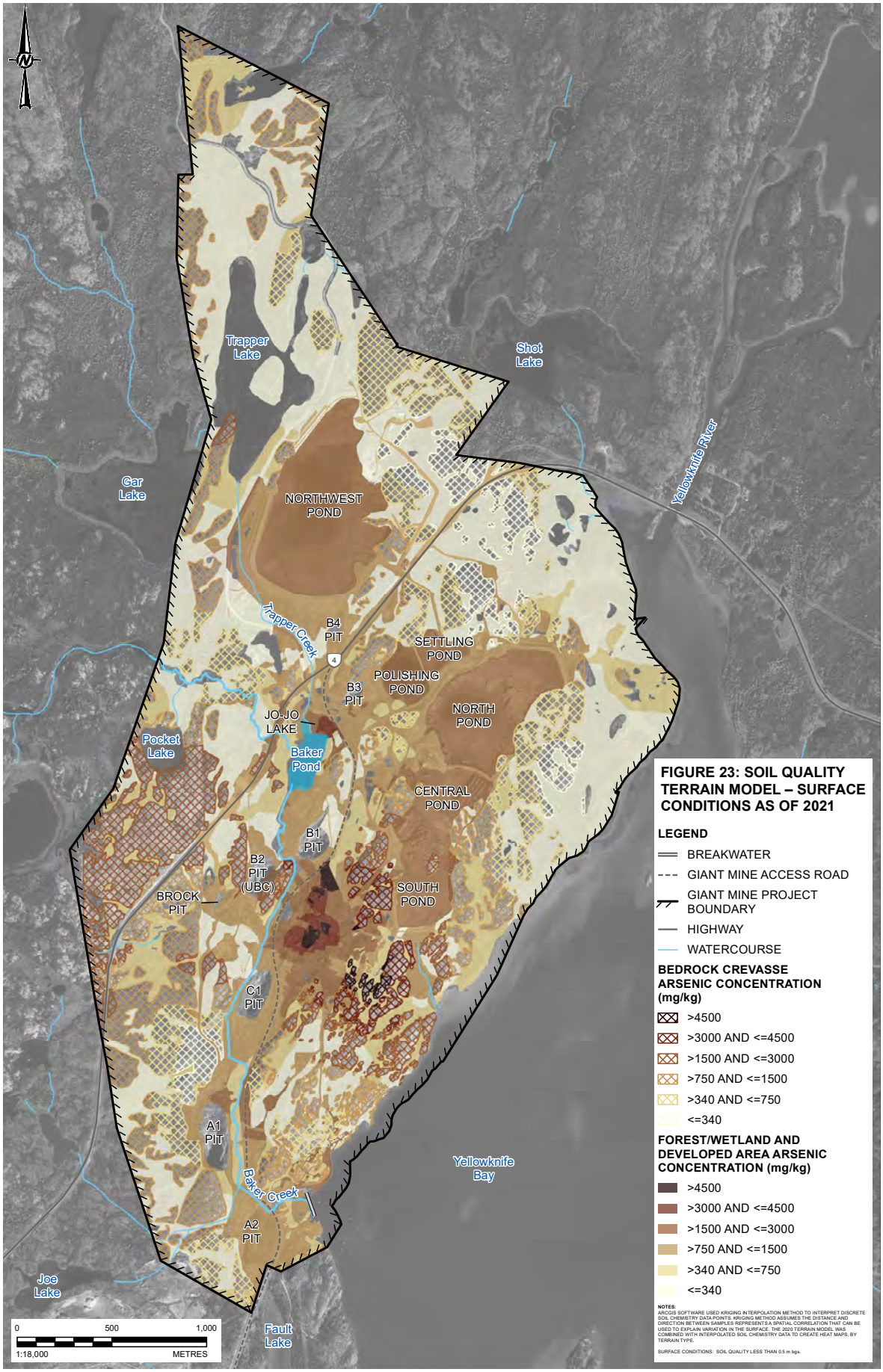


FIGURE 23: Soil Quality Terrain Model – Surface Conditions as of 2021

7.3 UNDERGROUND

Background

The underground mine at the site is approximately 5 kilometres long (Figure 24) and 0.5 kilometres wide, on average. There are hundreds of open tunnels and some openings called "mining voids" (Photo 24). There are 62 "near-surface voids," which means they are generally less than 35 metres below ground surface. Fifteen of these are arsenic-containing stopes and chambers (used for storage of arsenic trioxide dust) and 47 are non-arsenic stopes (previously mined and empty or partially filled with granular fill) (see Figure 25 for general concept of underground mine).

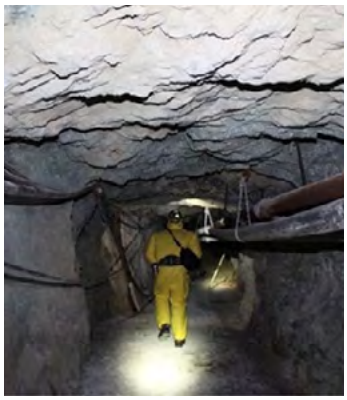


PHOTO 24: Example of Opening in the Underground at the Giant Mine

Near-surface voids are important to understand because if the overlying rock mass, called a crown pillar, were to collapse, it could result in settlement on surface which could pose a risk to people and wildlife as well as potentially damage structures or impact Baker Creek. Some of the non-arsenic voids are also underneath the arsenic stopes and chambers, and the collapse of the rock between them, known as a sill pillar, could result in the release of arsenic trioxide dust.

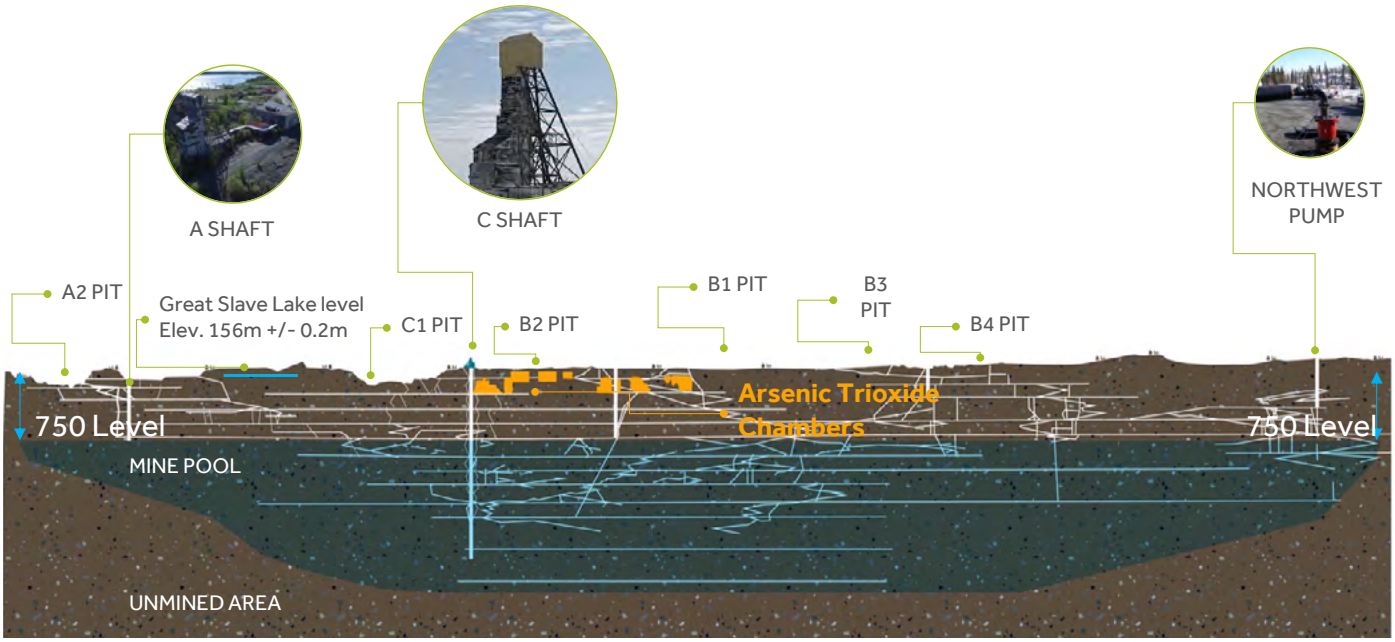


Figure 24: Section View of Underground Looking West

Lightly cemented tailings backfill is put underground into potentially unstable voids to make them more stable (see concept in Figure 25). The backfill stabilizes voids by providing support to the overlying rock mass.

The backfill also reduces the impact of a failure; a failure would be unlikely to reach surface or overlying areas such as buildings or arsenic storage areas.

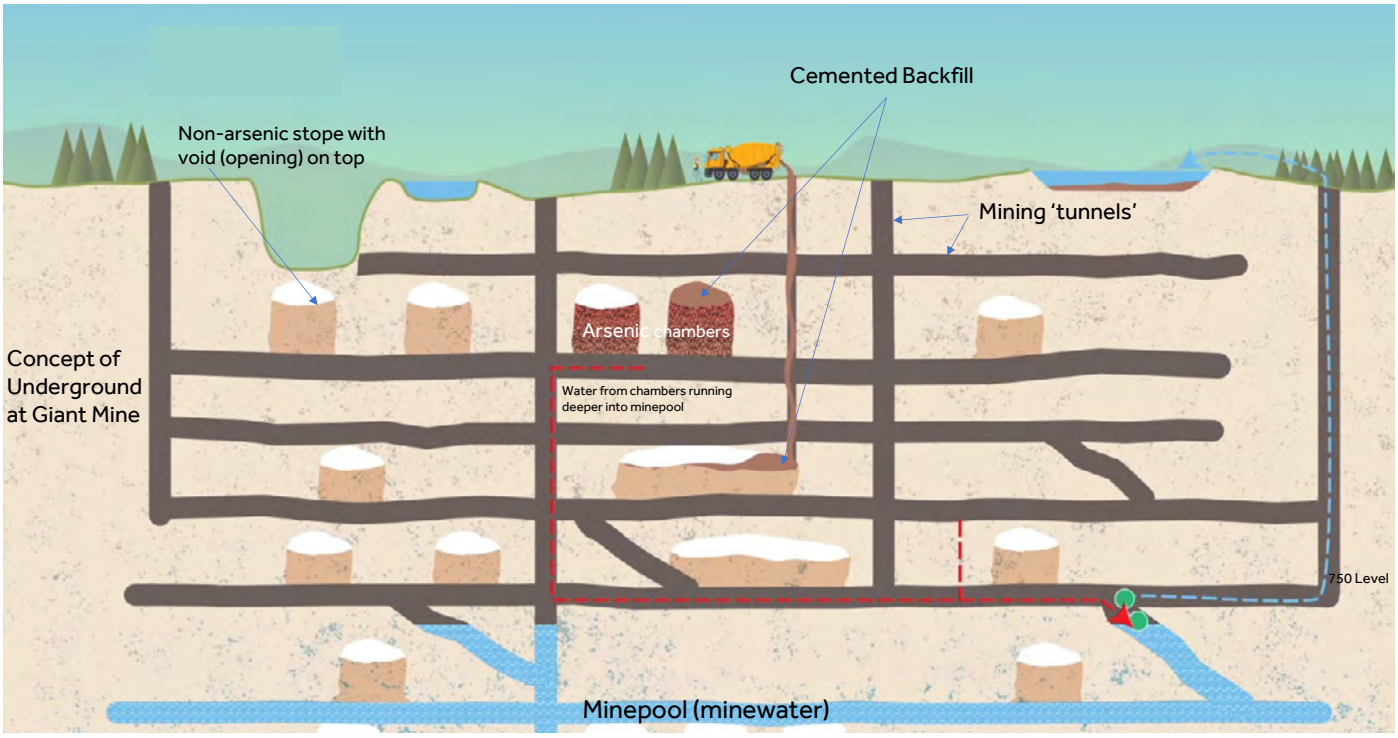


FIGURE 25: Schematic Example: Underground at the Giant Mine Site

What was done from 2013 to 2021?

In 2013, underground stabilization began in non-arsenic stopes (B1-18, B3-06, B3-10, and A-370) and two arsenic stopes (B-208 and B2-12/B2-13/B2-14). More underground stabilization activities continued in 2015 and ended in 2018. The work focused on backfilling voids that were identified as being potentially unstable in the short term. In total, between 2015 and 2018, 128,747 cubic metres of lightly cemented tailings backfill was placed in addition to 10,667 cubic metres that was placed in 2013, for a total of 139,414 cubic metres of lightly cemented tailings backfill placed to date. As a result of these efforts, seven non-arsenic stopes and four arsenic stopes have been stabilized. Stopes stabilized so far were either arsenic stopes with relatively thin crown pillars, stopes under Baker Creek with relatively thin crown pillars, or stopes with relatively thin sill pillars under or adjacent to arsenic stopes and chambers.

The primary work in 2015 to 2018 focused on a series of connected non-arsenic stopes called Stope Complex C509 (Photo 25). Stope Complex C509 was critical to backfill as it is underneath the C2-12 arsenic storage chamber and has experienced past backfill instability. The backfill in Stope Complex C509 was unique in that there was a layer of self-consolidating concrete which was designed to form a plug at the base of the stope before the remainder of the stope was backfilled with tailings paste. The plug will protect the stope if any of the underlying backfill settles again as it has in the past. The plug will hold up the rest of the backfill and the rock above it until the GMRP has time to place more backfill and further stabilize the void.

PHOTO 25: Filling Stope Complex C509 with Cement/Tailings Backfill in 2018

Did you know?

Contractors working on the Site Stabilization Program won awards!!

1. Award of Excellence for engineering design of the underground paste backfill from the Canadian Consulting Engineers (2015)
2. Slag Cement Project of the Year Award in the category of Innovative Applications from the Slag Cement Association (2019)

The backfill placed to date during the Site Stabilization Program has been made of a combination of Giant Mine tailings, water, and cement binder (Photo 26). Because the backfill is made of a lightly cemented sand (or tailings) it is considered resistant to weathering from water infiltration, does not require maintenance, and is expected to continue to function for the next hundred years or more. Backfilling voids with tailings also has the advantage of reducing the amount of tailings that remain on surface for relocating or covering during closure.

PHOTO 26: Trucks at the Giant Mine Site Cement Silo for the Underground Stabilization Program

How was the stability of underground backfill monitored?

Monitoring and inspection of the underground backfill was done by:

- Visual checks with cameras and inspection to confirm backfill did not settle, which could create open voids.
- Use of equipment (vibrating wire extensometers) to document if instability occurs: Equipment is cemented in place in the ground, and measures changes in the distance between its two ends. This is used to measure displacement and detect instability.

Data collected to date have indicated good performance with no stability concerns. The C509 backfill plug was a unique approach to remediation at the site and was further evaluated in 2021. The evaluation consisted of drilling through the backfill to collect samples. These samples were used to confirm that the concrete was strong enough to match the design requirements. Sample strength exceeded design requirements in all cases. The sampling drill holes were left open and will be used in the future for camera surveys to confirm the condition of the plug and supplement extensometer data to check for signs of settlement or other displacement indicating instability.

What is the status of the underground?

All monitoring related to underground is reviewed quarterly and annually. For the reporting period, monitoring indicated acceptable performance of backfill and that these voids were stable. The underground requires further remediation in the future. The Closure and Reclamation Plan[70] provides more information on how the underground will be remediated, including a comprehensive backfill program. Details on each void/stope to be stabilized is found in the Underground Design Plan[71]. The lessons learned (Chapter 10) from the past programs will be used for the final remediation.

7.4 PIT SAFETY

Background

Eight open pits were mined at Giant Mine (Figure 26); one of these was used as a quarry (Brock Pit). The open pits are a visible feature on the land (see example in Photo 27). The pits contain contaminated material in the base as well as openings to the underground, both from historical mining. Some of the openings are still open and access to the underground is possible; others are backfilled but there are voids in the underground beneath these. Access to A1, A2, and B1 pits is restricted with fencing, signage, and berms (small embankments that stop loose rock that has fallen from walls from rolling and injuring workers).

These pits pose risks on site, including:

- steep slopes where people or animals might fall into the pit
- pathway for surface water to flood into the underground mine; flooding could result in an increased minewater level, and in an extreme case, a risk of spilling untreated minewater into the environment
- instability of the underground

PHOTO 27: B1 Pit

[70] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada.

[71] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2022. Giant Mine Remediation Project Underground Design Plan. Version 1.3. March 2022.

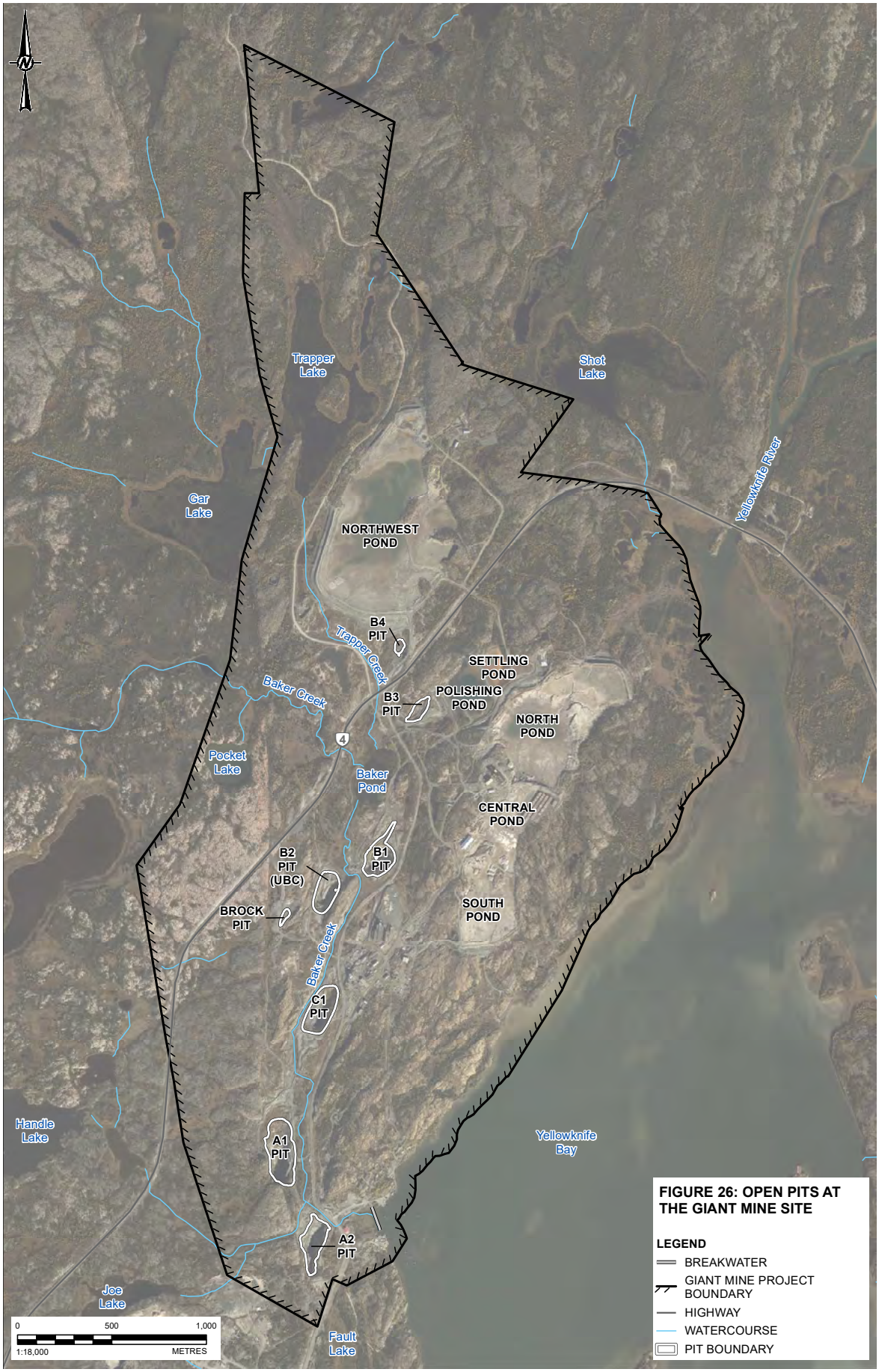


FIGURE 26: Open Pits at the Giant Mine Site

What was done in 2015 to 2021?

1. Work was done to stabilize stopes underneath B1 Pit as part of the Site Stabilization Program described for the underground in Section 7.3. While this work was done underground, it helped stabilize the walls and base of B1 Pit on surface. Work began in 2013 and was completed in 2015.
2. In 2012, geotechnical investigation drilling on the west wall of C1 Pit (Photos 28a and b) identified a potentially unstable area that, if left as is, could potentially allow water from Baker Creek to enter the underground by way of the pit. From 2014 to 2015, a rehabilitation program to stabilize this west wall of the pit to prevent such a failure was designed and implemented. Stabilization was completed by placing compacted rock fill materials (a buttress) along the side of the pit. In the short term, the buttress provides security to keep Baker Creek out of the underground, while in the longer remediation project, the buttress will effectively become part of the backfill placed in C1 Pit as part of the Closure and Reclamation Plan (Chapters 1-4, 5.0-5.4, 5.5, 5.6, 5.7-7.0).

PHOTO 28A AND B: C1 Pit Area and Buttress

How were the pits monitored?

Monitoring of pits was done by the following methods:

- The pits were reviewed for safe access/conditions for workers when access is needed.
- Portals were inspected daily by site staff to confirm no unauthorized access into the underground has occurred.
- Routine monitoring for stability was carried out at two pits:
  - This includes monitoring of the stability of the B1 Pit walls, which has been conducted since 2013, and of the C1 buttress, which has been conducted since 2018.
  - Monitoring is done using a reflector (called a prism) that is installed on a metal rod positioned at key locations where a tension crack or other signs of instability have been identified (Photo 29). These fixed locations are then surveyed two times per year to determine if there have been any changes in location from the previous measurements. By measuring the location of the prisms, it is possible to track and assess movements within millimetres of change. Frequency of sampling would be increased if results showed movement of the prisms.

What were the results of pit stability monitoring?

General pit inspections: Overall, the pits were stable from 2015 to 2021. If local instabilities were found that could pose a hazard to workers, they were dealt with by scaling (removal of loose rock from pit walls) or installation of berms. Documentation of pit inspections was not always available.

B1 Pit: The prisms along the east wall of B1 Pit have shown a very slow movement of the soils that are on top of bedrock. These have moved towards the pit, with a total movement since they were installed of approximately 625 millimetres over nine years. This is approximately 70 millimetres per year. Prisms located on the north wall have generally been more stable, indicating a total movement towards the pit of approximately 150 millimetres over the nine-year period, with the exception of one isolated prism which has moved 900 millimetres in the nine-year period. Prisms on the south and west walls have been stable, with less than 100 millimetres of movement over the nine-year period (Photo 30).

C1 buttress: For the 2015 to 2021 period, the C1 buttress has remained stable, with the prisms showing approximately 60 millimetres of movement during the three years since installation.

Results from the monitoring information are used to provide guidance about how to safely access B1 Pit and the C1 buttress area. Although access is only required for specific activities, by monitoring these areas on an ongoing basis, the GMRP can provide short-term stability assessments that are important for worker safety.

The Closure and Reclamation Plan (Chapters 1-4, 5.0-5.4, 5.5, 5.6, 5.7-7.0) provides more information on the open pits and how they will be remediated.

PHOTO 29: Pit Slope Movement Monitoring Location

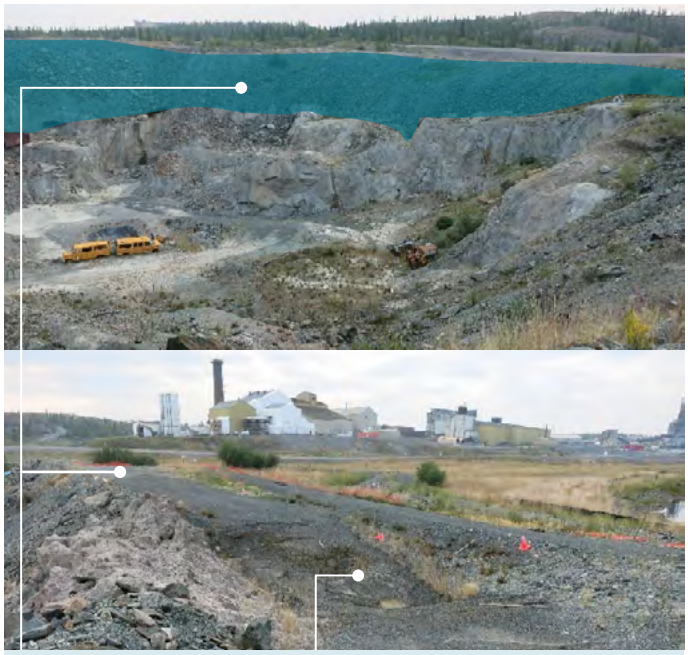


PHOTO 30: Pit Slope Movement Monitoring Location

7.5 TAILINGS CONTAINMENT AREAS

Background

Tailings are small rock particles left over after grinding rock to remove the gold from the ore. They contain arsenic, other metals, and silica. Tailings were initially deposited into Yellowknife Bay in 1948. Beginning in 1951, tailings were deposited into what became the Tailings Containment Areas. This started with tailings deposition into lakes and low elevation areas. Over time, storage requirements necessitated the construction of dams in these areas (a total of 16 discrete dams by end of mining operations). Tailings on site are now retained by a combination of rockfill dams (see Photo 31) and higher areas of surrounding topography.

There are two main Tailings Containment Areas on the site: the Original Tailings Containment Area, which consists of the North, Central, and South ponds, and the Northwest Tailings Containment Area, which consists of the Northwest Pond (Figure 27). In addition to storing tailings, these facilities are also used as part of water management on the site, providing temporary water storage; the Settling Pond and Polishing Pond for effluent management are also part of the Original Tailings Containment Area. Some tailings were released to Yellowknife Bay and form an area called the Foreshore Tailings Area. The locations of the tailings are shown in Figure 27 and summarized in Table 18.

PHOTO 31: Rockfill Dam on Site

Table 18: Summary of Tailings Containment Areas and Foreshore Tailings Area at the Giant Mine Site

NORTHWEST TCA	• Surface area of roughly 44 ha • Estimated to contain 5 million m^3 of tailings • Contains Northwest Pond • Constructed in 1987 • Perimeter dams constructed of rockfill located at the north and south extents • Bedrock outcrops along a portion of the western perimeter and along almost the entire eastern perimeter. • Perimeter dams have maximum vertical heights of between 12 and 15 m.	

ORIGINAL TCA	• Footprint of approximately 5 million m^3 of tailings. Made up of five separate ponds that are divided by dams or dykes:
	  • South Pond (9 ha)
	  • Central Pond (13 ha)
	  • North Pond (29 ha)
	  • Settling Pond (4 ha)
	  • Polishing Pond (5 ha)
	• Has several external dams that vary size but at approximately 10 to 15 m high.
		

FORESHORE TAILINGS AREA	• Prior to the early 1950s, 300,000 and 375,000 tonnes of tailings were deposited in the area, • Approximately 35% of the tailings located above water level in Yellowknife Bay • In 2001, rock cover with geotextile placed over shoreline area to reduce further erosion of tailings into the Bay.	

TCA = Tailings Containment Area; ha = hectare; m3 = cubic metre; m = metre; % = percent.

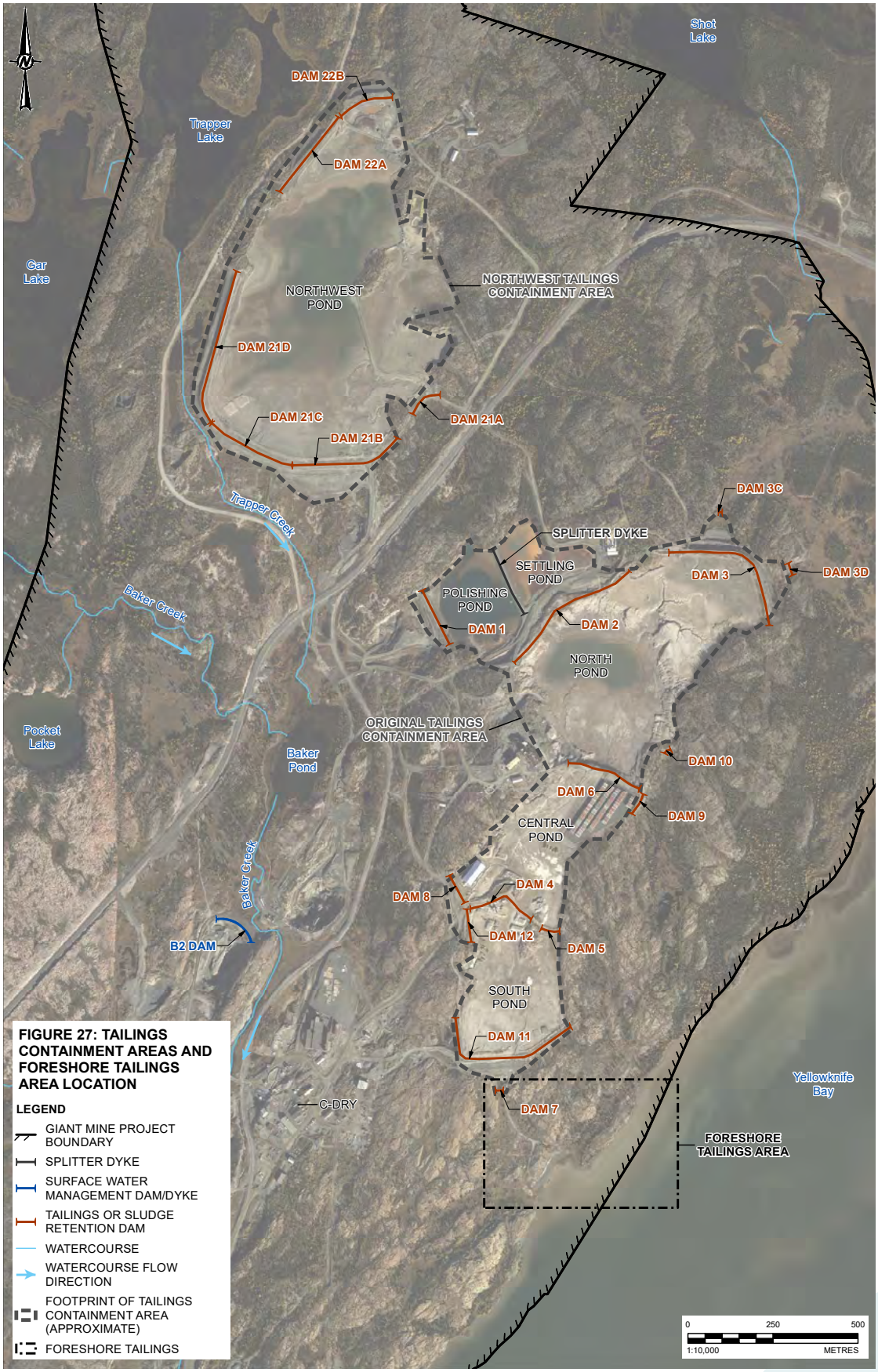


FIGURE 27: Tailings Containment Areas and Foreshore Tailings Area Location

In the past decade, activities at the Tailings Containment Areas have included monitoring, investigation, and maintenance. Each of these is described in more detail below.

What was done on the Tailings Containment Areas and dams from 2015 to 2021?

Investigations

Numerous investigations of the dams and tailings have been carried out in the past years. These investigations were needed to inform evaluations of dam stability and to support development of the remediation activities for the Tailings Containment Areas. These investigations have improved the GMRP Team's understanding of everything from the exact dam sizes to the materials that make up both the dams and the tailings within the facilities.

The understanding of the physical extent of the Tailings Containment Areas, dams, and tailings deposited outside of the Tailings Containment Areas has been refined through a combination of conventional land surveys, surveys of surfaces below the water (bathymetric surveying) in 2019, and the use of specialized airborne survey equipment (LiDAR) in 2018.

Conditions below ground have been investigated through drilling programs, including drilling into dams, tailings, foundation soils, and (through ice cover) tailings deposited in the Foreshore Tailings Area (Photo 32). Thanks to these programs, the GMRP Team now has a better understanding of the materials that make up these areas, and their physical characteristics.

The investigations showed that the material below tailings in the Tailings Containment Areas is mostly peat, clay, and silt, with bedrock as well. The material under the tailings in the Foreshore Tailings Area consists of clay and silt overlying bedrock with some till zones. (Till is a mixture of gravel, sand, and silt and clay particles.) The investigations also showed that throughout the site, tailings consist of clay, silt, and sand particles. Above the water table, the tailings may be firm, but below the water table they can be quite soft. Tailings thickness of up to 19 metres was encountered at the Northwest Tailings Containment Area. Up to 15 metres thick of soft clay was encountered at the Foreshore Tailings Area and Nearshore Sediment Area; sediments below the tailings are also deep. This information will be used in the design of the remediation.

PHOTO 32: A Sonic Drilling Investigation on Ice at the Foreshore Tailings Area, April 2021

The results of dam stability assessment indicated that all dams, except a section of B2 Dam (Figure 27), a surface water dam built to divert Baker Creek water away from B2 Pit, meet the Canadian Dam Association guidelines. A section of B2 Dam that did not satisfy Canadian Dam Association guidelines will require improvement. The remediation design for this section of B2 Dam has been completed; remediation construction is planned for summer 2022.

Dam 1 retains water in the Polishing Pond. Dam 1 meets Canadian Dam Association guidelines; however, settlement of this dam reduced the storage capacity of the Polishing Pond. Rehabilitation of this area was needed (see Chapter 10).

Monitoring

Dams that retain water and tailings require regular monitoring and reporting to confirm that they are performing as required. There are numerous guidelines and requirements that help to define the monitoring required, including guidance documents that are provided by the Canadian Dam Association, as well as requirements that form part of the Water Licence for the site.

In accordance with Canadian Dam Association guidelines, an Operation, Maintenance, and Surveillance Manual has been developed for the site and describes in detail the monitoring of the Tailings Containment Areas that is needed on a daily, weekly, monthly, and yearly basis to confirm that the facilities are operating within expectations. Monitoring includes measurements of water levels within Tailings Containment Areas and observations of any physical changes in the dams (such as the development of cracks or erosion features).

Did you know?

An approved dust suppressant is put on the Tailings Containment Areas to reduce dust into the air on site.

Of particular importance to the monitoring program is the annual dam safety inspection, which is conducted by a qualified professional engineer familiar with the site. As part of this annual inspection, the engineer inspects the dams on site, reviews data collected over the past year, and makes recommendations for any needed actions. The annual dam safety inspection report is provided to both the GMRP and to the Mackenzie Valley Land and Water Board. As part of the report preparation, the Operation, Maintenance, and Surveillance Manual is also reviewed and updated.

The data reviewed by the qualified professional engineer includes the water level data, as well as results from various instruments that have been installed to monitor conditions in the Tailings Containment Areas, including groundwater levels, soil temperatures, and movements of the ground or at the surface that may not be visible to the eye.

The Canadian Dam Association guidelines also require that a dam safety review be conducted by a qualified, independent third party every 5 to 10 years depending on the dam consequence classification. The most recent independent dam safety review was conducted in 2019.

Maintenance

Based on the results of both monitoring and investigation of the dams, maintenance activities have been carried out on the Tailings Containment Areas to keep them functioning as needed until remediation can begin.

Some of these maintenance activities responding to issues raised in annual inspections have been relatively minor, such as grading of dam surfaces, removing excessive vegetation on the dams, and clearing away unwanted materials that accumulate near dams. A more significant maintenance activity was carried out 2015, when an internal division of the Original Tailings Containment Area (called the splitter dyke) was rebuilt with the placement of new granular material. This restored a division between two sections used for water management (the Settling Pond and the Polishing Pond).

Another significant maintenance activity was carried out in 2020 with additional stabilization of Dam 1. Dam 1 is part of the Original Tailings Containment Area, located between the Polishing Pond on upstream side and B3 Pit on downstream side (Figure 27).

While the overall stability of Dam 1 was meeting Canadian Dam Association guidelines, the crest of Dam 1 had been steadily sinking over the years. This was identified and measured through the monitoring program. Back in 2002, the Dam 1 crest had been raised by 1.5 metres to account for settlement, but approximately 1.3 metres of new settlement was measured at the crest of Dam 1 between 2002 and 2020. Without maintenance activities, there was a risk that settlement would continue, affecting how much water could be stored behind the dam. The ongoing settlement also had the potential to eventually damage the dam itself if nothing was done.

Based on the results of an investigation program, it was determined that thawing of ice within the dam core and/or its foundation was the likely cause of the settlement. To stop this settlement, a row of thermosyphons was installed along the crest of the dam to promote freezing of the dam. These are shown in Photo 33. Initial monitoring suggests that the thermosyphons have been successful and have stopped sinking of the dam crest.

PHOTO 33: Thermosyphons Installed along Dam 1 Crest

7.6 LAND STATUS OF ENVIRONMENT INDICATOR

Table 19 shows the status of key indicators of the environment for land from 2015 to 2021. The status reflects the historical impacts on the land, which have not yet been remediated. These ratings are expected to stay the same until the areas are remediated. Remediation activities are needed to improve soil quality and pit safety and to reduce risks to dam stability by draining and covering tailing containment areas; erosion and stability of the foreshore tailings area will be improved by installation of an expanded cover in this area.

The status of land was rated as shown below:

Soil quality: The status of land for soil quality in within and outside the core area and in the Townsite was rated as "red." This is because soil concentrations are well above the approved closure plan standard.

Substrate quality: Substrate at the bottom of Baker Creek on site was rated as "red." This is because most samples, from more than one sampling program, were above the aquatic life guideline for arsenic.

Dam stability: Dam stability was rated as "green/yellow." The annual dam safety inspection showed compliance with the Canadian Dam Association requirements and those dams were overall stable. Maintenance/repairs were required, however, indicating issues were emerging. Repairs were made.

Pit safety: Pit safety was rated as "yellow/red". This is because documentation of inspections was inconsistent, and maintenance and monitoring were required on the pits.

Foreshore Tailings Area: The status of land in the Foreshore Tailings Area was rated as "yellow/red" because while the cover is stable, erosion in the bay continues.

Table 19: Land Status of Environment Indicator

COMPONENT	INDICATOR	EVIDENCE	STATUS 2015-2021
Land (including Infrastructure) 	Soil quality in developed areas	On average, soils had total arsenic more than the approved closure plan standard of 340 mg/kg for the site.	
	Soil quality in bedrock, forest, wetland areas	On average, soils had total arsenic more than the approved closure plan standard of 340 mg/kg for the site.	
	Soil quality in Townsite	On average, soils had total arsenic more than the approved closure plan standard of 160 mg/kg for the Townsite.	
	Substrate quality in Baker Creek	Baker Creek substrates at bottom of creek (sediment) were elevated in metals and were above the aquatic life guideline for total arsenic.	
	Dam stability	The annual dam safety inspection showed compliance with Canada Dam Association requirements. Dams were stable. Maintenance/repairs are completed when required.	
	Pit safety	Pit walls maintenance/monitoring is required; signs/fences/access control are in place, but there was a hazard to human health and wildlife health. The C1 buttress was constructed to limit Baker Creek water entering pit; an informal process is in place to limit access before an activity near/in a pit but not always documented consistently.	
	Foreshore Tailings Area in Yellowknife Bay	The condition of the existing foreshore cover was stable. There were signs of erosion of tailings in the bay past the cover.	

Wildlife

The GMRP could affect wildlife in the reporting period and over the next 15 years. This is due to historical mining contamination on the land, use of buildings and roads where animals and birds might visit, site stabilization activities, and construction activities during upcoming remediation.

BACKGROUND

Elders from the Yellowknives Dene First Nation report that before mining, the Giant Mine area was an abundant source for many species, including moose (Alces alces), caribou (Rangifer tarandus), bear (Ursus sp.), wolf (Canis lupus), wolverine (Gulo gulo), beaver (Castor canadensis), lynx (Lynx canadensis), fox (Vulpes vulpes), coyote (Canis latrans), porcupine (Erethizon dorsatum), otter (Lontra canadensis), muskrat (Ondatra zibethicus), fisher (Pekania pennanti), marten (Martes americana), mink (Neogale vison), and rabbit (Lepus americanus). Rabbits were so plentiful in an area near the Yellowknife River that it became known as "rabbit place." Aside from hunting and trapping, the area on and around the site was preferred for harvesting berries, medicinal plants, and wood[72]. The area was so important that the Yellowknife Dene First Nation discouraged people from settling there to keep it undisturbed for harvesting.

Today, the Giant Mine site is still home to some of these wildlife species[73]. The types of animals and birds that can live on site are affected by the habitat around them (location of the site with forest, rocky areas, and near Great Slave Lake), as well as by the disturbance on the land from historical mining and by the City

Did you know?

The Wìlìdeh names for some of the common species in the area are nǫndi (wolf), nǫgha (wolverine), tsà (beaver), nǫ̀da (lynx), nǫnditsoa (coyote), ch'oh (porcupine), nàmbe (otter), dzǫ (muskrat), whacho (fisher), wha (marten), tehji (mink), gah (rabbit), ekwà (caribou), and sah (bear).

[72] YKDFN (YKDFN Elders Advisory Council) and Trailmark Systems. 2019. Yellowknives Dene First Nation Knowledge and History of the Giant Mine: Concerns, Recommendations, and Closure. Prepared for the Giant Mine Remediation Plan. March 2019.

[73] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Giant Mine Remediation Project: Closure and Reclamation Plan. Version 2.1. March 2021.

of Yellowknife, the city's solid waste facility (landfill), and the nearby highways, of which Highway 4 cuts through a portion of the site. Wildlife observations with intermittent monitoring were done on site to protect wildlife during care and maintenance activities.

What monitoring programs were done from 2015 to 2021?

Site staff note wildlife in a wildlife log if they are observed. Birds were monitored in spring on site to determine if they were near site activities and if action to protect them was required. Two programs were completed to support the Human Health and Ecological Risk Assessment: mammals were monitored once during the reporting period in a winter camera survey, and tissues of small mammals were collected to document metal concentrations.

8.1 MONITORING

Birds

During the reporting period, birds were monitored onsite almost every year[74,75,76,77,78,79]. (Formal bird monitoring was not conducted on site in 2020 due to COVID-19; however, monitoring including wildlife sighting reporting continued.) Monitoring was done in spring and summer when birds were likely to be nesting, which is approximately 9 May through 13 August for migratory birds in the North [80]. Surveyors looked for roosting and nesting of birds and identified possible risks to birds from activities on site. Different buildings and areas were surveyed each year, depending on the activities on site. If a risk was found, the biologists suggested ways to reduce risks to birds while avoiding delays to site activities.

Mammals

All workers on site watch for wildlife year-round and record sightings in the wildlife log. This includes the furred animals (mammals). One winter wildlife survey was done in 2016 including the use of remote cameras and winter track counts to support the Human Health and Ecological Risk Assessment.

Metals in Tissue/Human health and Ecological Risk Assessment

As noted in Chapter 6 on fish, a Human Health and Ecological Risk Assessment (Part 1, Part 2, Part 3, Part 4) was completed in 2018[81]. This study used the measurements of potential contaminants in the flesh (tissue) of wildlife to assess if there was a risk to humans eating wildlife (the human health part of the assessment) or from predators eating other animals (the ecological part of the assessment) for both now and after remediation:

- **Human health:** People also volunteered to provide harvested animals from around the area to support this study; they provided small pieces of tissue from animals such as rabbit, beaver, and moose, as well as other animals.
- **Ecological:** In 2016 small mammals such as mice and shrews were collected from the site, and the metal concentrations were determined.

Separate from the Human Health and Ecological Risk Assessment, a survey/investigation was done in 2019 to update the small mammal tissue chemistry before remediation begins. This is intended to provide data to compare tissue after remediation.

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[74] Golder (Golder Associates Ltd.). 2015. 2015 Giant Mine Bird Activity Surveys. Final Report prepared for AECOM Canada by Golder Associates Ltd. 14 January 2016.

[75] Golder (Golder Associates Ltd.). 2016. Giant Mine 2016 Bird Activity Survey. Technical Memorandum prepared for AECOM Canada by Golder Associates Ltd. 24 October 2016.

[76] Golder (Golder Associates Ltd.). 2017. 2017 Site Wide Bird Survey. Final Report prepared for AECOM Canada by Golder Associates Ltd. 25 August 2017.

[77] Golder (Golder Associates Ltd.). 2018. 2018 Giant Mine Bird Activity Survey. Technical memorandum prepared for AECOM Canada by Golder Associates Ltd. 17 July 2018.

[78] Golder (Golder Associates Ltd.). 2019. 2019 Giant Mine Bird Activity Survey. Technical memorandum prepared for AECOM Canada by Golder Associates Ltd. 11 October 2019.

[79] Golder (Golder Associates Ltd.). 2021. Final Report of the Giant Mine Remediation Project Bird Activity Surveys for 2021. Technical Memorandum prepared for AECOM Canada by Golder Associates Ltd. 7 October 2021.

[80] ECCC (Environment and Climate Change Canada). 2022. General Nesting Periods of Migratory Birds. Available at:https://www.canada.ca/en/environment-climate-change/services/avoiding-harm-migratory-birds/general-nesting-periods/nesting-periods.html accessed March 11, 2022.

[81] CanNorth (Canada North Environmental Services). 2018. Giant Mine Human Health and Ecological Risk Assessment, Prepared for Public Services and Procurement Canada – Western Region, Environmental Services and Contaminated Sites Management. Edmonton, AB, Canada.

Method of 2019 tissue investigation

Small mammals were captured in an investigation between 16 September 2019 and 20 September 2019. Traps were set along ten transects each with multiple stations approximately 20 m apart. Traps were baited with a mixture of peanut butter and oats and were deployed overnight for a minimum set of 14 hours. At stations where small mammals were caught, vegetation and soil samples were collected. The target species for vegetation were cranberry leaves (Vacciniumvitis-idaea) and alder leaves (Alnus sp.). Soil samples were collected from three locations near the trap from up to 15 centimetres below surface; the three samples were blended into one sample for the laboratory for each trap with mammals captured. Small mammal samples were identified by species, weighed at the end of each day, and submitted for laboratory analysis of metals[82].

8.2 KEY RESULTS

8.2.1 Birds

Over 50 types of birds were seen on site in the last seven years (Table 20). There were many types of ducks, geese, and songbirds such as warblers. Some birds, such as ravens (Corvus corax), live near the site all year and are called a "resident" bird. Other birds only live near Yellowknife and the site in the spring and summer; these are called "migratory" birds. An example of a migratory bird is the robin (Turdus migratorius); it is a sign of spring when the robin returns to the Yellowknife area. A few types of birds were seen nesting on site, such as osprey (Pandion haliaetus) and kestrel (Falco sparverius) (Photo 34 and 35). Ptarmigans are present in high numbers around the site and the Yellowknife area, in part due to feeding by residents of Yellowknife (Photo 36). Surveys show that the tailings ponds on site are not frequently used by waterfowl but are used by gulls and terns.

Six types of birds that were seen on site are listed as Species at Risk by the federal government (Table 20). The GMRP works hard to protect all birds, including Species at Risk.

Wildlife surveys were used to plan the mitigation used during remediation activities to reduce wildlife disturbance. In 2021, biologists surveyed the old Townsite buildings. These buildings will be taken down (decommissioned) in 2022/2023. This work will happen in spring and summer, when birds could be nesting on site. The survey recommended steps to minimize the potential to disturb any active nests, for example, covering up building vents now so birds will not have access to nest inside the buildings in spring (Photo 37).

PHOTO 34: Osprey on Site

PHOTO 35: American Kestrel on Site

PHOTO 36: Ptarmigan on Site

PHOTO 37: Building Vent to Be Covered to Prevent Access for Nesting in Building

[82] Golder (Golder Associates Ltd.). 2020. Small Mammal and Vegetation Sampling, Giant Mine Remediation Project. Submitted to AECOM and PSPC, Edmonton. April 2020.

Table 20: Birds Observed at Giant Mine Site from 2015 to 2021

SPECIES GROUP	COMMON NAME[a]	SCIENTIFIC NAME	NESTING ON SITE?
Grouse (grouse, ptarmigan, quail)	ptarmigan species	N/A	-
Waterfowl (ducks, geese, swans)	green-winged teal	Anas crecca carolinensis	-
	American wigeon	Anas americana	-
	bufflehead	Bucephala albeola	-
	canvasback	Aythya valisineria	-
	duck species	N/A	-
	lesser scaup	Aythya affinis	-
	mallard	Anas platyrhynchos	-
	northern pintail	Anas acuta	-
	norther shoveler	Anas clypeata	-
Loons and grebes	**common loon**	Gavia immer	-
	horned grebe	Podiceps auritus	Yes
	red-necked grebe	Podiceps grisegena	-
Raptors (hawks, eagles, falcons)	American kestrel	Falco sparverius	-
	merlin	Falco columbarius	-
	osprey	Pandion haliaetus	Yes
Waterbirds (cranes, rails, coots, herons)	sand-hill crane	Grus canadensis	-
	sora	Porzana carolina	-
Shorebirds	solitary sandpiper	Tringa solitaria	-
Gulls and terns	Bonaparte's gull	Chroicocephalus philadelphia	Yes
	gull species	N/A	-
	herring gull	Larus argentatus	-
	mew gull	Larus canus	Yes
Woodpeckers	northern flicker	Colaptes auratus	Yes

a) Bold text indicates federally listed Species at Risk. Italicized text indicates NWT Species at Risk.
N/A = not applicable; - = not observed.

SPECIES GROUP	COMMON NAME[a]	SCIENTIFIC NAME	NESTING ON SITE?
Songbirds	alder flycatcher	Empidonax alnorum	-
	American robin	Turdus migratorius	-
	American tree sparrow	Spizella arborea	-
	barn swallow	Hirundo rustica	Yes
	belted kingfisher	Megaceryle alcyon	-
	black-billed magpie	Pica hudsonia	Yes
	chipping sparrow	Spizella passerina	-
	cliff swallow	Petrochelidon pyrrhonota	Yes
	common raven	Corvus corax	Yes
	dark-eyed junco	Junco hyemalis	-
	eastern phoebe	Sayornis phoebe	Yes
	fox sparrow	Passerella iliaca	-
	Harris's sparrow	Zonotrichia querula	-
	hermit thrush	Catharus guttatus	-
	house sparrow	Passer domesticus	-
	Lincoln's sparrow	Melospiza lincolnii	-
	orange-crowned warbler	Oreothlypis celata	-
	palm warbler	Setophaga palmarum	-
	red-winged blackbird	Agelaius phoeniceus	Yes
	ruby-crowned kinglet	Regulus calendula	-
	savannah sparrow	Passerculus sandwichensis	-
	sparrow species	N/A	-
	Swainson's thrush	Catharus ustulatus	-
	swamp sparrow	Melospiza georgiana	-
	tree swallow	Tachycineta bicolor	Yes
	white-crown sparrow	Zonotrichia leucophrys	-
	white-throated sparrow	Zonotrichia albicollis	-
	yellow warbler	Setophaga petechia	-
	yellow-rumped warbler	Setophaga coronata	-

a) Bold text indicates federally listed Species at Risk[83]. Italicized text indicates NWT Species at Risk[84].
N/A = not applicable; - = not observed.

[83] Government of Canada. 2022. Species at Risk Public Registry. Available at: https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html accessed March 11, 2022.

[84] GNWT (Government of the Northwest Territories). 2020. Species at Risk in the Northwest Territories, 2020. Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT.

8.2.2 Mammals

During the winter survey, the types of wildlife detected were as follows: coyote, snowshoe hare, wolf, red fox, ermine (Mustela erminea), marten, least weasel (Mustela nivalis), lynx, red squirrel (Sciurus vulgaris), and small mammals (e.g., mice, voles, or shrews)[85]. The most common species seen in the camera survey were snowshoe hare (Photo 38), red squirrel, red fox, and coyote. Site staff reported seeing foxes, hares, wolves on site intermittently. A wolverine was seen by staff in December 2020; this was reported to the Government of the Northwest Territories because it is a species of concern in Canada. A grizzly bear (Ursus arctos horribilis) was seen by staff in September 2020; the Government of the Northwest Territories was notified, and actions were taken to protect workers from possible bear encounters.

Beavers sometimes build dams on site, and muskrats are sometimes seen in Baker Creek. Beaver dams could cause flooding of pits and other areas, so they are removed from Baker Creek on site. This is done with permission of the Government of the Northwest Territories and the help of local Indigenous trappers.

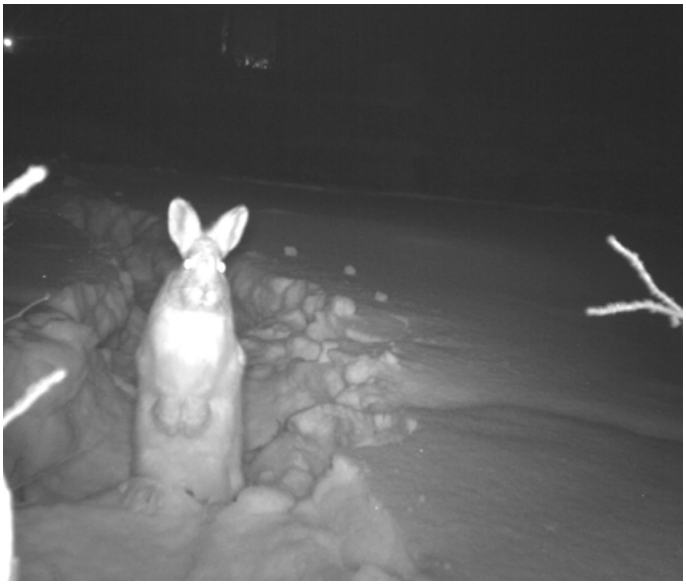


PHOTO 38: Snowshoe Hare on Site

Did you know?

The area on and near the site is home to many ravens, likely because of the proximity to the city and the city's landfill, which have acted as a source of food over the past 20 years in Yellowknife. A population of black-billed magpies (Pica hudsonia) has also established and was found on site. This is an invasive species. Both ravens and magpies eat eggs and young from other bird nests. (see photos below of these birds in buildings on site).

[85] Golder (Golder Associates Ltd.). 2016. Winter Wildlife Monitoring at Giant Mine 2016. Final Report prepared for AECOM Canada by Golder Associates Ltd. 11 March 2016.

8.2.3 Metals in Tissue

Human Health and Ecological Risk Assessment

The Human Health and Ecological Risk Assessment used the measurements of potential contaminants in the flesh (tissue) of wildlife to assess if there was a risk to humans eating wildlife or from predators eating other animals. Results showed that concentrations of total arsenic in moose and rabbit and some ducks were higher on or near the site than away from the site. Arsenic was found in the small mammals on site. The Human Health and Ecological Risk Assessment concluded that the risks to humans from eating wildlife are predicted be very low to low and will be further reduced after remediation. Please refer to the Human Health and Ecological Risk Assessment (Part 1, Part 2, Part 3, Part 4) for detailed information on assumptions and methods.

Small mammal tissue update

A 2019 survey was completed to update the small mammal tissue chemistry before remediation[86]. There were 64 mammals across 60 stations and nine transects submitted for analysis (one transect was archived), in conjunction with 60 plant and soil samples from the same stations. Deer mice and northern red-backed voles and shrews were captured; too few shrews were captured to submit to the laboratory.

Arsenic and other metals were found in small mammals, vegetation, and soil. Data from the Human Health and Ecological Assessment (2016 data) and 2019 data were analyzed. Data analysis showed that arsenic concentrations were related between small mammals and vegetation (and soils considering both 2016 and 2019 data. This result matches the findings of the Human Health and Ecological Assessment.

These results will be useful in comparing concentrations of metals in small mammals, soils, and vegetation after remediation.

8.3 WILDLIFE STATUS OF ENVIRONMENT INDICATOR

No indicator for wildlife was identified. The monitoring data are not collected in a way to support identification and rating of an indicator, which relies on many observations over time. For wildlife on site, the data are mostly occasional observations by workers on site and from annual surveys from various areas around site. Further, the species and amount (abundance) of wildlife on site are affected by the surrounding habitat, which includes many types of human disturbances (e.g., roads, City of Yellowknife, nearby large lake). Because of the type of data available and the significant influence of other disturbances on wildlife, it was not possible to set a meaningful indicator that reflected the status of the wildlife on site.

[86] Golder (Golder Associates Ltd.). 2020. Small Mammal and Vegetation Sampling, Final Report. Giant Mine Remediation Project. Prepared for Public Works and Government Services Canada

9.0

Cumulative *Effects*

BACKGROUND

In 2010, potential effects of the GMRP plus those of other activities and developments in the area (cumulative effects) was assessed (Developer's Assessment Report Section 11[87]). The assessment was done to:

- Identify issues of concern for the GMRP and other projects and/or activities to see if there would be negative (adverse) effects.
- Determine how far the effects could reach out in the area (spatial extent) and how long they might last for (duration).
- Identify ways to help mitigate negative effects and monitor these in the future.

Other activities that could combine with the GMRP to create cumulative effects were identified; some examples were the construction of new Highway 4 realignment, development of the Townsite, future City of Yellowknife developments including landfill expansion, resource harvesting, closure of Con Mine, new oil and gas or mining developments, and the regional contamination/effects on people's health and well-being from the operation of the historical Giant Mine. Some of these activities were complete before the remediation began in late 2021, including the closure of Con Mine and the rerouting of Highway 4.

[87] INAC and GNWT (Indian and Northern Affairs Canada and Government of the Northwest Territories). 2010. Giant Mine Remediation Project Developer's Assessment Report. EA0809-001. October 2010.

Table 21: Cumulative Effects of Remediation Plus Other Activities and Legacy Mining

CUMULATIVE EFFECTS ISSUES OF CONCERN	DESCRIPTION	DEVELOPERS ASSESSMENT CONCLUSION	HOW IS IT MONITORED?
Arsenic contamination of water	Contamination from old mining operations and potential release during remediation activities	Minor adverse effects; not significant	See Chapter 5 of this report
Arsenic contamination of fish	Contamination in fish (fish tissue) that humans might then eat, caused by old mining operations and potential release during remediation activities	Minor adverse effects; not significant	See Chapter 6 of this report
Arsenic contamination of wildlife	Contamination in wildlife (wildlife tissue) that humans might then eat, caused by old mining operations and potential release during remediation activities	Minor adverse effects; not significant	See Chapter 8 of this report and the Wildlife and Wildlife Habitat Management and Monitoring Plan[88]
Traditional land uses and decreased quality of the land (degradation)	Reduced and/or restricted the land area for local Indigenous Peoples to practise traditional land use activities. In addition, there could be a loss and/or degradation of habitat	Minor adverse effects; not significant	Not appropriate for monitoring at this time, avoidance of the site occurs; Perpetual Care Working Group set up to discuss future safety of land and constraints for use/development

Source: Modified from Table 11.4.2, Chapter 11 of the Developer's Assessment Report[89]

The Developer's Assessment Report concluded that there would be no significant negative effects of remediation in combination with other activities (cumulative effects; Table 21). This is because the effects of remediation are primarily positive and extra care will be taken to protect the environment from harm during remediation (known as "mitigation"). An example of a mitigation measure is to dig a sump to collect water from areas where heavy equipment is working and moving contaminated soil; this would prevent the water from entering Baker Creek. The assessment concluded that no additional mitigation measures were needed to prevent cumulative effects beyond those measures already planned.

Despite the GMRP's assessment of effects, the Mackenzie Valley Environmental Impact Assessment Review Board ruled in its Report of Environmental Assessment and Reasons for Decision[90] that the GMRP in combination with legacy effects of historical mining may have significant negative cumulative effects on:

- the well-being of people (Section 8.3.3 of the Reasons for Decision)
- the water in Yellowknife Bay (Section 9.7 of the Reasons for Decision)

Based on that determination, the Mackenzie Valley Environmental Impact Assessment Review Board set out two measures (requirements) for the GMRP Team to complete before remediation could proceed:

- **Measure 10:** conduct a Human Health and Ecological Risk Assessment of the current and future condition, and if necessary, identify additional mitigation necessary to prevent harm to people.
- **Measure 14:** add an ion exchange process to its proposed water treatment process to produce water treatment plant effluent that at least meets Health Canada's drinking water standards for arsenic (containing no more than 10 µg/L), to be released using a near shore outfall immediately offshore of the Giant Mine site.

[88] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Giant Mine Remediation Project Wildlife and Wildlife Habitat Management and Monitoring Plan. Version 2.0. March 2021.

[89] INAC (Indian and Northern Affairs Canada). 2010. Giant Mine Remediation Project Developer's Assessment Report. Submitted to the Mackenzie Valley Environmental Impact Review Board, Yellowknife, NT, Canada.

[90] MVEIRB (Mackenzie Valley Environmental Impact Review Board). 2013. Report of Environmental Assessment and Reasons for Decision – Giant Mine Remediation Project. EA0809-001. Yellowknife, NWT, Canada. 20 June 2013.

Status to Mid-June 2021

The Mackenzie Valley Environmental Impact Assessment Review Board's Reasons for Decision and its measures were accepted by the GMRP Team in 2014. Since then, both Measure 10 and Measure 14 have been met. As discussed in this report in the chapters on fish and wildlife (Chapters 6 and 8, respectively), the Human Health and Ecological Risk Assessment (Part 1, Part 2, Part 3, Part 4) [91] was conducted and concluded in 2018. It identified that if the remediation was conducted as proposed in the Closure and Reclamation Plan (Chapters 1-4, 5.0-5.4, 5.5, 5.6, 5.7-7.0)[92], the risk to people was low. In 2019, the Closure and Reclamation Plan included a new water treatment plant design that can meet the low concentrations of arsenic required. Criteria for the discharge of treated effluent were included in the Water Licence for remediation. Given that the above measures are met, the GMRP assesses that the risk of negative cumulative effects to human health and water in Yellowknife Bay with the GMRP is not significant.

The GMRP continues to conduct, support and share data on health and water-related cumulative effects monitoring, including:

- Air quality and water quality are monitored on site as well as in the surrounding area by the GMRP (see Chapters 4 and 5 of this report). This monitoring documents the quality of air and water affected by the GMRP and any other regional inputs. The data are available publicly.
- A Health Effects Monitoring Program (health study) is taking place to establish current (baseline) levels of arsenic and other contaminants of concern in people's bodies so it can be compared to levels during, and after remediation. The GMRP also supports and participates in the Health Effects.

Monitoring Program Advisory Committee and Hoèla Weteèts'eèdeè (Understanding Community Well-Being Advisory and Technical Committee).

- The GMRP shares data with other researchers who study the impacts of mining in the area. This includes groups such as Environment and Climate Change Canada, Natural Resources Canada, various universities, the Government of the Northwest Territories, the Yellowknives Dene First Nation, and the North Slave Métis Alliance.
- The GMRP supports the Yellowknives Dene First Nation and the North Slave Métis Alliance in funding community-based monitoring programs in the region.

Where data are available, summaries of these studies will be included in the next Status of the Environment Report in 2024.

[91] CanNorth (Canada North Environmental Services). 2018. Giant Mine Human Health and Ecological Risk Assessment, Prepared for Public Services and Procurement Canada – Western Region, Environmental Services and Contaminated Sites Management. Edmonton, AB, Canada.

[92] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada.

10.0

Lessons Learned *And Adaptive Management*

10.1 ADAPTIVE MANAGEMENT DURING CARE AND MAINTENANCE

The Giant Mine site has been in care and maintenance since 2005. Since entering care and maintenance, activities have been carried out where practicable, or where urgently needed to address specific site health and safety or environmental issues. Numerous lessons were learned on site in this time. The GMRP Team wants to use what was learned over the past several years to help with the remediation in the future. "Adaptative management" is the term that is used to describe this: continually improving by learning the lessons from what was previously done. By learning from the lessons of the past few years, the remediation design and planned remediation activities will be stronger and result in more protection of the environment and workers. This section describes some of the main lessons learned from key activities with a focus on environmental protection. For more detailed information on activities and lessons learned, please refer to Chapter 4 and Appendix 4A of the Closure and Reclamation Plan.[93]

Baker Creek Realignment – 2006

A section of Baker Creek was relocated into a new channel in 2006. The primary objective of the realignment was to isolate the contaminated Mill Pond, which overlies Stope C2-12, from Baker Creek, thereby eliminating a source of ongoing contamination and preventing seepage loss from Baker Creek into areas of the underground mine itself (via C1 Pit). Secondary objectives of the realignment were to provide a stable channel that could convey a flood, maintain or improve fish passage, and provide spawning and rearing habitat for native fish species.

The key lessons learned for environmental protection were related to permafrost and vegetation:

ENVIRONMENTAL LESSONS LEARNED FOR **FUTURE REMEDIATION OF BAKER CREEK**
Careful consideration of permafrost conditions and subsidence should be given to new design features. This will be built into designs and mitigation for specific activities and outlined in Design Plans and Construction Plans, as applicable.
Ice or frozen ground should be expected when excavating the creek. Ice-rich sediment/soil must be thawed and the meltwater must be collected and sent to treatment.
Work in the stream could continue at times when rain is light. Heavy rains are expected to shut down work in the stream and cause delays to prevent silty water from entering the environment.
A contingency plan of watering is required during dry weather to increase survival rates of planted vegetation during establishment, as well as realistic planning for locations where vegetation can grow.

[93] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada.

Icing in Baker Creek Upstream of the Site – 2011

In May 2011, icing in upper Baker Creek caused changes to the regular flow path of the creek near the site. The normal flow path of Baker Creek is from Lower Martin Lake to Baker Pond through a series of wetlands and a waterfall upstream of the pond. In fall 2010, rain prevented areas of the ground from freezing, and this allowed the creek to flow beneath the snow for the winter. The flow of water froze in layers for numerous weeks of the winter. Ice built up over a distance of approximately 1 kilometre upstream of Baker Pond, causing early spring flows from Martin Lake to flow northeast around the ice jam instead of the usual flow path through the ice. The diverted flow eroded an old mine road and entered historical Jo-Jo Lake (Photo 39) where sediments had been impacted by mine tailings during the early years of mining. The flow of water through historical Jo-Jo Lake resulted in re-suspension and transport of tailings impacted sediments through lower Baker Creek to Yellowknife Bay. This was reported as a spill to the government (Spill#11-159).

ENVIRONMENTAL LESSONS LEARNED FOR CARE AND MAINTENANCE OF SITE

Flows in Baker Creek can occasionally continue in winter, and ice buildups may result (see Chapter 3 for details on flows).
Staff are needed to monitor key areas of the site even in winter when active water management activities are usually not required.
Road access to water management areas is needed to facilitate remedial actions around the site.

The site was given a letter of direction from Crown-Indigenous Relations and Northern Affairs Canada – Water Resources on 30 May 2011 to take permanent mitigative measures to remove the potential for release of tailings into the receiving environment. A tailings cover was placed on the Jo-Jo Lake area in 2011 and completed in 2012.

PHOTO 39: Aerial view of Baker Creek Area

Roaster Complex Stabilization – 2015

Between 2013 and 2015, the decontamination and deconstruction of the roaster buildings were completed. The Roaster Complex contained free and poorly contained arsenic-containing dust, asbestos, cyanide, and other hazardous substances. The buildings had been locked up and not maintained since 1999. Many lessons were learned during this program, including safety and hygiene for workers, medical monitoring of workers, and managing spills. One key area was waste assessment, where the volume of waste was underestimated:

- Waste assessments were completed in two stages during periods of very cold weather in restricted access buildings. Conditions hampered the assessor's ability to fully understand issues and constraints, the collection of samples, and the determination of quantities.
- Previous assessment reports regarding volume of material within sealed structures were found to be very inaccurate. The inability to access the interiors of sealed structures resulted in a significant underestimation of the volume of material to be removed.

For the remediation, it is important for the demolition of the Townsite and core industrial buildings on site to properly account for and manage the waste from the demolition.

ENVIRONMENTAL LESSONS LEARNED FOR FUTURE DEMOLITIONS

Work such as site assessment is more easily done during warmer weather.
Waste quantities can vary from estimates and need to include a contingency allowance to account for actual volumes exceeding estimates developed during the assessment stage.

Underground Stabilization – 2013 to 2018

A 2013 to 2018 underground stabilization program provided progressive stabilization works for previously mined stopes where unacceptable failure risks were identified for crown or rib pillars (intact rock that separates two underground voids which had been excavated adjacent to each other). Section 7.3 of this report provides information on the program. Critical underground stopes were stabilized with lightly cemented tailings paste backfill.

Three key risk categories were identified for the stope failures:

- crown pillar failure that would allow flooding of the underground mine
- crown pillar failure that would expose the public or workers to undue risks
- crown or rib pillar failure that would allow arsenic solids to escape to the environment or the mine workings and ultimately the mine pool

Paste was placed into four non-arsenic stope complexes (B1-18, B3-06, B3-10, and A-370) and the two arsenic stopes (B-208 and B2-12/B2-13/B2-14) to stabilize the pillars by tight filling. Paste backfill was added to the voids in the stopes by way of boreholes drilled from surface. Backfill of the stopes was completed with a paste material composed of Giant Mine tailings, binding agent, cement and/or slag cement, and water. One additional stope (C509) below an arsenic stope was backfilled; layers of paste backfill, self-consolidating concrete, and paste were used. Paste was placed to create a level working platform before remotely constructing a plug. The remainder of the void was then filled with paste to provide confinement to the overlying crown pillar.

In addition to achieving stabilization and controlling unacceptable risks, the program provided valuable experience with backfilling techniques, which will help to minimize construction uncertainty for future remediation work underground. Chapter 4 of the Closure and Reclamation Plan[94] outlines these lessons in detail. The key lessons learned in relation to the environment are about dust control when working with tailings.

ENVIRONMENTAL LESSONS LEARNED FOR FUTURE UNDERGROUND STABILIZATION

Stacking tails (making a tall pile) does not achieve any efficiencies. Smaller stacks (piles) that are spread out are more efficient. Tall piles also cause potential challenges for dust control.
Dust monitoring in the backfill area was very sensitive (e.g., fog conditions would trigger it) and this needs to be planned for in future programs.
Proposed construction activities for each day to be discussed with all subcontractors, including the air quality monitoring subcontractor.

[94] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada. Chapter 1-4

Underground Pumping Redundancy – 2019

Underground pumps are used to pump water from the underground mine to the Northwest Pond for storage and eventual seasonal treatment and discharge (Chapter 5, Figure 16; Photo 40). It is not ideal for the pumps to be located in underground drifts because workers must go down to repair and operate them, which can lead to health and safety risks for workers. Further, if water were to rise underground, the pumps and the power for the pumps could become wet and not usable, making pumping to the surface challenging. In 2019, the GMRP installed a new surface pumping station with two wells and two submersible pumps, called the Northwest Pumping System. The main benefits of the new system include:

- The new submersible pumps can be serviced from surface (Photo 41), eliminating the need for workers to access the underground to perform maintenance and repairs, reducing potential health and safety risk.
- The pumps increase the pumping capacity of the water management system, allowing the GMRP Team to be better prepared for emergency response in the case of a flood.

ENVIRONMENTAL LESSONS LEARNED FOR **CARE AND MAINTENANCE AND FUTURE UNDERGROUND PUMPS**
Large pumps for minewater are not quickly purchased.
Extra backup pumps should be maintained on site in case of pump failure.

PHOTO 40: Underground Pumps That Move Minewater to Surface (known as the backup high lift pumps)

PHOTO 41: Submersible Pumps That Bring Minewater to the Surface (known as the Northwest Pump System)

Dam 1 Stabilization – 2020

Dam 1 is in the Original Tailings Containment Area (shown in Chapter 7, Figure 28 and Table 18). It is currently classified as a high consequence dam, which means if it were to be damaged, it could release minewater/sludge and there may be environmental effects and health and safety implications. The slope of Dam 1 (safety factor) meets the Canadian Dam Association guidelines (Photo 42); however, it has experienced continuous dam crest settlement that impacted the current water management plan. Ongoing settlement could result in cracking and internal erosion of the upstream seepage barrier of the dam during operations.

Dam settlement is measured on plates called "settlement plates." From 2003 to 2020, the dam settled at an average rate of approximately 60 millimetres per year; the total settlement over that time was almost 90 centimetres (Figure 28).

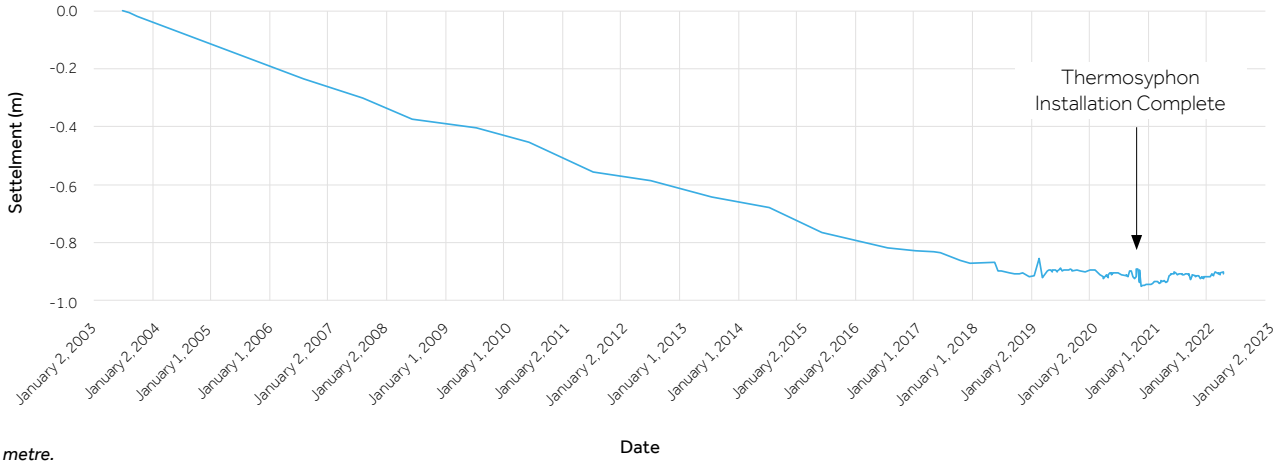
Over the years, investigations were done to determine the cause of the settling. In 2019, it was confirmed that the main cause of settlement of Dam 1 occurred due to the thawing of ice within the soil foundation. To stabilize Dam 1, a thermosyphon system was installed along the upstream dam crest in 2020 (Chapter 7, Photo 32). This freezes the area. The thermosyphons have reduced the rate of thawing of foundation soils and improved the stability condition of Dam 1.

Visual inspection, topographic surveying, and instrumentation are used to monitor the dams. Monitoring of the dams continues daily to yearly depending on the classification of the individual dam. An annual geotechnical inspection is undertaken for all dams. Once the remediation is complete, the dams will no longer store water, and the risk to the environment will be reduced.

PHOTO 42: Dam 1 Slope Condition

ENVIRONMENTAL LESSONS LEARNED FOR **FUTURE CARE AND MAINTENANCE/REMEDIATION OF TAILINGS DAMS**

Continuous vigilance for thawing permafrost and its effects on infrastructure/land/water on site is required.
Future infrastructure should not be built on top of permafrost given the changing climate and the likelihood of settling; the new water treatment plant is designed to be built on top of bedrock.
Temperature data from the Dam 1 thermosyphons will be used to evaluate the performance of the thermosyphons and calibrate a thermal model, which will be used to compare to the design of the freeze program.



m = metre.

FIGURE 28: Settlement of Dam 1 Crest since 2003

Dust on Tailings Containment Areas, 2020

In October 2020, increased wind speeds persisted for several days in the Yellowknife area. Additional dust mitigation began when winds were forecast to reach 15 kilometres per hour, which was site practice. Additional water trucks were brought to site beginning 10 October. As forecasted, wind levels increased on 13 October and visual dust was observed on site (Photo 43). Community members were able to see the dust on site. Water trucks were deployed to the Tailings Containment Areas and roads requiring additional dust suppression. Watering continued from 13 October to 15 October in area that trucks could access. In the Northwest Pond (Figure 27), higher than usual water volumes stored from previous treatment season left tailings areas saturated throughout the summer, and all Tailings Containment Areas witnessed poor drying conditions making it impossible for heavy equipment to access certain areas for application. With increasing visual dust and high winds (gusting to 70 kilometres per hour), helicopter support was added on 15 October to reach those areas of the Tailings Containment Areas that were not accessible by truck. A total of 151 cubic metres of water from Back Bay was placed on the Northwest and South ponds by two helicopters (see the 2020 Water Licence Annual Report[95] for more details).

In summary, wind-generated dust was measured at one or more site stations from 12 October to 16 October as well as visible dust. No air quality criteria were exceeded. Additional mitigation measures were needed to control the dust, including water trucks and helicopters.

PHOTO 43: Tailings Containment Area with Visible Dust, October 2020

ENVIRONMENTAL LESSONS LEARNED FOR FUTURE CARE AND MAINTENANCE/REMEDIATION

Dust suppressant may not reach all corners of the Tailings Containment Areas when applied.
Water spray is needed as a backup. Water cannons obtained for use on site to increase capacity to reach harder to access areas of the Tailings Containment Areas.
Water application by helicopters may be needed in extreme cases to react to very high winds.
Constant vigilance of dust from site is required.

10.2 ADAPTIVE MANAGEMENT IN THE FUTURE

Overall, the GMRP has been able to adapt to changing site conditions. Numerous lessons were learned in the care and maintenance period that will be applied to remediation. Going forward, the approved management and monitoring plans outline "action levels." An adaptive management approach is used to link monitoring results to actions with the purpose of maintaining management as planned. Should monitoring or inspection indicate something is not performing as anticipated, a series of actions would be initiated. This provides a systematic approach to responding to the results of the monitoring.

In general, the process will be:

- Action levels are evaluated based on monitoring findings in a given month or year.
- If an action level is exceeded, the actions for the action level exceedance will be completed, as per the approved management and monitoring plan.
- Any exceedances will be reported to Mackenzie Valley Land and Water Board and interested parties as per the applicable management and monitoring plan and Engagement Plan.

[95] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada. Chapter 1-4

11.0

Where Do We Go *From Here*

The next Status of the Environment Report is due in three years (2025) and will cover the time period of mid-June 2021 to mid-June 2024. The anticipated main activities that will occur on site in the next three years are remediation, continuing care and maintenance, and monitoring.

The remediation activities that are proposed for the next three years are as follows:

- Continue care and maintenance of the site.
- Stabilize/backfill the underground.
- Construct the Area 1 freeze pad.
- Operate the non-hazardous waste landfill.
- Decontaminate and demolish the Townsite buildings.
- Build the new water treatment plant and outfall.
- Continue monitoring.

Monitoring will continue on the site including:

- greenhouse gas emissions
- dust / air quality[96]
- water quality on site[97]
- water quality in Yellowknife Bay[98]
- underground water level[76, 99]
- water level in Tailings Containment Areas on site[76, 100]
- water flows and levels in Baker Creek[76,78]
- wildlife[101]
- aquatics (fish and benthic invertebrates and sediment quality)[102]
- underground stability[103]
- inspections of site structures such as dams and pits
- construction monitoring to confirm the environment and people are protected during remediation activities
- investigations of areas for preparation for final remediation activities (e.g., drilling holes to determine stability of pit walls)

Monitoring will follow the approved management and monitoring plans. Results from monitoring are reported every year to the Mackenzie Valley Land and Water Board through the Annual Water Licence Report (2020, 2021) and will be summarized in the next Status of the Environment Report. If there are accidental spills to the environment or the remediation activities are not progressing as planned, Rights holders and stakeholders, the GMRP Working Group, and the Mackenzie Valley Land and Water Board are notified.

Over the next few years, engagement with Rights holders and stakeholders and regulators will continue (see description in Chapter 2). The GMRP plans to engage on design plans for different closure and remediation components, management and monitoring plans, health and aquatic effects monitoring and results of these programs, and constraints mapping to help identify future land considerations of the site. Details on engagement activities are reported on in the Engagement Plan and the Annual Water Licence Report (2020, 2021).

One new activity that will occur from 2022 to 2026 is engagement on vegetation. The GMRP Team will be meeting with Rights holders and stakeholders and regulators to talk about vegetation on the site after remediation. How the site looks and what plants are on site after remediation is important. Groups will be asked for advice on types of plants and where to source plants, as well as how local businesses could get involved. If you are interested in this topic and have ideas, please contact the GMRP information line at 1 867-669-2426, or via email at giantmine@rcaanc-cirnac.gc.ca.

The Status of the Environment on site is not expected to change significantly in the next three years. Improvements to the environment are not expected to occur until more of the remediation is complete, such as covering the tailings ponds or operating the new water treatment plant. It is likely that remediation activities will generate more dust than the care and maintenance activities in the past, but this will be monitored and efforts made to keep the amount of dust low as is required in the Dust Management and Monitoring Plan.

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[96] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Dust Management and Monitoring Plan. Version 2.1. June 2021. https://registry.mvlwb.ca/Documents/MV2007L8-0031/MV2007L8-0031%20-%20DIAND-GIANT%20-%20Dust%20MMP%20-%20Version%202.1%20-%20Jun25-21.pdf

[97] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Water Management and Monitoring Plan. Version 2.1. February 2021. https://registry.mvlwb.ca/Documents/MV2007L8-0031/MV2007L8-0031%20-%20DIAND-GIANT%20-%20Water%20Management%20and%20Monitoring%20Plan%20-%20Rev.%202.1%20-%20Feb%2011_21.pdf

[98] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Engagement Plan. Version 2.1. March 2021

[99] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2022. Giant Mine Remediation Project 2021 Annual Water Licence Report. April 2022.

[100] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada

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[102] CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2021. Aquatic Effects Monitoring Program 2020 Annual Report. July 2021. https://registry.mvlwb.ca/Documents/MV2007L8-0031/DIAND-GIANT%20-%20AEMP%202020%20Annual%20Report%20V1.1%20-%20Part%201%20of%203%20-%20July8_21.pdf https://registry.mvlwb.ca/Documents/MV2007L8-0031/DIAND-GIANT%20-%20AEMP%202020%20Annual%20Report%20V1.1%20-%20Part%202%20of%203%20-%20July8_21.pdf https://registry.mvlwb.ca/Documents/MV2007L8-0031/DIAND-GIANT%20-%20AEMP%202020%20Annual%20Report%20V1.1%20-%20Part%203%20of%203%20-%20July%208_21.pdf

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Appendix A

Summary of Status of Environment Report Environmental Agreement Requirements

Articles of the Giant Mine Remediation Project Environmental Agreement (signed 15 June 2015) are summarized in the following conformity table (Table A-1) along with sections of the Status of Environment Report where each article requirement is addressed.

Table A-1: Environmental Agreement Article Requirements and How Addressed in Report

ARTICLE 6 STATUS OF THE ENVIRONMENT REPORTING	CORRESPONDING CHAPTER IN REPORT	HOW ADDRESSED?
6.1 Status of the Environment Report - At the times identified in section 6.4 the Co-Proponents shall prepare, provide to the Oversight Body, and make available to the public a comprehensive report on the Project. Each report shall include in respect of each reporting period:	--	--
a) a summary of the Project's key operational activities;	Chapter 2	Listed key care and maintenance activities, planning for remediation, and engagement.
b) an assessment of the long-term effects of the Project;	Chapter 1	Long-term effects and estimated long-term monitoring are summarized in Section 5.11 and 5.12 of the Closure and Reclamation Plan. No changes to this are proposed unless remediation activities are amended. Hyperlinks to these sections provided for ease of reference. Assessment too large to repeat in this report.
c) a summary of the methodology, and the results or findings, of all monitoring done for the Environmental Programs and Plans and a description of actions taken or planned to implement Adaptive Management;	Chapters 3, 4, 5, 6, 7, and 8	Summary of results, methods, and actions taken provided for each environmental component. Reference to original data reports provided.
d) a summary of any changes to the environmental impact prediction models, or other conceptual models used by the Co-Proponents to guide Project management, and of the rationale for the changes;	Chapter 1	During the Water Licence process, new predictions were made for water quality (Effluent Quality Report) and human and ecological health (Human Health and Ecological Risk Assessment [Part 1, Part 2, Part 3, Part 4]). Hyperlinks to those reports are provided.
e) the identification of any cumulative effects of the Project on the environment, meaning any effects of the Project considered in the combination with the effects of other human activities;	Chapter 10	Review of the cumulative effects identified by MVEIRB and measures taken to mitigate these provided as well as listing of cumulative effects related monitoring.

Table A-1: Environmental Agreement Article Requirements and How Addressed in Report

ARTICLE 6 STATUS OF THE ENVIRONMENT REPORTING	CORRESPONDING CHAPTER IN REPORT	HOW ADDRESSED?
f) a comparison of the results or findings of all environmental monitoring programs under the Environmental Programs and Plans to the results predicted in the Developer's Assessment Report submitted as part of the MVRMA environmental assessment;	Not applicable for this reporting period	Remediation had not yet begun in this reporting period. Comparisons to predictions for remediation cannot yet be made.
g) an evaluation of the performance of Adaptive Management;	Chapter 10	Remediation had not yet begun in this reporting period. Adaptative management for care and maintenance summarized, including key lessons to apply to remediation.
h) a summary of the Project's planned key operational activities for the upcoming reporting period;	Chapter 11	Listed proposed remediation activities for mid-June 2021 to mid-June 2024
i) references to all sources relied on by the Co-Proponents in coming to conclusions in the report; and	Chapter 12	Reference section provided as well as footnotes on each page with hyperlinks to digital sources of data
j) a plain-language summary of the report.	Summary	--

MVEIRB = Mackenzie Valley Environmental Impact Review Board.

Appendix B

Rationale for Choice of Indicators and Evidence for Rating the Status of the Environment

A large volume of information about the environment on the Giant Mine site (the site) has been collected since 2015. Much of it was summarized in the Closure and Reclamation Plan (Chapter 2)[104] and in annual reports to the Mackenzie Valley Land and Water Board or the Giant Mine Oversight Board. To simplify the large amount of information and summarize the status of the environment on the site, indicators for each of the environmental components (air, water, fish, land [including infrastructure]), were developed (see Table 4 in main document and Table B-1 below). The indicators are provided as a "snapshot" of the status of the environment for the period of this report (mid-June 2015 to mid-June 2021). This appendix outlines the methods used to identify and define the indicators and their ratings.

The indicators are meant to be "backward looking" to the period of the report. Some may improve in subsequent reports, as remediation progresses. For example, soil quality is expected to improve with remediation; others like air quality might worsen slightly during remediation and then improve. The ratings are not meant to be indicative of the success of the project, only a "snapshot" in time. The Closure and Reclamation Plan closure criteria and the Performance Assessment Reports will be used to track success of remediation over time.

How were indicators chosen?

The indicators were chosen to represent the main aspect of concern about an environmental component, using the following considerations, where possible:

- directly measured in monitoring programs and tracked over time
- potential environmental concern related to water use, land use, or environmental effects
- care and maintenance activities on site or future remediation could cause effects on indicator
- valued component in the environmental assessment has data that can be compared to guideline or reference area to allow data interpretation
- linked to a closure criterion in the Closure and Reclamation Plan and expected to be monitored through active remediation and adaptive management phase

What evidence was used to review the status of each indicator?

As noted above, a large volume of data exists from the site monitoring programs. Not all the data from each component are useful in determining the status of the component. Some of the data are collected for other purposes, such as operational decisions, design, or informing predictive models, or are collected from numerous locations on and off site. There needed to be a process to narrow down the information to that which was most representative of the status of the environment for a snapshot. The Giant Mine Remediation Project filtered the types of data down to what was thought to be the most relevant for characterizing the component and the primary environmental attributes of the component. This process is recognized to be subjective but is aligned with general feedback from engagement with the Giant Mine Oversight Board on draft indicators, general feedback from the Water Licence process, and the environmental assessment process. The indicators may be assessed based on narrative or numeric evidence, as applicable.

[104] CIRNAC and GNWT (Crown-Indigenous Relations and Northern Affairs Canada and Government of the Northwest Territories). 2021. Giant Mine Remediation Project Closure and Reclamation Plan. Version 2.1. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada.

How were indicators rated?

Each component was rated based on the evidence from monitoring/inspections over the seven-year reporting period (see Table B-1). Ratings were set as green, yellow, or red, or as a combination of green/yellow or yellow/red (also see Table 1-3 in the main document). Green means the condition on site is stable or "ok" for the reporting period (pre-remediation); it does not mean the component is clear of contamination. Yellow means the component needs attention and the status is of concern. Red means the status of the component is poor and a more serious hazard or risk exists. A combination colour indicates the component is monitored in various locations and they are showing different results: green/yellow indicates good/medium status with some areas stable and some that require attention; yellow/red means some of the locations are of concern and some are in worse condition and pose a hazard or risk. Ratings were assigned (Table B-1) qualitatively based on evidence (narrative and numeric) from the past seven years for each indicator.

The Giant Mine Remediation Project has action levels, which are different from the indicators used in this report. The action levels in the management and monitoring plans outline specific monitoring results that trigger management responses. Rating of the indicators is "backward looking" based on the conditions in the past seven years and meant to show a general status of the components on the site. The indicators are therefore not the same as the action levels.

While quantitative data were gathered for each component, the many types of data/inspection results for each component were pooled into qualitative ratings as outlined in Table B-1. Many ratings included multiple comparisons that were both numeric and narrative. The sources for the data are described in Chapters 4 through 7 with hyperlinks to original data reports.

Once ratings were assigned to each indicator per component, this was tabulated in each of Chapters 4 through 7. Appendix C lists the ratings from each individual chapter. Table 2 of the Summary of this report was then created by selecting one rating per component based on the dominant rating. For example, land ratings varied from yellow:green to red, but because red was the most frequent/dominant, the overall rating for land was assigned as red.

Table B-1 Indicators and Evidence for Each Rating Applicable from 2015 to 2021

ENVIRONMENTAL COMPONENT	INDICATOR	INFORMATION USED TO RATE STATUS OF ENVIRONMENT	TYPE OF DATA	GREEN RATING	YELLOW RATING	RED RATING
Air	Dust on site	Was there visual dust observed on site and/or due to activities on site? Was the total suspended particulate measured at or below the ambient air quality criteria for site at the site perimeter air quality monitoring stations?	Visual observations, laboratory analysis of filters from air quality monitors compared to ambient air quality criteria in the Air Quality Monitoring Plan	Rare to see visible dust, dust limited to site area only; none to rare exceedance of ambient air quality criteria due to site activities	Occasional visible dust, limited to the site, exceedance of ambient air quality criteria rare to occasional due to site activities	Common to see visible dust; exceeds ambient air quality criteria often (seasonally, monthly) due to site activities, dust still limited to the site and not toward communities
	Dust at community stations	Was visual dust observed at the community air quality monitoring stations due to site activities? Were the measurements at the community air quality monitoring stations at or below the ambient air quality criteria?		No visible dust from the site; no exceedances of ambient air quality criteria due to site activities	Rare visible dust from the site; few exceedances of ambient air quality criteria due to site activities	Frequent dust from the site and common exceedance of ambient air quality criteria due to site activities

Table B-1 Indicators and Evidence for Each Rating Applicable from 2015 to 2021

ENVIRONMENTAL COMPONENT	INDICATOR	INFORMATION USED TO RATE STATUS OF ENVIRONMENT	TYPE OF DATA	GREEN RATING	YELLOW RATING	RED RATING
Water	Water quality on site and in Baker Creek(a)	Water in Baker Creek on site: Was arsenic on site greater than upstream? Was total arsenic less than the national regulation for metal mines (MDMER[106])? Treated effluent: Did it meet the licensed discharge criteria[(a)]?	Water quality sample from SNP 43-5 compared to upstream reference area on site at SNP 43-11 and compared to 0.3 mg/L Water quality samples from SNP 43-1 compared to discharge criteria from Water Licence(s)(a)	Total arsenic from SNP 43-5 less than or equal to SNP 43-11 and always <0.3 mg/L Met discharge criteria from Water Licence(s); stable treated effluent quality over time	Total arsenic from SNP 43-5 often greater than SNP 43-11 and often <0.3 mg/L Occasionally did not meet discharge criteria from Water Licence(s); stable quality over time	Total arsenic from SNP 43-5 >0.3 mg/L total arsenic Often did not meet discharge criteria; fluctuations in effluent quality
	Water quality in Yellowknife Bay	Was arsenic in the water in Yellowknife Bay, near the site, below the drinking water quality standard and below the site-specific water quality objective?[(b)]	Water quality samples from Yellowknife Bay near the mouth of Baker Creek compared to the total arsenic drinking water quality standard of 0.01 mg/L and site-specific water quality objective of 0.031 mg/L	<0.01 mg/L in most samples and ≤0.031 mg/L all the time	Occasionally <0.010 mg/L in samples and ≤0.031 mg/L	Rarely <0.01 mg/L in samples and occasionally >0.031 mg/L

[105] Metal and Diamond Mining Effluent Regulations (justice.gc.ca)

Table B-1 Indicators and Evidence for Each Rating Applicable from 2015 to 2021

ENVIRONMENTAL COMPONENT	INDICATOR	INFORMATION USED TO RATE STATUS OF ENVIRONMENT	TYPE OF DATA	GREEN RATING	YELLOW RATING	RED RATING
Fish	Fish food in Baker Creek	Were benthic invertebrates (fish food) present? Were they in similar amounts to a reference area? Did they have the same species as a reference area?	Benthic invertebrate data from mouth of Baker Creek and reference area of Yellowknife River from the Environmental Effects Monitoring Program: abundance, species composition	Abundance and composition data from Baker Creek similar to reference area, most of the time less than 2 standard deviations of difference	Abundance and composition data from Baker Creek dissimilar to reference area but not often more than 2 standard deviations of difference	Abundance and composition data from Baker Creek very dissimilar to reference area, estimated as more than 2 standard deviations of difference
	Fish in Baker Creek	Were fish species present? Did they have high concentrations of metals in their bodies? Was the fish size the same as in a reference area?	Fish capture data from Baker Creek and reference area of Yellowknife River and Horseshoe island Bay from the Environmental Effects Monitoring Program: presence/ absences, concentration of metals in fish tissue, fish size	Data from Baker Creek similar to reference area with similar species present, metals found in fish tissue in similar concentrations to reference, most of the time <10% difference in fish condition and <25% difference in organ size relative to body size	Data from Baker Creek compared to reference area with similar species present, metals found in fish tissue in Baker Creek above concentrations to reference, but >10% difference in fish condition and >25% difference in organ size relative to body size	Data from Baker Creek not similar to reference area with not all the same species present, metals found in fish tissue at much higher concentrations than reference, often >10% difference in fish condition and >25% difference in organ size relative to body size

Table B-1 Indicators and Evidence for Each Rating Applicable from 2015 to 2021

ENVIRONMENTAL COMPONENT	INDICATOR	INFORMATION USED TO RATE STATUS OF ENVIRONMENT	TYPE OF DATA	GREEN RATING	YELLOW RATING	RED RATING
Land (including Infrastructure)	Soil quality in developed areas	Did soils have total arsenic above the approved closure plan standard of 340 mg/kg for the site?[(c)]	Soil chemistry sample from developed area from any investigation compared to 340 mg/kg total arsenic	Most samples <340 mg/kg total arsenic	Most samples >340 mg/kg total arsenic	Most to all samples substantially >340 mg/kg total arsenic
	Soil quality in forest, bedrock, wetland areas	Did soils have total arsenic above the approved closure plan standard of 340 mg/kg for the site?[(c)]	Soil chemistry sample from bedrock/forest wetland area from any investigation compared to 340 mg/kg			
	Soil quality in Townsite	Did soils have total arsenic above the approved closure plan standard of 160 mg/kg for the Townsite?[(c)]	Soil chemistry sample from Townsite from any investigation compared to 160 mg/kg	Most samples from Townsite <160 mg/kg total arsenic	Most samples from Townsite >160 mg/kg total arsenic	Most to all samples from Townsite core area substantially >160 mg/kg total arsenic
	Substrate quality in Baker Creek	What was quality of Baker Creek substrates at bottom of creek? Were they above the aquatic life guideline for total arsenic?	Sediment chemistry sample from Baker Creek on site is greater than aquatic life guideline of 17 mg/kg dry weight total arsenic	Most samples in creek on site ≤17 mg/kg total arsenic (dry weight)	Most samples in creek on site >17 mg/kg total arsenic (dry weight)	Most samples in creek on site substantially >17 mg/kg total arsenic (dry weight) and occur on more than one sampling program
	Tailings Containment Area dam stability	Did the annual dam inspection show compliance with Canada Dam Association requirements? Were dams stable? Were maintenance/repairs completed when required?	Annual dam inspection reports, records of repairs by qualified professional	Compliance with Canadian Dam Association requirements, dam stable, maintenance done as and when required	Compliance with most of Canadian Dam Association requirements, dam stable, maintenance not completed in timely manner	Out of compliance with Canadian Dam Association requirement on more than one occasion, maintenance not completed in timely manner

Table B-1 Indicators and Evidence for Each Rating Applicable from 2015 to 2021

ENVIRONMENTAL COMPONENT	INDICATOR	INFORMATION USED TO RATE STATUS OF ENVIRONMENT	TYPE OF DATA	GREEN RATING	YELLOW RATING	RED RATING
Land (including Infrastructure)	Pit safety	Was maintenance/ monitoring required? Were access controls in place?	Documentation of pit inspections by qualified professional and maintenance activities; review of access controls/ signage	Inspections completed consistently and documented, and access secure	Inspections completed, but not consistently and/or documented; rock fall in pit walls not addressed or access control/ signage not visible / not maintained	Inspections not completed; hazards not mitigated or not known by workers in area; access control/signage not visible / not maintained
	Foreshore Tailings Area in Yellowknife Bay	Was the existing foreshore cover stable? Were there local signs of erosion outside of the cover?	Annual geotechnical inspection by qualified professional with results on stability, erosion, and maintenance	Results listed as stable without erosion visible outside of the cover	Results listed as stable with erosion visible outside of the cover	Results listed as unstable with erosion present

Note: green:yellow and yellow:red ratings were based on evidence from various locations across site.

a) From 2015 to September 2020 of this reporting period, the GMRP operated the effluent treatment plant to meet the discharge limits (effluent quality criteria) of expired Water Licence #N1L2-0043. From September 2020 onward, the GMRP operated under a new Water Licence with updated effluent quality criteria (#MV2007L8-0031).

b) Site-specific water quality objectives for Yellowknife Bay near site were approved in the Effluent Quality Criteria Report.

c) The Government of the Northwest Territories remediation objective at the time of the development of the Giant Mine environmental assessment and final closure plan was 340 mg/kg arsenic for industrial use and 160 mg/kg for residential use. These are site-specific human health-based soil quality remediation objectives for the Yellowknife area. These are now the approved closure plan standards for the remediation.

GMRP = Giant Mine Remediation Project; SNP = Surveillance Network Program; MDMER= Metal and Diamond Mining Effluent Regulations; % = percent; mg/kg = milligrams per kilogram; mg/L = milligrams per litre; µg/L = micrograms per litre; < = less than; ≤ = less than or equal to; > = greater than.

Appendix C

Overview of Ratings of Status of Environment by Component

The rating for each indicator for each environmental component is listed in Table C-1. Individual tables are provided in Chapters 3 through 7 but are summarized here for ease of reference.

Table C-1 Summary of Status of Environment for each component for 2015 to 2021

COMPONENT	INDICATOR	EVIDENCE	STATUS FOR 2015–2021[a]
Climate Change	No indicator for this report, but under review to determine if one can be developed in future years. Water flows, precipitation, air temperature and greenhouse gas data are provided in Chapter 3.		
Air	Dust on site	Dust was observed on site in a few cases and action needed to be taken; overall dust was limited to the site and rare exceedances of the air quality criteria occurred[b]. Measured dust particles were overall low on site except in 2017 during regional forest fires.	
	Dust at community stations	Measured dust particles were low at community stations except in 2017 during regional forest fires. Community air quality monitoring stations were below the ambient air quality criteria[b]	
Water	Water quality on site and in Baker Creek	Water in Baker Creek on site: had arsenic that was higher than upstream of the site when effluent was being discharged, but remained within the national regulation for metal mines. Treated effluent: met licensed discharge criteria almost all of the time[c]	
	Water quality in Yellowknife Bay	Arsenic was often less than current drinking water quality standard and always less than the site-specific water quality objective.	
Fish	Fish food in Baker Creek	Benthic invertebrates (fish food) were present, and creek had similar amounts but not all the species as reference area.	
	Fish in Baker Creek	Numerous fish species were present, but fish sizes were not the same as in reference area; eating fish from creek did not pose a risk to humans.	

Table C-1 Summary of Status of Environment for each component for 2015 to 2021

COMPONENT	INDICATOR	EVIDENCE	STATUS FOR 2015–2021[a]
Land (including infrastructure)	Soil quality in developed areas	On average, soils had total arsenic more than the approved closure plan standard of 340 mg/kg for the site.	
	Soil quality in bedrock, forest, wetland areas	On average, soils had total arsenic more than the approved closure plan standard of 340 mg/kg for the site.	
	Soil quality in Townsite	On average, soils had total arsenic more than the approved closure plan standard of 160 mg/kg for the Townsite.	
	Substrate quality in Baker Creek	Baker Creek substrates (sediment) at bottom of creek were elevated in metals and above the aquatic life guideline for total arsenic.	
	Dam stability	The annual dam safety inspection showed compliance with Canada Dam Association requirements. Dams were stable. Maintenance/repairs are completed when required.	
	Pit safety	Pit walls maintenance/monitoring is required; signs/fences/access control are in place, but there was a hazard to human health and wildlife health. C1 buttress was constructed to limit Baker Creek water entering pit; an informal process is in place to limit access before an activity near/in a pit but not always documented consistently.	
	Foreshore Tailings Area in Yellowknife Bay	The condition of the existing foreshore cover was stable. There were signs of erosion of tailings in the bay past the cover.	
Wildlife	No indicator for wildlife was identified due to two factors 1) wildlife on site is influenced by the nearby developments (e.g., highway, City of Yellowknife and its Solid Waste Facility) and 2) data (e.g., observations of wildlife by workers on site) were intermittent and not collected in the same locations over time. It was not possible to develop a meaningful indicator of the status of wildlife on site independent of other influences and with the type of data available. However, a summary of the wildlife data is provided (Chapter 8).		

[a] Status of Environment was rated as per method in Appendix B and evidence provided in each chapter.

[b] Refer to the Air Quality Monitoring appendix of the Dust Management and Monitoring Plan.

[c] From 2015 to September 2020 of this report period, the GMRP operated the effluent treatment plant to meet the discharge limits (effluent quality criteria) of expired water licence #N1L2-0043. From September 2020 onward, the GMRP operated under a new water licence with updated effluent quality criteria (#MV2007L8-0031).