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GIANT MINE REMEDIATION PROJECT

Closure and Reclamation Plan

January 2019

Ver 1.0

PLAIN LANGUAGE SUMMARY

This section provides a Plain Language Summary of the Giant Mine Closure and Reclamation Plan (CRP), part of the Giant Mine Remediation Project. The Plain Language Summary is for both non-technical readers and for those looking for an overview of the CRP. For more information and technical details relating to the CRP, please see Chapter 5 of this document.

Introduction

The CRP explains how the Site will be closed, including the actions for remediation and those for future management. The CRP was developed following closure guidelines for the Northwest Territories. The CRP will need to be approved by the Mackenzie Valley Land and Water Board before the remediation can proceed.

Giant Mine Remediation Project Location

The Giant Mine is located near Yellowknife, Northwest Territories. It is 1.5 kilometres from the community of Ndilǫ and 9 kilometres from the community of Dettah.

The mine site has:

- eight open pits
- an underground mine with an arsenic trioxide storage area
- tailings containment areas and associated dams
- a tailings retreatment plant (not operating)
- an effluent treatment plant (currently operating)
- a mill with several warehouses
- a townsite and other infrastructure (roads, debris areas, buildings)

Baker Creek flows through the Site from spring until fall, and has one ponded area, known as Baker Pond.

Closure Goals, Objectives, and Criteria

The overall goals for the Giant Mine Remediation Project are to:

- minimize public and worker health and safety risks
- minimize the release of contaminants from the Site into the environment
- remediate the Site in a way than inspires public trust
- implement an approach that is cost-effective and robust over the long term

An important part of the Giant Mine Remediation Project includes setting clear aims for a successful closure, called “closure objectives”. For example, a closure objective for water quality is that discharge meets approved limits, which protect people and the environment. The closure activities are such that they will confirm that those objectives are met. Giant Mine Remediation Project has also set specific and measurable targets or standards for

achieving closure objectives, called “closure criteria.” For example, a closure criterion for water quality is that the limit of arsenic to be released from the new water treatment plant is 10 parts per million. Each part of the Site has closure objectives and criteria.

Community Engagement

Ongoing engagement and regular consultation with local Indigenous Government or organizations and other affected parties has helped develop the CRP. Design decisions have been made considering feedback received during engagement. The Giant Mine Remediation Project will continue to work with affected parties and communities to inform them of Site activities and allow for continued input throughout the project.

Description of Closure Activities

The CRP has been divided into the following 10 major site components:

1. Underground mine workings
2. Freeze program
3. Open pit mine workings
4. Contaminated soils and sediments
5. Baker Creek and surface water drainage
6. Tailings Containment Areas
7. Borrow material
8. Water treatment plant and outfall systems
9. Buildings and site infrastructure
10. Landfill

An overview of how each of these components will be addressed is presented in the following sections.

1. Underground Mine Workings

Gold was mined by excavating rock and moving the rock through a large network of underground openings, tunnels and shafts. Some of these tunnels are near the surface (both within and outside the pits) and some are directly underneath Baker Creek. Instability in any of these tunnels or shafts may result in cave-ins. These cave-ins can result in depressions at the ground surface (sinkholes), which may be a safety risk for people and wildlife. If a cave-in occurs under Baker Creek, then water could enter the underground mine and become contaminated.

The closure activities for the underground mine workings include:

- Stabilizing the underground
  - Where there is a risk of sinkhole formation, backfilling the tunnels and shafts with various materials will reduce the risk. The backfilling will be done with a mix of mine waste rock and tailings. Sometimes cement will be added to the tailings to give it some strength. This material is called paste backfill.
- Closing openings to surface
  - The openings to surface will be sealed. Openings within pits will be blocked and sealed by adding rock fill, or by plugging the opening with paste backfill. Vertical surface openings will be sealed with a concrete cap and horizontal surface openings will be filled with waste rock or plugged with concrete or cemented paste.
- Maintaining the minewater level
  - Ongoing pumping will be used to maintain the water at its current level in the mine, which is below the arsenic trioxide storage areas. The option to increase the water level is being researched, as raising the water level would reduce long-term care and maintenance needs such as pumping and treating water. Higher water levels may also increase physical stability underground.
- Creating a long-term access portal
  - Once the underground has been stabilized, a new access to provide safe, long-term access to the underground mine will be built so workers can get in and out of the mine, if needed.

2. Freeze Program

Approximately 237,000 tonnes of arsenic trioxide dust is stored underground at the Site. It is necessary to contain the dust and separate it from water, as it can dissolve and is toxic to humans and the environment.

Arsenic trioxide dust was made during the roasting of the ore in processing.

Several options to manage the dust were considered. These options included removing the dust or keeping it in place. The decision to keep the dust in the underground and freeze it in place was made with input from communities, government and independent experts. There is still the opportunity to remove the dust in the future if an appropriate technology is identified and this is being examined by the Giant Mine Oversight Board.

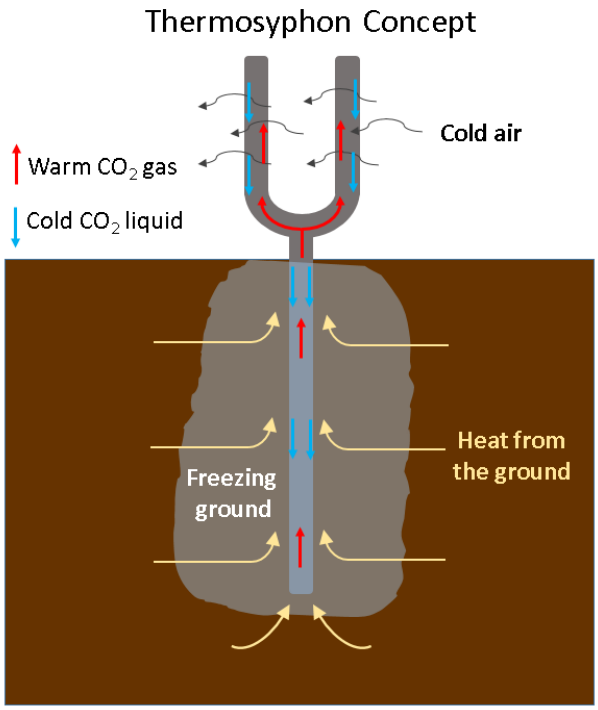
The freeze process uses devices called “thermosyphons” (described below) to promote freezing of the ground. The effectiveness of thermosyphons has been demonstrated at many sites in the north, including a test site that was constructed around one of the arsenic chambers and operated at Giant Mine from 2010 to 2015.

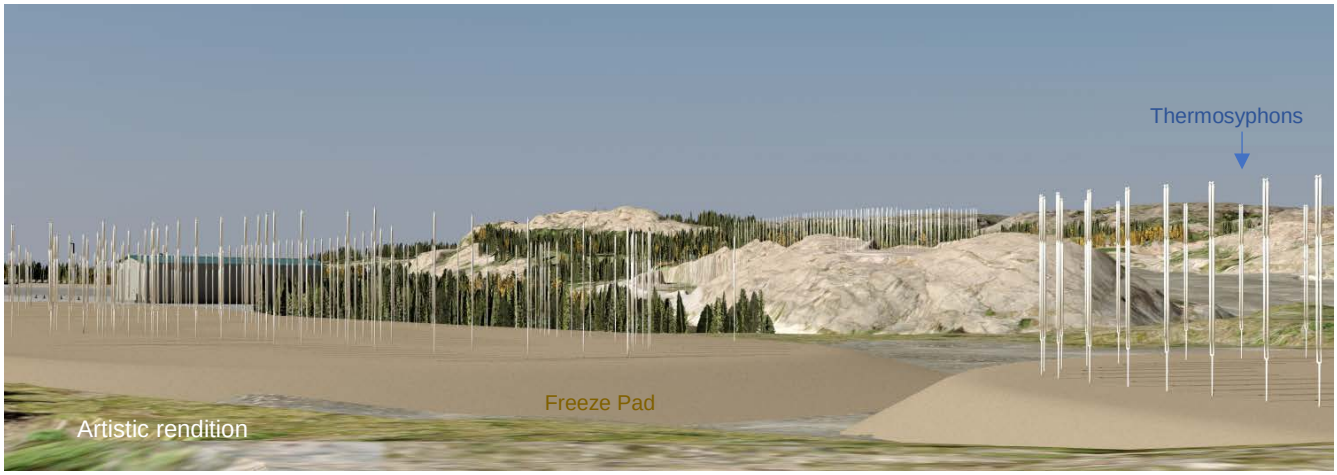
The following closure activities are part of the freeze program:

- Preparing the freeze area
  - The surface of the ground must be prepared for the freeze. This will include building access roads, levelling the ground, and providing power. Roads and power will also be needed for maintenance and monitoring the thermosyphons once they begin to work.
- Freezing the ground
  - Thermosyphons will be placed into the ground around the arsenic storage areas.

Thermosyphons are pipes filled with carbon dioxide (CO_2) gas that have a portion of the pipe sticking out above the ground surface as shown in the image.

Thermosyphons freeze the ground by having the heat from the ground warm the CO_2 in the bottom portion of the pipe. As the CO_2 gas warms, it rises until it reaches the length of the pipe that is sticking up into and exposed to the cold winter air. As winter air cools the gas, it condenses to a liquid. The cooled CO_2 then flows back down to the bottom of the pipe, where it is again heated by the ground, evaporates and rises to the top of the pipe. This process continues as long as the air is cold enough to condense the gas and the ground is warm enough to evaporate it. When the air temperature gets warmer than the ground, the process temporarily stops. In Yellowknife, even with predicted global warming, there is more winter cooling time than summer shutdown time during any full year so over several years, the ground cools gradually and then stays frozen.





- Ground around the thermosyphons will gradually freeze. Any water flowing into the frozen area will freeze, creating a barrier of ice in a self-sealing wall that will stop water flow from reaching the dust. A portion of B1 Pit will also be frozen so that contaminated material can be stored in the pit safely.

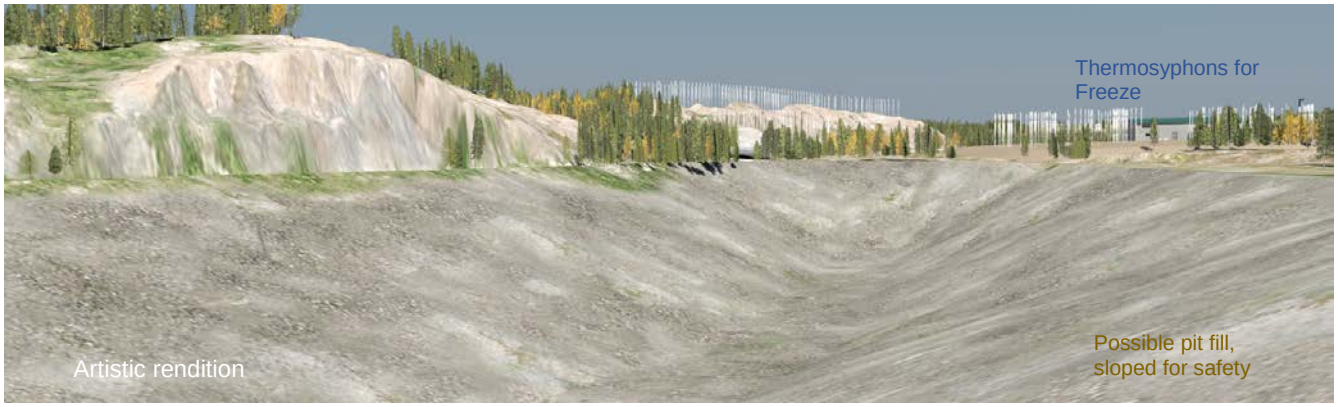
3. Open Pits and Mine Workings

Eight open pits were mined during operations. The steep slopes of open pits create risks. People or animals could fall into the pit if they are not aware of the cliff. An additional risk at Giant is that Baker Creek could flood over its banks into some of the pits and flow down into the underground where it could wet the arsenic trioxide chambers before freezing has completed. This could allow the arsenic to be released into the environment.

During engagement many affected parties preferred options that filled the pits. Based on this input and technical considerations such as flood risk and having a good location for the disposal of contaminated materials, it was determined that the pits would be filled.

The closure activities for open pits include:

- Filling the pits with clean rock and/or contaminated soil and waste rock
  - Some pits may not be filled all the way to the top but will be filled enough to reduce safety risks and confirm that flood water cannot enter the pits.
  - Some pits may need berms to direct flood water away and/or a cover to provide extra protection from water seepage into the pits.



4. Contaminated Soils and Sediments

Contaminants from the roaster stack, releases of tailings, and other mine activities introduced arsenic contamination into soils and sediments at the Site. Other contaminants of concern include fuel contamination in soils near old fuel storage tanks.

A risk assessment confirmed when the Giant Mine clean-up is done, it would result in low risk to people.

During engagement, affected parties were clear that selected options for contaminated soils and sediments must protect people, animals and the environment and the risks must be clearly communicated. Different options were decided for different areas of the Site based on input from affected parties. A risk assessment was completed and confirmed that the selected options in the CRP for contaminated soils and sediments will result in low risks to people and risks to small animals that will be monitored.

The closure activities for contaminated soils and sediments include:

- Excavating and safely disposing of contaminated soils
  - Contaminated soils around the former mill and roaster building with the highest concentrations of arsenic will be disposed in the freeze area.
  - Contaminated soils located in other areas developed by the mine will be disposed in the pits or the Tailings Containment Areas.
  - Excavated areas will be backfilled with about half a metre of clean material and shaped to support drainage.
  - Government standard to be used includes remediation to residential standards for arsenic and fuel in soils in the Townsite and Marina areas, and industrial standards elsewhere in the developed areas of the Site.

- Capping areas where contamination is deep
    - There are areas of contaminated soils where the contamination is greater than 2 metres. In these areas, the contaminated soil will be capped to reduce the risk of human or wildlife contact with the contaminated soil.
- Building a fence around areas with high arsenic concentrations in bedrock, forest and wetlands
    - In bedrock, forest and wetlands areas, removing contaminated soil would cause a lot of disruption to those areas and be very difficult to do. In these areas human health will be protected by a fence to restrict access.
    - Excavating the contaminated sediment in Baker Pond, Jo-Jo Lake and Baker Creek.
    - The excavated sediment will be disposed in the Tailings Containment Areas (TCA).
    - In Baker Creek and Baker Pond the sediment will be replaced with clean material and new vegetation. Parts of Baker Pond may be turned into a wetland, which might also help clean the creek water; more research into wetlands is planned.
- Excavating and/or capping the nearshore sediments located near the Townsite and Marina area
- Excavating areas with tailings solids in the area near Dam 3 of the TCA
    - Yellowknives Dene First Nation members identified the area northeast of TCA Dam 3 as an area of concern due to past tailings spills and pond water releases. More research will be completed to understand the contamination in this area and how to remediate it.

Baker Creek and Surface Water Drainage

Baker Creek is a spring spawning stream for Arctic Grayling and Longnose Sucker. Other fish such as Northern Pike live there from spring until fall. During mining, several parts of Baker Creek were moved so open pit mining could happen. Sediments and water in Baker Creek has been contaminated by mining activities.

In its current route, there is a risk that in a large flood event, Baker Creek could overflow and flood some of the pits and then the underground. Various options for addressing both the flood risk and the historical contamination issues in Baker Creek have been engaged on with affected parties. This includes options for moving the creek either to a different location on-site or moving it completely off-site, re-shaping the creek so that it can handle larger flood events without overflowing, and various options for its final path through the Site. Together with affected parties the decision was made that Baker Creek would remain on-site, with slight changes to its path.

The closure activities for Baker Creek include:

- The Baker Creek area (flood plain) will be widened, to handle larger flows without overflowing the banks of the creek.
- Portions of the creek will be re-aligned.
- Contaminated sediments along the entire Baker Creek will be removed.

Additional meetings with affected parties are planned to help design the details of fish habitat that could be built in the creek once the contaminated sediment is removed.

Rainfall and snowmelt at the Site generate surface water runoff. Much of the runoff generated at the Site currently comes into contact with soils or waste that has been contaminated by arsenic, and this may contaminate the water. As a result, water is currently controlled and pumped to the treatment system to reduce the contamination going to the environment. Once the Site remediation works have been done, much of this surface water will no longer require treatment, and natural water flow to Baker Creek can resume. Runoff from areas such as the covers on tailings, may take some time to become clean. This water will be treated until it can be shown that the water does not require treatment and can flow to Baker Creek.

5. Water Treatment Plant and Outfall Systems

The existing plant only operates during the summer. Minewater pumped out of the underground goes to the Northwest Pond to be stored while waiting for treatment. Any surface water requiring treatment also is pumped here, and then to the plant for treatment. Treated water is then released to Baker Creek.

The plan is to build a new and better water treatment plant. When it is running, treated water will no longer be released into the creek.

Options for treating contaminated water generated on the Site have been evaluated including both the requirements from the environmental assessment process and technical work and engagement with affected parties. Based on input from affected parties, the location of the treated water into Yellowknife Bay was chosen to be near-shore and near the mouth of Baker Creek. This was chosen so the potential for thin ice would be near shore and close to an area already impacted by Baker Creek.

This resulted in the following closure activities:

- A new water treatment plant and treatment and release of water
    - The selected design will remove more arsenic from the water than the current plant and meet drinking water levels.
    - The new water treatment plant will operate year round.
    - Instead of releasing directly to Baker Creek, the release of treated water will occur as part of an outfall (a pipe carrying treated water) into Yellowknife Bay near the mouth of Baker Creek.

Once the new water treatment plant is operating, water will no longer need to be stored in various ponds on Site. The underground parts of the mine will be used for water storage.

6. Tailings Containment Areas

Tailings are small rock particles left over after grinding rock to remove the gold from the ore. The tailings contain higher concentrations of arsenic. There are four tailings areas, these are the South Pond, Central Pond, North Pond, and Northwest Pond. There is also the Foreshore Tailings Area, where tailings were deposited along the shore without dams to contain them in the early days of mining.

Options for the closure and reclamation of the tailings were evaluated, including different types of covers for the tailings and options for relocation of the tailings, such as moving them to pits, or consolidating them within a smaller area. Based on a combination of input from engagement with affected parties and technical evaluations, the following closure activities were selected:

Tailings are small rock particles left over after grinding rock to remove the gold from the ore.

- South Pond Relocation
  - The South Pond tailings and contaminated soils downstream of the dam will be relocated to North and Central ponds. This will reduce the total footprint size of the tailings.
  - A dam will be left in place to help catch surface water runoff until the water quality consistently meets the runoff discharge criteria. The dam will then be decommissioned.
- Waste placement in tailings containment areas
  - Some contaminated soils will be disposed of in the tailings containment areas prior to cover placement.
- Covers and Surface contouring
  - An engineered cover will be placed on top of all the tailings ponds. The cover will be made of a synthetic liner covered by sand and rock. The crushed rock will isolate the tailings, minimize erosion, reduce vegetation growth and not encourage future use of tailings areas.
  - Water will be drained to make the tailings more stable and easier to shape.
  - The tailings and waste surface will be shaped to promote drainage.
- Spillway construction
  - Spillways will be constructed at the edge of the covered tailings containment areas to drain water from the surface.
  - Initially the runoff water will be held in storage ponds and treated if required until the water quality meets the standards needed for release to the environment.
- Dam improvements
  - Where needed, existing dams will be re-enforced to make them safer. Instrumentation installed on the tailings containment areas and the dams will help to monitor their condition and performance.

- Foreshore Tailings Cover
  - The existing cover over the Foreshore Tailings Area will be extended to minimize further disturbance of the tailings in Yellowknife Bay.

7. Borrow Material

To carry out the closure activities described in this plan, a large amount of rock fill, gravel and smaller material will be required. This will include material for filling pits and constructing covers around the Site.

Borrow material will be used for pit fill, and the construction of covers and the freeze pads.

Some of the activities planned for closure, such as recontouring pit slopes, re-aligning Baker Creek, and constructing spillways will require excavation and blasting. The material generated from these activities will be used to meet some of the demand for borrow material.

These activities will not generate all the borrow material needed for the closure. The additional borrow material needed will come from within the mine property. Some borrow will be dug up and some will be blasted. To find the most suitable locations for these excavations, additional investigations will be carried out of the physical and chemical properties of the rock as well the locations of archaeological artifacts.

The areas where borrow is to be excavated will be designed to limit the impact of borrow extraction on the surrounding landscape. Further consultation will be conducted with respect to the location and final shape of the borrow areas. Engineering design of the borrow areas will also be conducted to form areas that blend with the existing landscape.

Some borrow areas will be excavated down to bedrock. Others may leave soil exposed after excavation. Where soil is exposed after the completion of excavation, native plants will be used to vegetate exposed areas and control erosion. Throughout the Site, vegetation will only be planted where necessary to prevent wearing away of soil.

8. Buildings and Site Infrastructure

Site infrastructure includes site buildings, structures, roads, utilities, debris, and existing waste disposal locations. The plan is to deconstruct, decontaminate, and remove from the Site all infrastructure with no future use. This includes:

- removal of around 101 structures from mining activities
- removal of 25 areas of debris and stockpiled waste
- removal of utilities, site access roads, and fencing that are no longer needed

The types of waste produced and the corresponding disposal locations are:

- hazardous wastes—removed off-site for disposal in an authorized facility
- arsenic wastes—to be disposed of in the freeze zone
- non-hazardous wastes—to be disposed of in the on-site landfill (discussed below)

Some infrastructure will remain in place or will be built for closure activities and long-term Site management. Some of the newly built infrastructure to support closure will include fencing, signage, security, roads, and utilities. A commemorative plaque, monument, or memorial is planned.

9. Non-hazardous Waste Landfill

A landfill will be constructed on the Site for non-hazardous waste generated during the Giant Mine Remediation Project. Various options for the location and configuration of the landfill were evaluated and discussed with affected parties. The landfill location was chosen to:

- avoid new land disturbance
- be away from waterbodies
- be large enough to dispose of predicted waste volumes
- minimize waste haulage distances
- not disturb culturally valued areas

For the selected design:

- The landfill will contain two cells:
    - The first cell will contain waste consisting of remaining site debris and wastes from the demolition of various buildings and other infrastructure. This cell will be closed and covered once the related activities are completed.
    - The second cell will contain dewatered sludge from the new water treatment plant (process residuals).
- Once the landfill cells are full, a liner with a one-metre thick layer of clean material will cover them. The surface will blend in with the surrounding landscape and will be shaped on the surface so that clean water from rain and snowmelt flows off the landfill cells.

Post-closure Monitoring and Maintenance

Once closure actions are complete in an area of the site, site monitoring will help to confirm the activities have been successful.

Monitoring programs will measure the success in meeting each of the closure goals in the CRP. Monitoring for some items, such as water treatment and the freeze program, will happen into the long term. Other items may be monitored for a shorter term, as long as needed to show that the closure objective has been met for that item. Regular reporting on the monitoring results will continue to affected parties as long as monitoring is conducted.

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Appendix 5.7A Supplemental Borrow Source Identification Report
Appendix 5.8A Water Treatment Plant Preliminary Design Report
Appendix 5.8B New Effluent Treatment Plant – Outfall Location Options Analysis
Appendix 5.9A Preliminary Design Report for Surface Demolition and Debris Removal
Appendix 5.10A Non-Hazardous Waste Landfill Preliminary Design Report
Appendix 5.10B Location Study For Non-hazardous Waste Landfill

List of Acronyms and Abbreviations

Acronym/Abbreviation	Definition
3D	three-dimensional
AANDC	Aboriginal Affairs and Northern Development Canada
AECOM	AECOM Canada Ltd.
AEMP	Aquatic Effects Monitoring Plan
AQMP	Air Quality Monitoring Program
ARD	acid rock drainage
AST	aboveground storage tank
As(III)	Arsenite
As(V)	Aresnate
As_2O_3	Arsenic trioxide
ATV	all-terrain vehicle
bgs	Below ground surface
CanNorth	Canada North Environmental Services
CCME	Canadian Council of Ministers of the Environment
CDA	Canadian Dam Association
CIRNAC	Crown-Indigenous Relations and Northern Affairs Canada
CO_2	carbon dioxide
CRP	Closure and Reclamation Plan
DAR	Developer's Assessment Report
DBR	design basis report
DFO	Fisheries and Oceans Canada
DIAND	Department of Indian Affairs and Northern Development
e.g.	for example
EA	Environmental Assessment
ECCC	Environment and Climate Change Canada
EEM	Environmental Effects Monitoring
ENR	Environment and Natural Resources (GNWT)
EPT	Ephemeroptera, Plecoptera, and Trichoptera
EQC	Effluent Quality Criteria
ESP	electrostatic precipitator (Cottrell precipitator)
ETP	effluent treatment plant
et al.	and others (Latin: et alia)
FeAsS	arsenopyrite
FOS	Freeze Optimization Study
GMAC	Giant Mine Advisory Committee
GMOB	Giant Mine Oversight Board
GMRP	Giant Mine Remediation Project
GNWT	Government of the Northwest Territories
Golder	Golder Associates Ltd.
GSSC	Great Slave Sailing Club
GU	general use
GYML	Giant Yellowknife Gold Mines Ltd.
HDPE	High-Density Polyethylene
HHERA	Human Health and Ecological Risk Assessment

Acronym/Abbreviation	Definition
i.e.	that is (Latin: id est)
INAC	Indigenous and Northern Affairs Canada
IPRP	Independent Peer Review Panel
L	Minewater level (e.g., 750L).
LiDAR	Light Detection and Ranging
Ltd.	Limited
LTMP	Long-Term Monitoring Program
MAA	Multiple Accounts Analysis
MBCA	*Migratory Bird Convention Act*
MCM	Main Construction Manager
MDMER	Metal and Diamond Mining Effluent Regulations
MGML	Miramar Giant Mine Limited
MMER	Metal Mining Effluent Regulations
MSA	Material Storage Area
MVLWB	Mackenzie Valley Land and Water Board
MVEIRB	Mackenzie Valley Environmental Impact Review Board
n/a	not applicable
NHW	non-hazardous waste
NO_2	Nitrogen Dioxide
NOx	Nitrogen Oxides
NSMA	North Slave Métis Alliance
NT/NWT	Northwest Territories
NTU	Nephelometric Turbidity Unit
OMP	Operational Monitoring Program
PCB	Polychlorinated Biphenyl
PCMMP	Post-closure Monitoring and Maintenance Plan
PEL	Probable Effects Level
PHC	petroleum hydrocarbon
PM	particulate matter
PM_{10}	particulate matter with a mean diameter less than 10 µm or smaller
$PM_{2.5}$	particulate matter with a mean diameter less than 2.5 µm or smaller
PMF	probable maximum flood
PMP	probable maximum precipitation
POPC	parameter of potential concern
PPE	personal protective equipment
PSPC	Public Services and Procurement Canada
QA/QC	quality assurance / quality control
QRA	Quantitative Risk Assessment
RBAL	Risk-Based Action Limits
Report of EA	Report of Environmental Assessment and Reasons for Decision
RSSI	Risklogic Scientific Services Inc.
SARA	*Species at Risk Act* (Canada)
SDE	Surface Design Engagement
SENES	SENES Consultants Limited
Site	Giant Mine
SLR	SLR Consulting (Canada) Ltd

Acronym/Abbreviation	Definition
SNP	Surveillance Network Program
SO_2	sulphur dioxide
spp.	Subspecies
SSP	Site Stabilization Program
SRK	SRK Consulting Inc.
SSP	Site Stabilization Plan
TCA	Tailings Containment Area
TDS	total dissolved solids
TRP	tailings retreatment plant
TSP	total suspended particulate
UST	underground storage tank
WMO	World Meteorological Organization
WSC	Water Survey of Canada
WTP	water treatment plant
ww	wet weight
YKDFN	Yellowknives Dene First Nation
YKDFNLEC	YKFDN Land and Environmental Committee

List of Units and Symbols

Unit/Symbol	Definition
%	percent
<	less than
°	degree (angle)
°C	degrees Celsius
" (double prime symbol)	second (angle)
' (prime symbol)	minute (angle)
#	number
$	dollars
µg/g	microgram per gram
µg/L	micrograms per litre
µg	microgram
µm	micrometre
µS/cm	microsiemens per centimetre
amsl	above mean sea level
Bq/L	becquerels per litre
cm	centimetre
d	day
dB	decibel
ft	foot
g	gram
h	hour
ha	hectare
hp	horsepower

Unit/Symbol	Definition
Hz	hertz
kg/yr	kilograms per year
kg	kilogram
kHz	kilohertz
km/h	kilometres per hour
km^2	square kilometre
km	kilometre
kV	kilovolt
kW	kilowatt
kWh	kilowatt hour
L	litre
lb	pound
m^2	square metre
m^3	cubic metre
m^3/s	cubic metres per second
m	metre
mbgs	metres below ground surface
m/s	metres per second
mg	milligram
mg/kg	milligrams per kilogram
mg/L	milligrams per litre
mg-N/L	milligrams nitrogen per litre
mg-P/L	milligrams phosphorus per litre
MHz	megahertz
mi	mile
min	minute
mL	millilitre
ML	megalitre
mm	millimetre
mo	month
mV	millivolt
ng	nanogram
nm	nanometre
oz	ounce
ppm	parts per million
qt	quart
s	second
t	tonne
V	volt
W	watt
yr	year

Glossary of Terms

Acid rock drainage (ARD)	The outflow of acidic water from metal mines or coal mines that forms when certain minerals are exposed to air.
Arsenic trioxide	A poisonous, white amorphous powder with the chemical formula As_2O_3.
Arsenopyrite	An iron arsenic sulphide with the chemical formula FeAsS; often associated with refractory gold deposits.
Backfill	Material used to refill an excavation.
Bedrock	Consolidated rock underlying the Earth's surface.
Borrow	Fine to coarse materials quarried on Site or imported to support construction.
Bulkhead	A water-resistant seal used in a mine where a wall is constructed across an access point.
Calcine	The residual product from roasting sulphide concentrates.
Chamber	Purpose built underground opening to store arsenic trioxide.
Closure Guidelines	The 2013 Guidelines *for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories* provided by Aboriginal Affairs and Northern Development and the Mackenzie Valley Land and Water Board. The Closure Guidelines outline expectations for closure and reclamation planning.
Contaminated fine-grained soil	Natural surficial deposits containing silt and clay, little to some sand. This material is located within the Developed Areas, below contaminated granular fill. Within the bedrock/forest/wetland terrain, this material is typically overlain by an organic peaty soil of variable thickness. Contaminant sources may include: arsenic leaching from overlying contaminated granular fill and/or petroleum hydrocarbons within the Developed Areas; and roaster stack emissions within the bedrock/forest/wetland terrain. Contains total arsenic concentrations greater than 340 mg/kg for Site and greater than 160 mg/kg within the Townsite/Marina and/or petroleum hydrocarbon concentrations greater than Environment and Natural Resources Guidelines.
Contaminated granular fill	Sand and gravel; minor to some silt and clay; occasional to frequent angular cobbles and boulders. Contaminant sources may include: mineralized waste rock; tailings; ore; roaster stack emissions; and/or petroleum hydrocarbons. Contains total arsenic concentrations greater than 340 mg/kg for Site and greater than 160 mg/kg within the Townsite/Marina and/or petroleum hydrocarbon concentrations greater than Environment and Natural Resources Guidelines. A subset of this material contains total arsenic concentrations greater than 4,500 mg/kg. This material is found in the mill/roaster area and is referred to as heavily contaminated. The primary contaminant source is roaster stack emissions.
Contaminated sediment	Coarse sand and silt, which grades towards a finer sand and silt with depth. Contaminant sources may include: effluent derived from tailings containment areas; minewater discharged from underground; tailings; historical mill/roaster operational process upsets; and roaster stack emissions. Concentrations of total arsenic greater than 150 mg/kg for Site.
Crown pillar	The mass of bedrock overlying an underground excavation, such as a stope.
Developed Areas	Developed Areas were developed to support mining operations (i.e., mill/roaster area, tailings retreatment plant, Townsite/Marina, roadway network, and various laydown and material storage areas). These areas were constructed primarily with mineralized granular material and, as a result, soil conditions typically consist of contaminated granular fill, underlain by natural fine-grained soil, and bedrock.
Drift	A near-horizontal passageway in a mine, typically following an ore body.
Effluent	Liquid wastes that are discharged into the environment, such as treated industrial wastewater or sewage.

Ex situ	Meaning moved from its original place.
Foreshore	The area between the water edge and high water mark.
Freeboard	The height of the watertight portion of a building or other construction above a given level of water in a river, lake etc.
Geotextile	Fabrics which are used in civil engineering applications for soil protection, and reinforcement.
Human Health and Ecological Risk Assessment (HHERA)	The process of estimating the potential risk of contaminants on a human population and environmental indicators under defined conditions.
In situ	Meaning in its original position or place.
Mineralized waste rock	Rock or overburden that has been excavated without being processed, which may contain traces of metals like arsenic
Ore	Naturally rock or sediment that contains minerals that can be economically mined.
Overburden	Weathered rock and/or soil overlying solid bedrock.
Paste	Tailings mixed with cement used to backfill underground openings.
Permafrost	Perennially frozen ground occurring wherever the ground temperature remains below zero degrees for several years.
Petroleum hydrocarbons (PHCs)	Complex mixtures of hydrocarbons that are found in gasoline and diesel that refined from crude oil.
Pillar	Un-mined rock left behind to support the roof and walls of an underground excavation or void.
Polishing Pond	The last in a series of settling ponds through which effluent flows before being discharged into the natural environment.
Portal	The point of connection between ground surface and underground development openings, or the entrance to underground from ground surface.
Probable Maximum Precipitation	The greatest amount of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of year.
Probable Maximum Flood	Largest flood that could conceivably occur in a particular location.
Raise	A vertical or inclined excavation that leads from one level, or drift, to another, and may also extend to the surface.
Ramp	An inclined development opening excavation to connect underground mine openings on different levels.
Remediation	The removal, reduction, or neutralization of substances, wastes or hazardous material from a site so as to prevent or minimize any adverse effects on the environment now or in the future.
Residual effect	An environmental effect that remains, or is predicted to remain, even after mitigation measures have been applied.
Riprap	Rock or other material used to armour shorelines, streambeds, bridge abutments, pilings and other shoreline structures against scouring from water or ice.
Roaster	The mine infrastructure where the roasting of the ore takes place.
Settling Pond	An earthen structure that promotes sedimentation to remove particulates and turbidity from treated minewater.
Shaft	A vertical development opening excavated to provide mine access from ground surface.
Sludge	A generic term for solids separated from suspension in a liquid.
Stope	Large underground open space or cavity left after ore has been mined out.
Tailings	The fine waste material left over after the ore milling process.
Thermosyphon	A device that carries out passive heat exchange based on natural convection.
Total suspended solids	A measurement of the concentration of particulate matter found in water.
Vulnerable topography	Landforms or infrastructure that are susceptible to flooding either because they are in a flow path, are easily erodible or have high value aesthetically or for the community and require protection from flooding

Waste rock	Rock (angular boulders and cobbles) excavated from the mine in the pits or the underground that has not been processed. May be mineralized with arsenopyrite or non-mineralized.

Underground Mine Elevation Conversion Chart

Mine Level and Other Relevant Areas	Elevation at C Shaft (above mean sea level [amsl])
C Shaft collar	173
A2 rim spill point	162
Great Slave Lake	156-157
100 Level	137
250 Level	83
425 Level	33
575 Level	-13
750 Level	-67
Current managed minewater elevation	-77
Bottom of C Shaft	-474

*Note: The elevation of tracked mine levels is provided in the table is measured at C-shaft; there is variation in elevation in the tracked underground development openings (e.g. levels) as they grade towards from C-shaft for drainage purposes.

CHAPTER 1
Introduction

1 INTRODUCTION

This document presents the final Closure and Reclamation Plan (CRP) for the Giant Mine (Site). The Site is located within the city of Yellowknife boundary, approximately 1.5 kilometres (km) from the community of Ndilǫ and 9 km from the community of Dettah (Figure 1.0-1). The Site is situated on Commissioner's Land administered by the Government of the Northwest Territories (GNWT). A Reserve (R622T) has been established to allow for the implementation of the remediation of the Site. Subsurface mineral rights are under federal jurisdiction and were withdrawn by Order in Council SI/2005-55 on 15 June 2005.

The Site produced gold from 1948 until 1999 and ore for off-site processing from 2000 until 2004. In 1999, the owner of the Site went into receivership; care, custody, and control of the site was transferred to Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) and the GNWT. Ongoing care, maintenance, and remediation of the Site is known as the Giant Mine Remediation Project (GMRP).

The CRP has been developed in accordance with the *Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories* (Closure Guidelines; MVLWB/AANDC 2013). It is intended to satisfy one of the submission requirements of the Water Licence and Land Use Permit Application defined by the Mackenzie Valley Land and Water Board (MVLWB) in its request for a Post–Environmental Assessment (EA) Information Package (MVLWB 2014).

The CRP incorporates changes made to the project during and resulting from the EA process and addresses specific measures defined in the Mackenzie Valley Environmental Impact Review Board (MVEIRB) 20 June 2013 *Report of Environmental Assessment and Reasons for Decision* (Report of EA; MVEIRB 2013) and the modified measures identified by the Minister of CIRNAC (formerly Aboriginal Affairs and Northern Development Canada [AANDC]) provided with final project approval on 11 August 2014 (AANDC 2014). In accordance with the *Mackenzie Valley Resource Management Act* (S.62 ss. 130[5]; Government of Canada 1998), once the Minister has accepted the MVEIRB Report of EA, the GMRP, Government of Canada, GNWT, and regulatory authorities must confirm that any approved measure is carried out. To confirm this, a concordance assessment with various requirements including the measures is provided in the UPD (CIRNAC and GNWT 2019a).

This CRP supersedes the *Giant Mine Remediation Plan* prepared for the GMRP Team by SRK Consulting and Senes Consultants Limited (SRK/Senes 2007) submitted to the MVLWB as part of the Type A Water Licence Application (MV2007L8-0031) on 19 October 2007. Where relevant and appropriate, information and technical support documents from the 2007 *Giant Mine Remediation Plan* and the *Giant Mine Remediation Project Developer's Assessment Report* (DAR; INAC and GNWT 2010) were used to support the development of this CRP and will be referenced herein. This CRP was developed according to the MVLWB guidance for Closure and Reclamation Plans (MVLWB/AANDC 2013) and concordance to this guideline is provided in Appendix 1A.

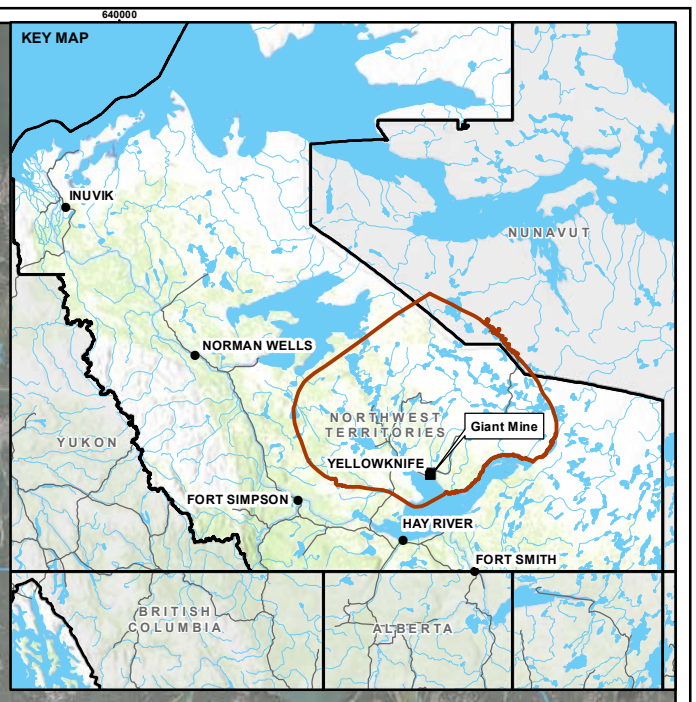
This section of the CRP describes the purpose of the document and provides a description of the proponent, a summary of engagement, and a list of the regulatory instruments applicable to the CRP.

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KEY MAP



Vee Lake
Walsh Lake
Martin Lake
North Shot Lake
Shot Lake
Trapper Lake
Yellowknife River
Gar Lake
Trapper Creek
Baker Creek
Lower Martin Lake
Pocket Lake
Baker Pond
Handle Lake
Hay Lake
Yellowknife Bay
Joe Lake
Fox Lake
Ndilǫ
Long Lake
Back Bay
Yellowknife Airport
Jackfish Lake
Niven Lake
Frame Lake
Yellowknife
Kam Lake
Dettah

LEGEND

- COMMUNITY
- GIANT MINE PROJECT BOUNDARY
- HIGHWAY
- ROAD
- WATERCOURSE
- MǪWHÌ GOGHA DÈ NJŁÈÈ BOUNDARY (SETTLED LANDS OF THE TŁJCHǪ)
- YELLOWKNIFE MUNICIPAL BOUNDARY

0 1,000 2,000

1:50,000 METRES

REFERENCE(S)

COMMUNITY, HYDROLOGY AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. MUNICIPAL BOUNDARY CONTAINS PUBLIC SECTOR DATASETS MADE AVAILABLE UNDER THE CITY OF YELLOWKNIFE'S OPEN DATA LICENSE V.1.
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-22
DESIGNED	HM
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

REGIONAL LOCATION OF GIANT MINE

REV. 0

FIGURE 1.0-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

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1.1 Purpose and Scope

The CRP is designed as a comprehensive document which provides a description of the closure and reclamation of the Site with technical appendices to support and document engineering designs/decisions.

The CRP includes:

- a summary of the goals and principles (Section 1.2) and objectives (Chapter 5) of remediation
- a summary of the engagement (Section 1.4) and regulatory instruments (Section 1.5) associated with the GMRP
- a summary of the project environment (Chapter 2)
- a project description (Chapter 3)
- a summary of closure works completed to date (Chapter 4)
- chosen closure and reclamation activities for specific remediation concepts and/or Site components, including alternatives considered (Chapter 5)
- estimated monitoring and maintenance activities from remediation into post-closure as well as contingencies (Section 5.12 and 5.13)
- the integrated schedule of remediation and reporting activities (Chapter 6)
- a description of the plan for post-closure site assessment (Chapter 7)

The CRP identifies the activities proposed to remediate the Site and presents actions for the ongoing management and mitigation of environmental effects. Engineering work has been advanced to a conceptual level to confirm the viability of the plan to close and reclaim the Site. Detailed engineering work is now in progress. The GMRP Team expects submission and implementation of final detailed design would be incorporated as potential terms and condition(s) within the Type A Water Licence issued by the MVLWB. A draft Water Licence application has been submitted together with the CRP. Section 5.0 outlines how the GMRP Team proposes the standard regulatory process be used to advance design (Figure 5.0-2).

Table 1.1-1 lists the additional plans or reports that link directly to the CRP, and which were required by the MVLWB (2014). Specific plans address the monitoring and management of CRP components during remediation. The management and monitoring plans are a separate but integral part of the CRP and associated Water Licence application process. Because management and monitoring needs will change over the duration of the CRP, these plans are stand-alone documents. The plans include actions for monitoring the progress of remediation and ultimately the achievement of the closure objectives and criteria as provided in the CRP.

Table 1.1-1: Supporting Plans and Documents Related to the Closure and Reclamation Plan

Management and Design	Monitoring and Maintenance	Operational	Documents to Meet EA Measures
Effluent Quality Criteria Report Water Management and Monitoring Plan (including Water Balance) Waste Management and Monitoring Plan Draft Designs (as included in the CRP) Engagement Plan and Log	Aquatic Effects Monitoring Program – Baker Creek (includes requirements for Environmental Effects Monitoring under the MDMER) Aquatic Effects Monitoring Program – Yellowknife Bay (includes requirements for Environmental Effects Monitoring under the MDMER) Surveillance Network Program Wildlife and Wildlife Habitat Protection and Monitoring Plan Erosion and Sediment Management and Monitoring Plan Dust Management and Monitoring Plan (including air monitoring)	Spill Contingency Plan QA/QC Plan and Standard Operating Procedures for Effluent and Water Monitoring	Human Health and Ecological Risk Assessment Quantitative Risk Assessment (*on-going at time of submission*) Tailings Management and Monitoring Plan

Note: Documents listed are based on the MVLWB's Post-EA submission requirements, the Measures as defined in the Report of EA, relevant commitments, Environmental Agreement requirements, and anticipated Water Licence conditions.

MVLWB = Mackenzie Valley Land and Water Board; CRP = Closure and Reclamation Plan; EA = Environmental Assessment; QA/QC = quality assurance / quality control; MDMER = Metal and Diamond Mine Effluent Regulations.

Design and Construction Plans, and Construction Completion Reports for specific components proposed in the CRP will be submitted during the term of the Water Licence, in accordance with the applicable conditions; these plans will include monitoring details specific to selected closure activities, as applicable. Refer to Section 5.04 for further explanation on how the GMRP proposes to use standard regulatory processes to advance site remediation and monitoring.

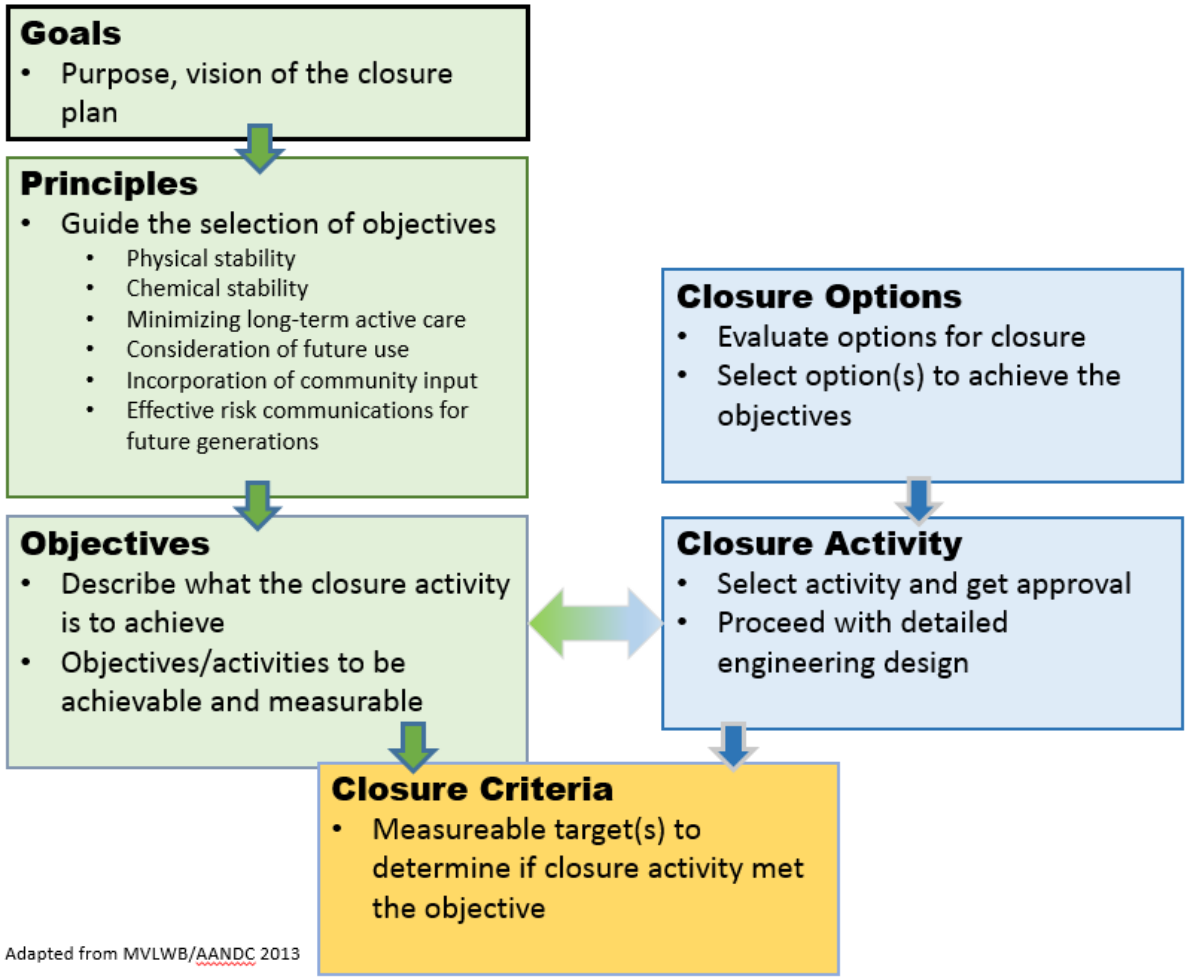
1.2 Goal of the Closure and Reclamation Plan

The goals for the GMRP are to:

- minimize public and worker health and safety risks
- minimize the release of contaminants from the Site to the surrounding environment
- remediate the Site in a manner that instills public confidence
- implement an approach that is cost-effective and robust over the long term

Following the Closure Guidelines (MVLWB/AANDC 2013), the goals for the closure and reclamation of the Site inform the principles, which in turn guided the development of specific, measurable, and achievable objectives for each main element of the remediation project. The approach is illustrated in Figure 1.2-1.

Figure 1.2-1: Objectives-Based Closure Planning for Giant Mine



The closure goals are supported by six closure principles. The first three principles are taken directly from the Closure Guidelines (MVLWB/AANDC 2013). The fourth principle in the guidelines, "no long-term active care," has been changed to "minimizing long-term active care requirements" as "no long-term active care" is not practically achievable at the Site and does not reflect the outcomes of the EA process. As a result of affected party input and concerns on various aspects of the GMRP, additional principles have been included regarding affected party input and risk communication to future generations.

The six closure principles are:

1) **Physical stability**—Any component that remains at the Site should be constructed to be physically stable under natural extreme events or disruptive forces so that closure would be successful for the closure period defined as 100 years as required by Measure 1 of the EA (MVEIRB 2013).

2) **Chemical stability**—Components that remain at post-closure should be chemically stable and any chemical released to the environment should not endanger humans, wildlife, or the health of the environment. Waste that remains on the Site should be managed such that there are no releases on or off site which would do harm to the environment or humans and wildlife.

3) **Constraints on future use**—The CRP should take into account restrictions and opportunities to permit future use of the closed mine to the extent practicable.

4) **Minimizing long-term active care requirements**—Aspects of the CRP require long-term maintenance, but the footprint of these areas will be reduced to the extent practicable. The CRP will make all reasonable efforts to minimize long-term active care and maintenance by designing post-closure components with this consideration.

5) **Incorporation of input from affected parties**—The CRP will reflect the input from engagement initiatives and reflect the values and direction provided by the local communities.

6) **Effective risk communications for future generations**— The CRP recognizes the need for ongoing effective risk communication to future generations, in particular considering the need for long-term management of the arsenic trioxide underground via the freeze, and other longer-term activities such as water treatment.

Six closure objectives were developed for the whole Site and 32 objectives were developed for the individual components of the Site (e.g., pits, tailings). These objectives are presented in detail in Chapter 5, along with the associated closure criteria. The closure objectives were developed based on affected party input provided during Giant Mine Working Group sessions in 2013, and 2017, 2018, and the Surface Design Engagement (SDE) process (Slater 2016; see Appendix 1B and Section 1.4.2 below), as well as the Report of EA (MVEIRB 2013) and September 2018 technical sessions.

The closure objectives are consistent with the those previously presented for the GMRP in the *Giant Mine Remediation Plan* (SRK/Senes 2007) and the DAR (INAC and GNWT 2010) but have been modified to be more specific and expanded to account for specific components of the remediation (e.g., tailings and borrow). For reference, the objectives previously presented in *Giant Mine Remediation Plan* (SRK/Senes 2007) and the DAR (INAC and GNWT 2010) were as follows:

1. *Manage the underground arsenic trioxide dust in a manner that will minimize the release of arsenic to the surrounding environment, minimize public and worker health and safety risks during implementation, and be cost effective and robust over the long-term.*

2. *Remediate the surface of the site to the industrial use guidelines under the NWT Environmental Protection Act, recognizing that portions of the site will be suitable for other land uses with appropriate restrictions.*

3. *Minimize public and worker health and safety risks associated with buildings, mine openings and other physical hazards at the site.*

4. *Minimize the release of contaminants from the site to the surrounding environment.*

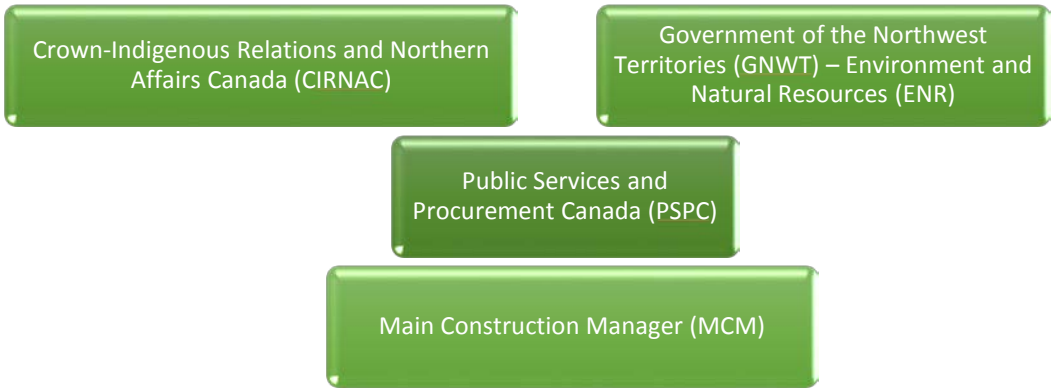
5. *Restore Baker Creek to a condition that is as productive as possible, given the constraints of hydrology and climate.*

1.3 Closure and Reclamation Team

The GMRP Team consists of CIRNAC and the GNWT, supported by the federal department of Public Services and Procurement Canada (PSPC). CIRNAC and GNWT are co-proponents for the GMRP and are responsible for all commitments made in the CRP. The organization of the GMRP Team is shown in Figure 1.3-1, with further detail on each of the principal organizations provided in the updated project description document submitted to the MVLWB. Affected parties are listed in Section 1.4.

- CIRNAC has the overall responsibility for management of the Site; it is the project authority and assumes the project liability. CIRNAC became responsible for the Giant Mine Site when the mine's owner was assigned into bankruptcy in 1999. This responsibility includes accepting the environmental liability related to the arsenic trioxide dust stored underground as well as the surface components of the Site.
- Given the Site is on Commissioner's land and given its role as co-proponent, the GNWT has participated in the development and review of the CRP. In addition, GNWT Environment and Natural Resources (ENR) has a mandate to prevent the discharge of contaminants into the environment and minimize impacts when they do occur.
- PSPC is a service provider of contract management services within the federal government. PSPC is actively involved in environmental remediation across Canada, including the North. Through the department's role in property dispositions and acquisition, PSPC has developed a broad-based knowledge of environmental issues and remediation practices. The department applies this knowledge to the Site as service provider to CIRNAC.
- While the federal and territorial governments are ultimately responsible for the GMRP, its implementation will be conducted by private sector contractors procured through PSPC. To this end, PSPC has awarded the Main Construction Manager (MCM) contract to Parsons Incorporated. The MCM will oversee the implementation and coordination of the overall remediation plan and associated activities. The MCM will be responsible for awarding various sub-contracts and providing employment and training opportunities for Indigenous peoples and Northerners and for health and safety.

Figure 1.3-1: Giant Mine Remediation Project Team



1.4 Engagement

The CRP has been shaped by ongoing engagement throughout its development (CIRNAC and GNWT 2019b; DIAND 2007). Through regular engagement and specific engagement initiatives, design decisions have been taken in a way that incorporates the feedback and preferences of those who have historically been most affected by the past operation of the Giant Mine.

Local Indigenous communities and other local organizations were not consulted on activities occurring at the Site over the majority of its operating life. Although more effective engagement at this time cannot address the issues of the past, it can contribute to developing a better relationship with our affected parties and provide a venue to work together to find solutions. The GMRP Team is committed to effective engagement and consultation, such that affected parties are well informed and feel that their input, including Traditional Knowledge, has been adequately and effectively integrated into the GMRP. It is important that affected parties feel engagement allows for opportunities for collaboration with the GMRP, are aware they have opportunities to participate in the project and that this can result in increased ownership and influence on the future of the Site.

The GMRP is committed to advancing the reconciliation mandate issued in the Ministers Mandate letter. The project will contribute to reconciliation through meaningful engagement, allowing equitable access to jobs, and long-term socio-economic benefits relating to the remediation of the project. The GMRP recognizes the importance of ensuring its team is well informed and continues to grow in their respect of the legacy of colonization and the mine and therefore is committed to meeting the Truth and Reconciliation Commission of Canada: Calls to Action (57): *We call upon federal, provincial, territorial, and municipal governments to provide education to public servants on the history of Aboriginal peoples, including the history and legacy of residential schools, the* United Nations Declaration on the Rights of Indigenous Peoples*, Treaties and Aboriginal rights, Indigenous law, and Aboriginal–Crown relations. This will require skills-based training in intercultural competency, conflict resolution, human rights, and anti-racism.*

Considerable engagement has been conducted as part of the development of this CRP (CIRNAC and GNWT 2019b). The following subsections provide a list of our engagement bodies, a summary of the communication methods, and key highlights of the engagement to date.

1.4.1 Engagement Methods

1.4.1.1 Engagement Bodies

Working groups are a key way for the GMRP Team to engage with key affected parties in a meaningful way both to provide information and to solicit input. Over time, a range of affected party engagement groups have addressed the needs and interests of affected parties. These engagement groups have supported the need for the GMRP to conduct effective engagement, and also satisfy the engagement requirements embedded in the regulatory process.

The principal engagement bodies are described in Table 1.4-1. The specific membership and timing of the meetings may change over time.

Table 1.4-1: Principal Engagement Bodies for the Giant Mine Remediation Project

Engagement Committee	Primary Purpose	Primary Participants	Primary Methods
Giant Mine Working Group	An opportunity to provide a forum for interested parties to discuss and make recommendations on technical, operational, and project activities regarding the remediation of Giant Mine. The GMRP also will engage this forum on updates to environmental management plans and programs.	City of Yellowknife, North Slave Métis Alliance (NSMA), Alternatives North, Yellowknives Dene First Nation (YKDFN), Environment and Climate Change Canada (ECCC), Fisheries and Oceans Canada (DFO), Health Canada, Giant Mine Oversight Board (GMOB), Public Services and Procurement Canada (PSPC)	Monthly meetings (face-to-face)
Giant Mine Advisory Committee	An opportunity to express concerns about the project, provide recommendations, and to receive updates from the GMRP.	Members of the Yellowknives Dene First Nations	Monthly meetings (face-to-face)
North Slave Métis Alliance	An opportunity to discuss key initiatives, provide recommendations and provide annual updates	NSMA members	Meetings upon request (face-to-face)
YKDFN Chiefs and Council	An opportunity to provide an annual update to YKDFN Chief and Council and provide recommendations to the GMRP.	YKDFN Chief and Council	Annual meetings (face-to-face)
City of Yellowknife Staff	Working level meetings with senior City staff to create an open dialogue and address questions on topics such as permitting and future land use.	City of Yellowknife Senior Staff	Monthly staff meetings with Directors (face-to-face)
City of Yellowknife Mayor and Council	An opportunity for the project team to attend regular City Council meetings and the Municipal Services Committee, to give updates on the project and answer questions. Media and the public are often present.	GNWT, CIRNAC, City of Yellowknife Mayor and Council	GMRP Team attends every six months
YKDFN Elders Senate	An existing YKDFN body that gives advice to the chiefs and councils and provides Traditional Knowledge to the project as and when needed.	YKDFN elders	GMRP Team meetings upon request
Health Effects Monitoring Program Advisory Committee	An opportunity for member groups to contribute to the development and implementation of the monitoring program by utilizing their health expertise and knowledge of regional and community level issues.	GNWT, GNWT Health and Social Services, CIRNAC, Health Canada, YKDFN, NSMA, GMOB, City of Yellowknife with additional support from Institute for Circumpolar Health Research	Monthly meetings
Great Slave Sailing Club	An opportunity to inform the Sailing Club of activities at Giant Mine as the club holds a lease on the Giant Mine site and discuss concerns.	Board of Directors and members of the Sailing Club	Annual meetings (face-to-face)

Table 1.4-1: Principal Engagement Bodies for the Giant Mine Remediation Project

Engagement Committee	Primary Purpose	Primary Participants	Primary Methods
Yellowknife Historical Society	A venue to discuss issues such as the society's lease on the Site and opportunities to preserve the heritage of the Giant Mine.	Board of Directors of the Mining Heritage Society	Annual meetings (face-to-face)
Back Bay Community Association	An opportunity to inform residents to activities at the Giant Mine Site and to obtain feedback.	Includes homeowners in the Back Bay area of Yellowknife	Upon request
Socio-economic Advisory Body	The Socio-economic Advisory Body's mandate is to provide direction and guidance to the Socio-economic Working Group as act as senior government champions for the implementation of the Socio-economic Working Group's approach. To ensure that members of the group will be able to address organizational barriers to implementing the Socio-economic Strategy and provide strategic advice to the working group.	City of Yellowknife, Citizen Services Yukon and Northwest Territories, PSPC, GNWT, Canadian Northern Economic Development Agency, CIRNAC, YKDFN.	Quarterly meetings
Indigenous Review Benefits and Monitoring Panel	Refer to Terms of Reference.	*TBD*	*Additional details to come in subsequent versions*
Socio-economic Working Group	Responsible for coordinating activities related to the implementation of the Socio-Economic Strategy, sharing information, and seeking opportunities to improve collaboration. Responsible for briefing the Senior Project Committee and the Socio-economic Advisory Body as required.	CIRNAC, GNWT, PSPC, Cannor, Parsons.	*Additional details to come in subsequent versions*
Aboriginal Business Advisory Panel	Refer to Terms of Reference	*TBD*	*Additional details to come in subsequent versions*

GMRP = Giant Mine Remediation Project; NSMA = North Slave Métis Alliance; YKDFN = Yellowknives Dene First Nation; ECCC = Environment and Climate Change Canada; DFO = Fisheries and Oceans Canada; GMOB = Giant Mine Oversight Board; PSPC = Public Services and Procurement Canada; CIRNAC = Crown-Indigenous Relations and Northern Affairs Canada; NWT = Northwest Territories; Cannor = Canadian Northern Economic Development Agency. TBD= To be determined.

1.4.1.2 Communications

Regular communications also form an important part of ongoing engagement. The communication methods that the GMRP Team currently undertakes as a part of ongoing engagement are outlined in Table 1.4-2; these methods are additional to meetings and workshops and the regulatory process. These communications will be maintained during and after the licensing process. As part of communications, key messages and questions and answers are developed on an as-needed basis, for use with media, public, affected parties, and in website updates.

The communications strategy for engagement also includes a crisis communications plan, for response to unforeseen events. This plan includes plans for the distribution of information through direct communication with key partners, Twitter feed, web postings, e-newsletter distribution lists and media interviews. This plan includes targets for developing and delivering messages within 24 hours for urgent matters, and within two to three days for other issues.

Table 1.4-2: Communication Methods for the Giant Mine Remediation

Types of Communications	Activity	Timing	Comments
Written Notification or Radio/Video Broadcast	Key message and Q&A development	As needed	For use with media, public and affected parties
	Reporting on regulatory Site activities (e.g., air quality monitoring results).	Weekly	Distributed to email list, posted to GNWT ENR website
	E-newsletter	8–10 per year	Distributed to email list, posted to website,
	Social Media	As and when needed	Giant Mine twitter account @GiantMine to communicate project information on a as and when needed basis
	Media relations (pro-active)	As required or as per annual work plan	Includes media tours, media technical briefings, planned interviews, media training for media spokesperson(s)
	Media relations (responsive)	As required	Project spokespersons are designated, trained and supported with approved messaging
	Site-related Public Service Announcements	As required	Includes print and radio
	Response to unforeseen events	Target: develop and deliver media messages within 24 hours in cases of emergency and 2–3 days for other issues	Based on Spill Contingency Plan and approved Crisis Communications Plan). Vehicles include: media interviews; web postings; Twitter feed; direct communication with key partners; e-newsletter distribution list
Written Notification or Radio/Video Broadcast (con't)	Videos	As and when determined	Has been previously carried out for technical components of the project (e.g., Freeze Optimization Study, Roaster Complex deconstruction)
	Website	Ongoing, updated as and when needed by significant project initiatives or engagement sessions (e.g., public forum event)	Provides project-specific information on the remediation plan, contact information, provides links to other relevant organizations (e.g., GMOB website)
	GMRP "info line"	Phone number advertised in most communications	

Table 1.4-2: Communication Methods for the Giant Mine Remediation

Types of Communications	Activity	Timing	Comments
Face-to-Face Meetings	In-person meetings or telephone calls (if appropriate) with representatives of affected parties, communities, interest groups, or other affected parties.	Regularly/as needed	Dependent upon the party in question and the issues being discussed.
Community Public Meetings	Community forums; informal public meeting where everyone in the community is invited to attend and discuss the project; broad community input required.	1 per year for YKDFN 1 per year for NSMA 1 per year for Yellowknife residents GMOB Annual Public Meeting	Are often accompanied by print materials (e.g., factsheets) The GMOB is mandated to hold semi-annual meetings and annual public meetings which GMRP Team participates in as a "party." GMRP Team also attends other community meetings as and when requested by the hosting organization.
Workshops	Focus workshops; discuss technical issues, or when information needs to be shared and feedback solicited with large groups of people.	As required	The format of workshops will vary based on the focus and interests of participants; the SDE process is an example of a large-scale workshop effort. The selection of the location of the landfill and outfall are more focused workshop examples.

GNWT = Government of Northwest Territories; ENR = Environment and Natural Resources; GMOB = Giant Mine Oversight Board; YKDFN = Yellowknives Dene First Nation; NSMA = North Slave Métis Alliance; GMRP = Giant Mine Remediation Project; SDE = Surface Design Engagement.

1.4.2 Key Engagement to Date

CIRNAC has led engagement and consultation with Indigenous communities and the public over the last 18 years since the Site management became its responsibility. Since the completion of the EA in August 2014, the GMRP Team has undertaken a number of engagement activities to support the development and implementation of the EA measures, as well as support the upcoming Water Licence process; a brief overview of this and relevant mine history are listed in Figure 1.4-1. Table 1.4-3 provides an overview of key engagement events and outcomes through the recent history of the GMRP; the comprehensive Engagement Plan and Engagement Log are provided under separate covers in this application (CIRNAC and GNWT 2019b,c). These engagement activities and regular communication tools provide direct opportunities for affected parties to voice concerns, identify their priorities, and provide overall input to the planning of the GMRP. Further, these engagement activities have led to refinements in the closure design based on affected party input, and community and traditional and local knowledge holder input, or in some cases changes to closure options that were presented in the 2007 *Giant Mine Remediation Plan* and the DAR (SRK/Senes 2007; INAC and GNWT 2010). Further examination of chosen closure activities based on input from engagement is discussed in Closure Options and Considerations within Chapter 5.

Table 1.4-3: Giant Mine Principal Closure Plan Engagement Overview

History of Engagement Activities Related to Closure Planning				
Activity	**Date Range**	**Comments**	**Purpose**	**Outcome**
Arsenic Trioxide Dust Remedial Option Selection	2001–2003	Over 40 public consultations with 3 major workshops to select the preferred option for long-term arsenic trioxide dust management.	To develop a remedial action plan to be submitted with the 2005 Water Licence package.	Input resulted in the selection of the in situ frozen block method (due to concerns raised in the EA method it has since been adjusted to the frozen shell method).
Site Stabilization Program (Decontamination and Deconstruction of the Roaster Complex and underground stabilization)	2013–2016	GMRP Team led engagement and input from affected parties (separate from the Giant Mine Working Group) was received throughout the process prior to submittal of materials to the MVLWB. The GMRP Team additionally led separate annual meetings (public forum) with the YKDFN and NSMA and their membership since 2014.	To ensure that every reasonable measure will be taken to address on-site dangers and risks in order to protect human health and safety as well as the environment. The separate YKDFN and NSMA meetings were to provide affected parties with an update of the SSP activities that year.	Input from engagement incorporated in air quality monitoring program, medical monitoring program for site workers, and emergency response plans.
SDE (Surface Design Engagement)	2015 to 2017	Eleven focused sessions over two years to provide input into plans for remediation of the surface of the mine (Baker Creek, Pits, Tailings, Contaminated Soils and Land Use). Detailed review of closure options and risks resulted in formative input on design decisions with respect to the remediation.	Suggestion #1 (EA) – to ensure surrounding communities are consulted prior to finalizing its project design and design improvements may be incorporated. Suggestion #13 (EA) – to ensure the feasibility of filling pits is explored. Measure #22 (EA) – to determine the appropriate depth of tailings cap and B1 Pit cover to ensure they are not compromised by vegetation growth. Measure #11 (EA) – to help meet the requirement to select options which minimize flood impacts from Baker Creek (supported by outcome to fill pits and decisions made regarding routing Baker Creek). Measure #11 (EA) - to minimize fish exposure to arsenic in contaminated sediments (removal of sediments). Measure #12 (EA) – to supports the achievement of water quality objectives at the outlet of Baker Creek (removal of sediments).	Key decisions based on SDE input included: -fill the open pits with waste rock and new quarried rock -remove contaminated sediments from Baker Creek and keep it in an on-site alignment, -relocate the South Pond into North and Central Ponds -cover all tailings ponds with a rock cover -excavate contaminated material from a historical spill from the North Pond area, and -remediate the Townsite and Shoreline Area to residential criteria

Table 1.4-3: Giant Mine Principal Closure Plan Engagement Overview

History of Engagement Activities Related to Closure Planning				
Activity	**Date Range**	**Comments**	**Purpose**	**Outcome**
Outfall	2016 to 2017	Assessment of outfall locations for discharge from effluent treatment plant, with 4 separate engagement sessions (larger YKDFN community, working group and Giant Mine Advisory Committee [GMAC]). Three potential discharge locations and three discharge cooling options were considered and evaluated.	Measure #14 (EA) –to ensure the diffuser option is replaced with a near shore outfall, with discharge criteria requiring the Health Canada drinking water standard for Arsenic be met.	As a result of engagement and factors associated with land use, a fourth outfall location was identified through engagement, located near the outlet/vicinity of Baker Creek.
Baker Creek Alignment	2017	Detailed evaluation of diversion alternatives separate from SDE process with Giant Mine Working Group, GMOB and GMAC, confirming selection of alignment.	Measure #11 (EA) – to thoroughly assess options for, and the environmental impact of, diversion of Baker Creek to a north diversion route previously considered by the Developer or another route that avoids the mine site and is determined appropriate by the Developer.	Confirmed selection of on-site alignment.
Landfill Siting	2017	Two engagement sessions for the selection of the preferred landfill site from six potentially viable options.	Suggestion #15 (EA) – to consult with the City of Yellowknife in the design of any landfill on the Giant Mine site.	Engagement resulted in support of recommended site location.
Health Effects Monitoring Program	2017 - present	Community consultation took place to inform about the program, discuss proposed study protocols, and provide the opportunity for people to provide feedback, and bring up any issues of concern.	Measure #9 (EA) – to design and implement a Health Effects Monitoring Program in Ndilǫ, Dettah and Yellowknife to ensure remediation activities that will take place at Giant Mine will not have a negative impact on people's health.	The Health Effects Monitoring research team will present results of baseline measured in 2017–2018 to the public in 2019 and continue to monitor exposure during closure (children in 5 years, adults in 10 years).
Human Health and Ecological Risk Assessment (CanNorth 2018)	2015 to 2018	Over 10 sessions, including scope development informed the implementation and delivery of the HHERA. The HHERA was carried out with significant affected party and Traditional Knowledge holder input, to better assess risks considering differences in traditional land use, food consumption, and lifestyles. Extensive community participation was part of voluntary country food sampling program.	Measure #10 (EA) – to commission a comprehensive quantitative human health risk assessment.	The final report released in January 2018 found that there is low risk to very low risk to human health for residents of Yellowknife, Ndilǫ and Dettah.

Table 1.4-3: Giant Mine Principal Closure Plan Engagement Overview

History of Engagement Activities Related to Closure Planning				
Activity	**Date Range**	**Comments**	**Purpose**	**Outcome**
Quantitative Risk Assessment (Environmental Assessment)	2018 - present	Phase 1 – to introduce the QRA and validate the engagement process (April 2018 meetings with Giant Mine Working Group) Phase 2 – to identify and discuss risk scenarios and consequence categories (May/June 2018 two day workshop). A second phase 2 workshop, with the YKDFN was held August 30 and31, 2018 Phase 3a and 3b – Fall 2018 to include meetings to discuss consequences of risk scenarios, what level of consequences are unacceptable (thresholds), and to agree on which scenarios will be analyzed in more detail in the QRA. Phase 4 will occur in 2019 and will involve meetings to review and discuss the results.	Measure #5 (EA) – to commission an independent quantitative risk assessment before the project receives regulatory approvals.	Results of this engagement TBD following the completion of QRA engagement sessions.
Archaeological Impact Assessment	2018	An Archeological Impact Assessment (AIA) was conducted in July 2018 with field assistance by members/representatives of the Yellowknives Dene First Nation, with a focus on areas of high archaeological potential that overlapped with areas of planned or potential remediation activities. Areas of high archaeological potential were identified through desktop studies as well as based on input from Traditional Knowledge holders and interested parties. A YKDFN community session was held in January 2019 to report back on the results.	To revisit (through pedestrian reconnaissance, visual ground inspection, and shovel testing) known traditional use areas and previously recorded archaeological sites, as well as mitigate areas of high potential ahead of planned remediation activities in existing developed areas and bedrock / forest / wetland areas, including those of potential borrow sources. A final report was produced for submission to the Prince of Wales Northern Heritage Centre summarizing findings and recommendations.	A total of 21 proposed borrow sites, 8 previously recorded traditional use areas, and 4 previously recorded archaeological sites were investigated, along with other areas identified for field investigation. Three new archaeological sites and one new traditional use area were identified in the field. Additional feature mapping is recommended for one new archaeological site. The boundary of a potential borrow areas will be reviewed to avoid disturbance to a traditional use area. Further Traditional Knowledge information gathering is recommended one traditional use area.

Table 1.4-3: Giant Mine Principal Closure Plan Engagement Overview

History of Engagement Activities Related to Closure Planning				
Activity	**Date Range**	**Comments**	**Purpose**	**Outcome**
Stress Study (Environmental Assessment)	2018 - present	Meetings with NSMA and YKDFN, and Giant Mine Working Group were conducted to work with affected parties to further refine the survey component of the study.	Measure #10 (EA) – to commission a comprehensive quantitative human health risk assessment.	Survey design, data collection timeline, sampling strategy informed by the approach carried out for the Health Effects Monitoring Program
Draft Water Licence Package Community Workshop	2018	Three days of technical discussions with affected parties.	This workshop focused on the technical aspects of the water licence submission, including the Closure and Reclamation Plan, and was planned and developed based on feedback from affected parties.	Input from these sessions incorporated into water licence package prior to submitting it to the MVLWB.
Closure and Reclamation Plan Site Tour	2018	Conducted two site tours with affected parties YKDFN (20 members participated) and NSMA (approximately 10 people participated).	To allow an opportunity for affected parties to see the care and maintenance work that is ongoing at the site, as well as learn how the GMRP Team plans to address different aspects of the site in the Closure and Reclamation Plan.	Input from these sessions incorporated into the water licence package prior to submitting it to the MVLWB.

EA = Environmental Assessment; GMRP = Giant Mine Remediation Project; MVLWB = Mackenzie Valley Land and Water Board; YKDFN = Yellowknives Dene First Nation; NSMA = North Slave Métis Alliance; SSP = Site Stabilization Program; SDE = Surface Design Engagement; GMAC = Giant Mine Advisory Committee; GMOB = Giant Mine Oversight Board; HHERA = Human Health and Ecological Risk Assessment; TBD = to be determined; QRA = Quantitative Risk Assessment.

1984
10,000th gold brick poured at Giant Mine

1981
» New effluent treatment plant operational, resulting in improved effluent quality released to the environment

1992
» Nine miners died in an explosion during a labour strike

1999
» Giant Mine operator Royal Oak Mines Inc. goes into receivership
» Control of Giant Mine transferred to CIRNAC in December 1999
» Roasting ceased at Giant Mine

Late 1970s
» Inspectors noted a lack of permafrost in underground and an increase in groundwater inflows in chambers

1975 - 1979
» Health studies related to arsenic conducted

1974
» Open pit mining started with A1 Pit

2001 - 2003
» Arsenic trioxide dust remedial options studies and public consultations conducted

1999 - 2004
» Miramar Giant Mine Ltd. purchased Giant Mine from CIRNAC and continued mining until 2004, with processing occurring at Con Mine

1965 - 1969
» Health studies related to arsenic conducted

1959
» Emission controls reduced roaster arsenic releases from 7500kg/day in 1949-1951 to 300 kg/day

1951
» Death of Dene child from arsenic poisoning
» Underground storage of arsenic trioxide in mined out stopes and excavated chambers begins.

2005
» Miramar Giant Mine Ltd. ended its obligation under the Reclamation Security Agreement
» Giant Mine became an abandoned mine
» CIRNAC resumed control. CIRNAC/PSPC awarded care and maintenance contract to Deton'Cho/Nuna Joint Venture » CIRNAC and GNWT signed Cooperation Agreement for remediation of Giant Mine

1949
» Roasting of ore at Giant Mine began
» First studies of arsenic pollution in Yellowknife area initiated

2007
» CIRNAC submitted a Remediation Plan and is referred to Environmental Assessment (EA)

1948
» Giant Mine opened

2009
» Freeze Optimization Study started (completed in 2015)

1938
» Con Mine opened

2013
» Site Stabilization/Urgent works begin: Roaster complex (2013), C Shaft (2015), and A Shaft deconstruction (completed in 2016), underground stabilization (ongoing) to protect environment and workers

2014
» Report of EA, issued by Mackenzie Valley Environmental Impact Review Board in 2013, signed off by Minister of CIRNAC in 2014
» Report of EA identified 26 Measures and 16 Suggestions, many of which were to be completed before Water Licence issuance

2015
» Giant Mine Remediation Project signed Environmental Agreement between the Canadian Government, GNWT, Yellowknives Dene First Nation, City of Yellowknife, Alternatives North and North Slave Métis Alliance
» Freeze optimization study completed

1930s
» Numerous claims staked around Yellowknife

2015 - 2017
» Surface Design Engagement

2016 - 2017
» Water treatment plant outfall location engagement and assessment

2017
» Baker Creek final alignment engagement and evaluation
» Non-hazardous landfill location engagement and selection
» Health Effects Monitoring Program started

2018
» Human Health and Ecological Risk Assessment completed (2015-2018)
» Water Licence Pre-engagement begins
» Quantitative Risk Assessment (QRA) process began

1923
» Liza Crookedhand found gold in the area that would become Giant Mine

2019
» Water Licence process to begin

2020/2021
» *Anticipated start of remediation activities*

2020
» *Anticipated Type A Water Licence and Land Use Permit*

» Closure activities are expected to take approximately 10 years, and include freezing of arsenic chambers, building new water treatment plant and outfall, soils and sediment remediation, building deconstruction, Baker Creek realignment (on-site), and covering tailings

Independent project reviews to take place every 20 years

» Long-term monitoring and management: water treatment, maintenance of the freeze, and site monitoring and maintenance will continue over the long term

1899
» Gold first discovered in area that would become Yellowknife

Mine Development and Mining

Care & Maintenance, Closure Studies & Urgent Works

Traditional Use

Closure Implementation

Legend

- Traditional Use
- Mine Development and Mining
- Care & Maintenance, Closure Studies & Urgent Works
- Closure Implementation
- Events spanning multiple years

PROJECT
Giant Mine Remediation Project

TITLE
GIANT MINE TIMELINE

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2018-11-27
DESIGNED	AM
PREPARED	AM
REVIEWED	K. Harris
APPROVED	K. Harris

REV. 0
FIGURE 1.4-1

As noted in Table 1.4-3, comprehensive engagement was undertaken to make the key closure decisions on the underground and the surface of the Site. Extensive public consultations and workshops were employed to select the in situ frozen block method for long-term arsenic trioxide dust management. This was reviewed and refined in the EA process. Given the success of this approach, an expansive two-year process for review of the surface closure options was conducted. Over 100 people from Yellowknife, Ndilǫ, and Dettah participated in this review. This is referred to as the SDE process.

The SDE process included the following steps:

- **Preparation, information sharing, and identifying objectives with affected parties and participants**—The GMRP Team first met with groups of people to share information about the Giant Mine site. There were separate meetings with an independent consultant to identify each group's objectives for the Site after the remediation is complete.
- **Identification and review of closure options for the mine components**—An Options Definition Workshop was held in Dettah in June 2015. Approximately 90 people worked together for two days to identify ideas for remediating Baker Creek, tailings ponds, open pits, and contaminated soils.
- **Development of engineering and risk aspects of closure options**—The GMRP Team worked with its engineers to turn the June 2015 ideas into six complete remediation plans.
- **Evaluation and presentation of closure options in the context of risk**—In December 2015, a smaller group of local affected parties worked with the GMRP Team to identify risks and concerns with each plan, and what improvements could be made.
- **Evaluation of closure options**—The final step was the Options Evaluation Workshop, which was held in Dettah in February 2016. More than 75 people participated. Members of each group sat together at tables of about six to ten people. Over a period of four days, each table evaluated the remediation plans against the objectives that were identified in May 2015 by affected parties.

The outcome of the SDE process was a report documenting the objectives, potential options, and the resulting evaluations by affected parties (SRK 2016; Appendix 1B). Key input received during SDE included the following:

- Affected parties preferred options where Baker Creek remained on Site, was put into a wider channel that can handle floods safely, and where contaminated sediments in the creek bottom were removed. There was disagreement among people about whether fish should be allowed to live in the creek after it was remediated. Some people thought there would be a risk for people who might eat the fish, while others thought Baker Creek was good fish habitat and the risk to human health would be very low.
- Affected parties preferred options that included backfilling the pits. There were different opinions on what materials should be used. Some groups wanted the pits to be filled with tailings, and others thought that clean rock should be used as fill.
- Many affected parties agreed that tailings should be placed in the underground mine as much as possible, and that some of the tailings should be moved into the pits or combined into a smaller tailings area. Everyone agreed that any tailings remaining on surface need to be covered. Some groups wanted soil covers with vegetation. Other groups wanted rock covers to prevent vegetation so that animals would not use the area, and so that future generations would always know there were contaminated tailings materials below the surface.

- Affected parties agreed that contaminated soils should be cleaned up from areas of the Site that had already been disturbed by mining activities, and most groups wanted to clean up soils across the southern part of the Site and along the shoreline. For parts of the Site where the soil is contaminated by dust only, people recommended sampling and testing, with remediation or restricted access to areas where there might be a risk to people or animals.
- There were different perspectives from affected parties on how much the rest of the Site should be used after it is remediated. Some groups thought that parts of the Site should be accessible for other uses but some groups, particularly the Yellowknives Dene First Nation (YKDFN), wanted the Site to remain off limits to people, so that future generations would never be exposed to any of the buried tailings, arsenic dust, or soils.

Input received from SDE was critical for the GMRP in developing and updating the CRP and preparing the Water Licence application. One favourable outcome of SDE is that while the final plan may not reflect every affected party's first choice for closure, there is at least more of an understanding of the many other perspectives that must be considered by the GMRP Team in selecting closure options. Please refer to Chapter 5 within the various mine component sections for more details on how SDE and the other engagement initiatives provided input into selecting closure options.

1.4.3 Ongoing Engagement

The GMRP Team will continue to work with affected parties to inform them of proposed Site activities, respond to questions and concerns about the activities, and provide opportunities for suggestions from affected parties to be considered in the detailed design process. The GMRP communication and engagement approach will allow for flexibility to respond to successes, challenges, and changes to the project. The Engagement Plan outlines the GMRP's proposed approach to engagement moving into remediation. This document is updated annually and any feedback from affected parties will be captured in implementation planning documents that are updated regularly.

Based on the engagement practices to date (see Appendix 1B), the GMRP believes affected parties have had an active role in closure planning and decision making. Accordingly, CRP decisions have been made on the basis of engineering, Traditional Knowledge and science making use of the best available information and technology. The GMRP intends to work with affected parties to gather updated traditional and local knowledge to help support detailed engineering and to help design monitoring activities (e.g., wildlife surveys, location and design of borrow locations).

1.5 Regulatory Instruments for Closure and Reclamation

The Giant Mine is located within the Mackenzie Valley area in the Northwest Territories, and the Site boundary is within the municipal boundaries of the city of Yellowknife. As such, the GMRP is subject to the federal, territorial, and municipal legislation outlined in Table 1.5-1.

Table 1.5-1: Relevant Federal, Territorial, and Municipal Acts and Regulations

Federal	Territorial	Municipal
Fisheries Act and Regulations	*Commissioner's Lands Act* and Regulations	Zoning By-law No. 4404
Arctic Waters Pollution Prevention Act and Regulations	*Environmental Protection Act* and Regulations	Consolidation of Orderly Use of Highways By-law No. 1276
Mackenzie Valley Resource Management Act and Regulations	*Environmental Rights Act* and Regulations	Noise By-law No. 3537
Canadian Environmental Protection Act, 1999 and Regulations	*Waters Act* and Regulations	
Navigable Waters Protection Act and Regulations	*Northwest Territories Lands Act* and Regulations	
Explosives Act and Regulations	*Safety Act* and Regulations	
Transportation of Dangerous Goods Act and Regulations	*Mine Health and Safety Act* and Regulations	
Canada Wildlife Act	*Scientists Act* and Regulations	
Species at Risk Act	*Archaeological Sites Act* and Regulations	
	Wildlife Act	
	Explosives Use Act and Regulations	
	Species at Risk (NWT) Act	

NWT = Northwest Territories.

In addition to the applicable acts and regulations, the GMRP currently holds a number of licences, permits, authorizations, and agreements (Table 1.5-2).

Table 1.5-2: Summary of Current Licences, Permits, Authorizations, and Agreements

Authorization	Summary	Permitting Agency	Expiry Date
Water Licence MV2012L8-0010	Site Stabilization Program	MVLWB	31 July 2020
Land Use Permit MV2016S0016	Site Stabilization Program	MVLWB	20July 2021
Water Licence MV2017L8-0006	Repair of the existing UBC Bridge	MVLWB	26 September 2024
Land Use Permit MV2017X0030	Repair of the existing UBC Bridge	MVLWB	26 September 2022
MDMER Discharge Criteria	Discharge limits specified in Schedule 4 for defined deleterious substances	ECCC	n/a
Environmental Agreement	Completion of closure and remediation activities	CIRNAC, GNWT, YKDFN, City of Yellowknife, Alternatives North, NSMA	n/a

MVLWB = Mackenzie Valley Land and Water Board; MDMER = Metal and Diamond Mining Effluent Regulations; ECCC = Environment and Climate Change Canada; CIRNAC = Crown-Indigenous Relations and Northern Affairs Canada; GNWT = Government of Northwest Territories; YKDFN = Yellowknives Dene First Nation; NSMA = North Slave Métis Alliance; n/a = not applicable.

The GMRP undertook emergency site stabilization activities to support the underground arsenic trioxide storage chambers, as well as to demolish the Roaster Complex. These activities were completed under Water Licence MV2012L8-0010 and Land Use Permit MV2016S0016. Repairs to the existing UBC Bridge were required to support the underground site stabilization activities. These activities were completed under Water Licence MV2017L8-0006 and Land Use Permit MV2017X0030.

The GMRP received ministerial approval under the *Mackenzie Valley Resource Management Act* (Government of Canada 1998) on 15 August 2014 based on the DAR (INAC and GNWT 2010) and supporting evidence. In June 2015, an Environmental Agreement was signed by CIRNAC, the GNWT, the City of Yellowknife, the YKDFN, Alternatives North, and the NSMA. Under this agreement, an independent oversight body (Giant Mine Oversight Board [GMOB]) was established with the primary objective of providing objective, high-level advice on the overall remediation of the Site. This Environmental Agreement also stipulates requirements related to development of management and monitoring plans, ongoing Status of the Environment reporting, active research toward a permanent solution for the arsenic trioxide stores, and an independent project review every 20 years.

Various permits and authorizations are anticipated to be required for the GMRP from federal, territorial, municipal, and co-management agencies. Key environmental authorizations required for project implementation are provided in Table 1.5-3.

Once the GMRP receives an approved Water Licence and Land Use Permit, there will be an ongoing process to review updated design development, implementation of remediation activities, and communication of CRP updates, progress, and any changes. This ongoing process has defined points of engagement to allow for affected party input and further MVLWB approvals. This process is outlined in detail in Section 5.0 and in the Engagement Plan.

The Site is located on Commissioner's Land, therefore the lands are managed by GNWT. It is also located within the municipal boundaries; therefore, the City of Yellowknife has jurisdiction for creating land use designations and controls within its boundary. The City exercises its authority by creating and passing a General Plan bylaw and a zoning bylaw. The General Plan bylaw sets the policies for land use, and the Zoning Bylaw implements the policies by designating land use zones and provides a set of rules about how, when and where land use and developments are carried out.

Currently, access to the Site is restricted by CIRNAC through physical barriers and controls, including fences, gates and other physical barriers. There is also 24 hour per day security and routine checks of buildings and other infrastructure. Once the closure activities outlined in the CRP are complete, the land required for the long-term management of the site will not be available for public use. This land located in the central areas of the Site (freeze areas, water treatment plant [WTP], non-hazardous landfill; see Figure 3.4-1) will remain under a reserve for use exclusively by CIRNAC.

The land not needed for the long-term management of the site may be available for disposal to the public once closure activities are complete. If a party is interested in establishing a legal interest in the land, the party would apply to the Commissioner (GNWT) through the City of Yellowknife; thereafter the City would make arrangements with the interested party, either by leasing or selling the land to that party. These arrangements would be subject to land claims. Use of these lands will have constraints, for example remediated tailings and waste areas would be restricted due to the potential of any activities to damage engineered covers. As a result, those lands would either not be available for leasing, or only permitted to be leased with potential conditions.

Table 1.5-3: Anticipated Federal, Territorial, and Municipal Authorizations Applicable to the Giant Mine Remediation Project

Authorization/Regulatory Requirement	Activity	Applicable Legislation	Permitting/Regulatory Agency
Federal			
Type A Water Licence	Discharge of treated water will be required to meet effluent quality criteria specified in the Water Licence	*Waters Act* and Regulations	Mackenzie Valley Land and Water Board
	Final detailed Design and Construction Plans must be submitted for approval by the MVLWB prior to implementation		
Type A Land Use Permit	Authorizes storage of fuels, use of machinery, and drilling and explosives on site	*Mackenzie Valley Resource Management Act* – Mackenzie Valley Land Use Regulations	Mackenzie Valley Land and Water Board
Fisheries Act Authorization(s)	Screening required for any work done near water to assess requirement of an authorization	*Fisheries Act*	Fisheries and Oceans Canada
	Placement of water treatment plant outfall will be in Yellowknife Bay and may require fish habitat offsetting		
	Modification and re-alignment of Baker Creek on site may require fish habitat offsetting		
Discharge limits for deleterious substances defined under Schedule 4	Discharge of treated water (effluent) into Baker Creek from existing effluent treatment plant (existing condition prior to and during remediation)	*Fisheries Act* – Metal and Diamond Mining Effluent Regulations (MDMER)	Environment and Climate Change Canada
	Discharge of treated water (effluent) into Yellowknife Bay from new water treatment plant (future condition during remediation and post-closure)		
	Required for benthos and fish health components of the Environmental Effects Monitoring (EEM) Program under the MDMER		
Licence to Fish for Scientific Purposes	Aquatic Effects Monitoring Program (AEMP) under the Water Licence will require the same type of permit for the plankton (if required), benthos, fish health and fish tissue components; it is assumed the EEM and AEMP will be harmonized and allow for a single permit	*Fisheries Act* – MDMER (EEM Program)	Fisheries and Oceans Canada
Animal Care Permit	Required for fish monitoring programs (e.g., AEMP, EEM, community monitoring, cumulative effects)		
Explosives Storage Permit	Storage, handling, and use of explosives	*Explosives Act* and Explosives Regulations, 2013	Natural Resources Canada
Fuel Tanks	Storage of fuel on site in above-ground fuel tanks	*Canadian Environmental Protection Act, 1999* and Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations	Environment and Climate Change Canada
Territorial			
Asbestos Notification Approval	Handling of asbestos-contaminated material (e.g., demolition of Townsite buildings and mill)	NWT *Safety Act* – Asbestos Safety Regulations	Workers' Safety and Compensation Commission
Wildlife Research Permit	Wildlife research permits are not required for basic surveys and studies (e.g., annual site-wide bird survey)	NWT *Wildlife Act*	Government of the Northwest Territories – Environment and Natural Resources
	Activity-specific wildlife research permits will be required for activities that have potential to impact to nesting or denning sites (e.g., building demolition, pit backfilling) or invasive surveys (e.g., tissue sampling)		
Quarry Permit	Quarry permit is not required for borrow obtained within the Giant Mine lease; however, GNWT has requested that volumes of borrow be recorded and submitted for tracking purposes	*Commissioner's Land Act*	Government of the Northwest Territories – Municipal and Community Affairs
	Obtaining borrow materials on Commissioner's land outside the Giant Mine lease would require a quarry permit		
Scientific Research Licence	Required for research studies not covered under the NWT *Archaeological Sites Act* or NWT *Wildlife Act*; includes research in the physical, biological and social sciences (e.g., AEMP/EEM, community-based monitoring, cumulative effects monitoring)	NWT *Scientists Act*	Aurora Research Institute
NWT Archaeologists Permit (if required)	Site activities in areas where archaeology sites have been identified will have to meet specific requirements	NWT *Archaeological Sites Act* and Archaeological Sites Regulations	GNWT Department of Education, Culture and Employment (Prince of Wales Northern Heritage Centre)
Explosive/Detonator Permit	Storage, handling, and use of explosives	*Explosives Use Act* and Explosives Regulations	Workers' Safety and Compensation Commission
Municipal			
Development Permit	Movement of trailers, demolition of buildings, site grading, pipe networks	City of Yellowknife By-laws	City of Yellowknife

CRP = Closure and Reclamation Plan; MVLWB = Mackenzie Valley Land and Water Board; MDMER = Metal and Diamond Mining Effluent Regulations; EEM = Environmental Effects Monitoring; AEMP = Aquatic Effects Monitoring Program; NWT = Northwest Territories; GNWT = Government of Northwest Territories.

CHAPTER 2
Project Environment

2 PROJECT ENVIRONMENT

Giant Mine is located within Yellowknife city limits, approximately 5 km north of the city centre, at a latitude of 62°31'N and longitude of 114°21'W (Figure 1.0-1). The site is considered to include everything within the boundaries of the former lease that was in place during the operational period of the mine (i.e., Lease L-3669T, now designated as Reserve R622T). Two impacted areas immediately outside of the reserve area are also considered part of the site. They are the Giant Mine "Townsite," which was removed from the surface lease in 1999 and is now a sub-lease held by the City of Yellowknife, and an area of historical deposition along the shore of north Yellowknife Bay (i.e., Foreshore Tailings area). This report will use the term "project boundary" to encompass the reserve and sub-leases held by the city of Yellowknife. The total area within the project boundary is 1,115 hectares (ha).

The Site consists of eight abandoned open pits; an underground mine with an arsenic trioxide storage area; mine waste rock that buttress Dams 11, 21B, and 21D; two Tailings Containment Areas (TCAs) with associated rock fill dams; a tailings retreatment plant (TRP; out of service since 1990); an effluent treatment plant (ETP); a Mill Complex several warehouses, and a Townsite (Figure 2.0-1; Golder 2009). Baker Creek flows through the Site seasonally with one ponded area. Photos of existing Site conditions can be found in Appendix 2A. This chapter summarizes mining-related disturbance and existing conditions in the Yellowknife region and at the Site, and provides an overview of the atmospheric, physical, chemical, and biological conditions.

The environmental conditions of the Site prior to mining are not well known. Pre-mining conditions are briefly outlined in Section 5 in relation to each mine component. Pre-mining and existing environmental conditions are informed by Traditional Knowledge documented in two reports related to Giant Mine as well as a recent heritage assessment (see below). Traditional knowledge documents are not meant to be used in isolation or out of context and readers are encouraged to read the reports in full.

The NSMA are currently undertaking a Traditional Knowledge Study. This study is not specifically focused on the Giant Mine. This work is not yet complete; however, the Project Team remains committed to incorporate input from the NSMA into the GMRP where possible.

A YKDFN Traditional Knowledge study will be finalized in 2019. The following information has been provided through that work.

The population of YKDFN ancestors in Yellowknife Bay was more concentrated than in any other bay in traditional YKDFN territory on the north shore of Great Slave Lake. Traditional Knowledge discouraged YKDFN families from living within areas where wildlife was known to be abundant, to preserve these areas. YKDFN oral history indicates that for this reason camps were established on the east shore of Yellowknife Bay opposite the preferred harvesting areas throughout the current Project Boundary. YKDFN ancestors occupied at least five villages along the east shore of Yellowknife Bay, including Ts'i Naìkwi Dah Kò or Burwash. This village was established long before the first fur traders arrived and served as the capital for the YKDFN.

Elders report that the area described by the project boundary was an abundant source for moose, caribou, bear, wolf, wolverine, lynx, fox, coyote, porcupine, beaver, otter, muskrat, fisher, marten, mink, and rabbit. Rabbit were so plentiful in one area near the Yellowknife River it was known as "rabbit place". In addition to hunting and trapping, the area was preferred for harvesting berries, medicinal plants, and wood. Baker Creek, within the Project Boundary, and the mouth of the Yellowknife River, immediately adjacent, were sources of trout and whitefish.

Elders say these fish were once so numerous during their annual spawn that they filled the river from shore to shore.

The YKDFN harvested thousands of Wı̨ìlı̨ì or Inconnu seasonally in Yellowknife Bay and Yellowknife River, which they named Wı̨ìlı̨ìcheh and Wı̨ìlı̨ìdeh after this critical and plentiful resource.

Weledeh Yellowknives Dene (1997) Weledeh Yellowknives Dene a History. Dettah: Yellowknives Dene First Nation Council.

The following report was prepared by the Elders Advisory Committee in 1997 documenting the Wı̨ìlı̨ìdeh (Yellowknives Dene) history. This report outlines the occupation of the Traditional Territory, Use of lands, Treaty 8, Impacts from Development, and Traditional Knowledge. It does reference Giant Mine and provides the history of the lands on which the Mine occupies. It also provides further understanding of the legacy impacts Giant Mine operations have had on the Yellowknives people and their communities. Please refer to the document in its entirety. This document is available from the Yellowknives Dene website at: https://www.akaitcho.info/linked/weledeh%20yellowknife%20dene%20history.pdf.

The Giant Gold Mine-Our Story: Impact of the Yellowknife Giant Mine on the Yellowknives Dene-A Traditional Knowledge Report YKDFNLEC (2005)

In 2005, the Land and Environment Division of the YKDFN carried out a specific Giant Mine Traditional Knowledge Report documenting the stories and histories of the Yellowknives, and the impact and legacy issues with respect to the operation of the Giant Mine. This report provides more information on the historical environment and traditional use of the Wı̨ìlı̨ìdeh lands, and the cultural significance of the Wı̨ìlı̨ìdeh area and the area now known as the Giant Mine site. Please refer to the full report. This report was provided by the YKDFN to the MVLWB and is available at http://registry.mvlwb.ca/Documents/MV2007L8-31/SD%20A1_Giant%20Mine%20TK%20Report%20YKDFN.pdf.

Giant Mine Environmental Assessment 2007-2014. Report of Environmental Assessment -Section 12.

Section 115 of the *MVRMA* required the Environmental Assessment process to consider the protection of the cultural well-being and the importance of conservation to the well-being and way of life of Indigenous peoples. It documented evidence pertaining to the effects of the Project on the traditional use of the Project area and downstream. The Report of Environmental Assessment page 185 reads:

“The Aboriginal Parties, and particularly the Yellowknives Dene, described to the Board the nature of the loss they suffered to their traditional use of the land because of the Giant Mine. They have told the Board how the area, was close to communities and used for fishing, hunting, trapping, harvesting berries, traditional teas, medicinal plants, traditional trails and burial sites. In their statements to the Board, it was clear that they believe impacts of Giant Mine continue to affect them. The Yellowknives Dene recognize that much of the damage is likely irreparable, and that the mine site is never going to be used in the same way in the future as it was before Giant Mine. The Yellowknives Dene reflected on what the land provided in the past, and the little benefit they received from Giant Mine.”

Specific individual stories and statements from various members of our Indigenous communities are further presented and documented in the September 12, 2014 EA Public Hearings transcripts.

Heritage Assessment 2012

At the request of the YKDFN, a Heritage Overview Assessment was conducted for the Giant Mine area in 2012, by Altamira Consulting Ltd on behalf of Det'on Cho Corporation. The purpose of the was to identify the nature and extent of heritage resources (archaeological and historic) within the Giant Mine Study area and to determine the need for additional heritage assessment work prior to the start of land disturbance activities associated with the remediation. Four previously identified archaeological sites, discovered in the 50s, and 60's, containing small artifacts, have been recorded with the Prince of Wales Heritage Center within their Northwest Territories (NWT) Cultural Places Program and these were outlined in the DAR. This assessment was intended to update the DAR and include general discussion on past land use and traditional land use.

A visual inspection of the Site area was undertaken in October 2012 with the YKDFN Land and Environment Department Traditional Knowledge staff member and a Traditional Knowledge holder. Field work consisted of revisiting the known or previously recorded archaeological sites on Site along with a visual survey of selected areas. The site visit found evidence of a possible food cache within the project boundary. This is in alignment with oral history related to traditional use in the area. YKDFN ancestors preserved and stored fish, meat and berries in the areas where they were harvested using holes lined with spruce boughs and moss. These caches were to be recovered by hunters and trappers returning from the barrens along traditional trails that crossed the current project boundary.

No new archaeological sites were recorded during the field survey although five new "Traditional Use" sites were recorded. The assessment did not consist of the incorporation of any testing or collection of materials or artifacts. The assessment indicated that these traditional uses sites would be further defined and additional archaeological and historical sites will likely be identified during a more detailed and formal archaeological impact assessment. A site investigation in 2018 identified and documented heritage resources, archaeological remains and/or artifact locations and the proposal of appropriate methods to preserve and protect mitigate all heritage locations as identified during the field assessment. The implementation of site-wide remediation activities will aim to avoid any disruption or disturbance of the identified features, where possible, while completing the necessary clean-up remediation.

Yellowknives Dene Traditional Knowledge Component for the Giant Mine Remediation Project (2019)

In 2018, Trailmark Systems interviewed YKDFN members on the history of the mine and remediation plans took place, as well as consolidation and review of past materials recorded on the Yellowknives experiences and impacts of the Giant Mine. This report, available in early 2019, will provide results of these interviews as well as build off of past documented material to share concerns, recommendations, and planning insight into GMRP activities, perpetual care monitoring, and closure site design.

Archeological Impact Assessment (2018)

Golder Associates Ltd. (Golder) conducted an Archaeological Impact Assessment in support of the Giant Mine Remediation Project on behalf of Crown-Indigenous Relations and Northern Affairs Canada and Public Services & Procurement Canada in July 2018. This work was carried out under Northwest Territories Class 2 Archaeologist Permit No. 2018-002 issued by the Prince of Wales Northern Heritage Centre, Government of Northwest Territories. The field program was carried out with the assistance of Yellowknives Dene First Nations members/representatives. In preparation and planning for the field component of the Archaeological Impact

Assessment, the GMRP and Golder met with numerous affected and interested parties, including: Yellowknives Dene First Nation (including the Giant Mine Advisory Committee [GMAC], the Elders Senate, and staff), an elder from the North Slave Métis Alliance (NSMA), archaeologists at the Prince of Wales Northern Heritage Centre, members of the Yellowknife Historical Society and City of Yellowknife Heritage Committee. As well, Trailmark interviewed a number of elders and knowledge holders to identify past use areas and areas of high potential to produce a figure used to help guide the field component.

Up to four members and/or representatives of the YKDFN participated in each day of the field investigation. Areas of high archaeological potential overlapping with areas of planned or potential areas of remediation were investigated. As well, previously recorded archaeological sites and traditional use areas were revisited. The 2018 field program examined 21 proposed borrow sources, two soil remediation areas, 4 known archaeological sites, and 8 known traditional use areas within the project area. Assessment consisted of pedestrian reconnaissance, visual inspection of ground surface exposures and shovel testing to document and evaluate archaeological and traditional use sites.

No archaeological or traditional use sites were identified in 17 of the assessed borrow source areas and there are no further archaeological concerns with these developments. Four of the borrow source areas (A1 Pit Highwall, Brock Pit Area, B2 Area, Potential Source Area 5) and the two soil remediation areas did contain archaeological or traditional use sites within or adjacent to their boundaries. This included three revisited and four newly recorded archaeological sites (KcPh-1, KcPh-3, KdPg-4; Giant 18-1, Giant 18-2, Giant 18-3, Giant 18-4), as well as eight revisited and one newly recorded traditional use site (TU-1 to 9). It is recommended that site recording and evaluation have adequately mitigated most of these sites and there are no further archaeological concerns.

The exceptions are:

- Giant 18-1: additional feature mapping is recommended at this 1940's exploration camp if it is determined soil remediation efforts will impact this site.
- TU-1: site avoidance is recommended of this traditional use campsite/lookout area by altering the boundaries of Potential Source Area 5.

The GMRP has committed incorporating the results of this study into the final selection of the borrow areas.

As well, the GMRP has committed to further archaeological work pending results from the ongoing traditional knowledge work of Trailmark and YKDFN, or if remediation activities in the future include areas not assessed during the 2018 AIA.

Results of the Archaeological Impact Assessment were presented to the Giant Mine Working Group in October 2018, to YKDFN staff/representatives in November 2018 and the YKDFN community in January 2019.

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634000 636000 638000

6936000 6934000 6932000

Trapper Lake
Shot Lake
DAM 22B
NON-HAZARDOUS MATERIALS STORAGE AREA
DAM 22A
HAZARDOUS MATERIALS STORAGE AREA
Yellowknife River
Gar Lake
NORTHWEST POND
DAM 21D
SOLIDS RETENTION DYKE (SPLITTER DYKE)
CONTAINMENT BERM
DAM 21A
EFFLUENT TREATMENT PLANT (ETP)
DAM 21C
DAM 21B
B4 PIT
Trapper Creek
DAM 3C
DAM 3
SETTLING POND
POLISHING POND
DAM 1
DAM 2
DAM 3D
Baker Creek
B3 PIT
NORTH POND
M&M DAM
TAILING REPROCESSING PLANT
DAM 6
Pocket Lake
Baker Pond
4
DAM 10 (REMOVED)
CENTRAL POND
DAM 4
DAM 9
STORAGE DOME
MATERIAL STORAGE AREA
CALCINE POND
B1 PIT
B2 DAM
DAM 8
B2 PIT (UBC)
DAM 5
DAM 12
BROCK PIT
FORMER ROASTER AND STACK
SOUTH POND
MILL POND
MILL
DAM 11
C SHAFT
DAM 7
C1 CLAY BORROW DAM
Baker Creek
C1 PIT
FORESHORE TAILINGS AREA
A SHAFT
Yellowknife Bay
Handle Lake
A1 PIT
TOWNSITE
DWC DAM
A2 PIT
MARINA

LEGEND

- BUILDING
- GIANT MINE PROJECT BOUNDARY
- HIGHWAY
- INDUSTRIAL WATERCOURSE
- INFRASTRUCTURE
- ROAD
- SPLITTER DYKE
- SURFACE WATER MANAGEMENT DAM/DYKE
- TAILINGS OR SLUDGE RETENTION DAM
- WATERCOURSE
- INDUSTRIAL WATERBODY
- PIT BOUNDARY
- WATERBODY

0 250 500
1:20,000 METRES

REFERENCE(S)

HYDROLOGY AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-22
DESIGNED	DP
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

GIANT MINE SITE LAYOUT

REV. 0

FIGURE 2.0-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0

2.1 Atmospheric

2.1.1 Climate Means

The climate of the North Slave region is characterized by cool summers, very cold winters, and low humidity; it is considered one of the drier regions of Canada (INAC and GNWT 2010). Climate data from the Yellowknife airport meteorological station are available and climate means for the 1943 to 2017 and 2007 to 2017 time periods for Yellowknife, NWT are summarized in Table 2.1-1. The 2007 to 2017 means are used to summarize recent conditions (within the last 10 years), for comparison with the 1942 to 2017 long-term mean.

Table 2.1-1: Climate Annual Means for Yellowknife, NWT

Climate Variable	Long-Term Mean (1943–2017)	Recent Mean (2007–2017)
Air temperature (°C)	-4.8	-3.7
Total snowfall (cm)	140.5	155.2
Total rainfall (mm)	157.7	173.8
Total precipitation (mm)	270.5	283.0

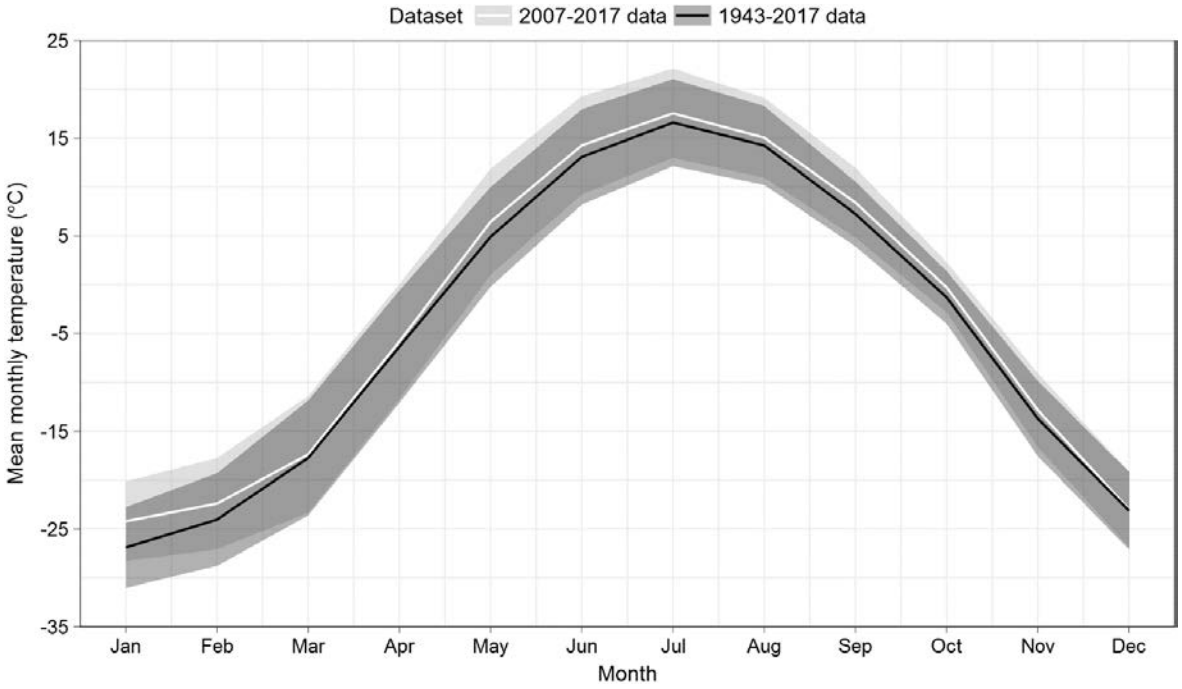
Source: ECCC 2017a.

°C = degrees Celsius; cm = centimetre; mm = millimetre.

2.1.2 Air Temperature

Yellowknife's long-term (1943 to 2017) mean annual air temperature is -4.8 degrees Celsius (°C), with July being the hottest month (highest recorded mean daily temperature of 27.1°C) and January being the coldest month (lowest recorded mean daily temperature of -47.6°C; Table 2.1-1 and Figure 2.1-1). The 2007 to 2017 mean temperature is 1.1°C warmer than the 1943 to 2017 long-term mean, but the annual temperature pattern has followed the same trend. Since 1943, the minimum temperature of -51.2°C was recorded on 31 January 1947 and the maximum temperature of 32.5°C was recorded on 16 July 1989 (ECCC 2017a).

Figure 2.1-1: Yellowknife Airport Temperatures, 1943 to 2017 and 2007 to 2017 Monthly Means (Lines) and Minima and Maxima (Ribbons)



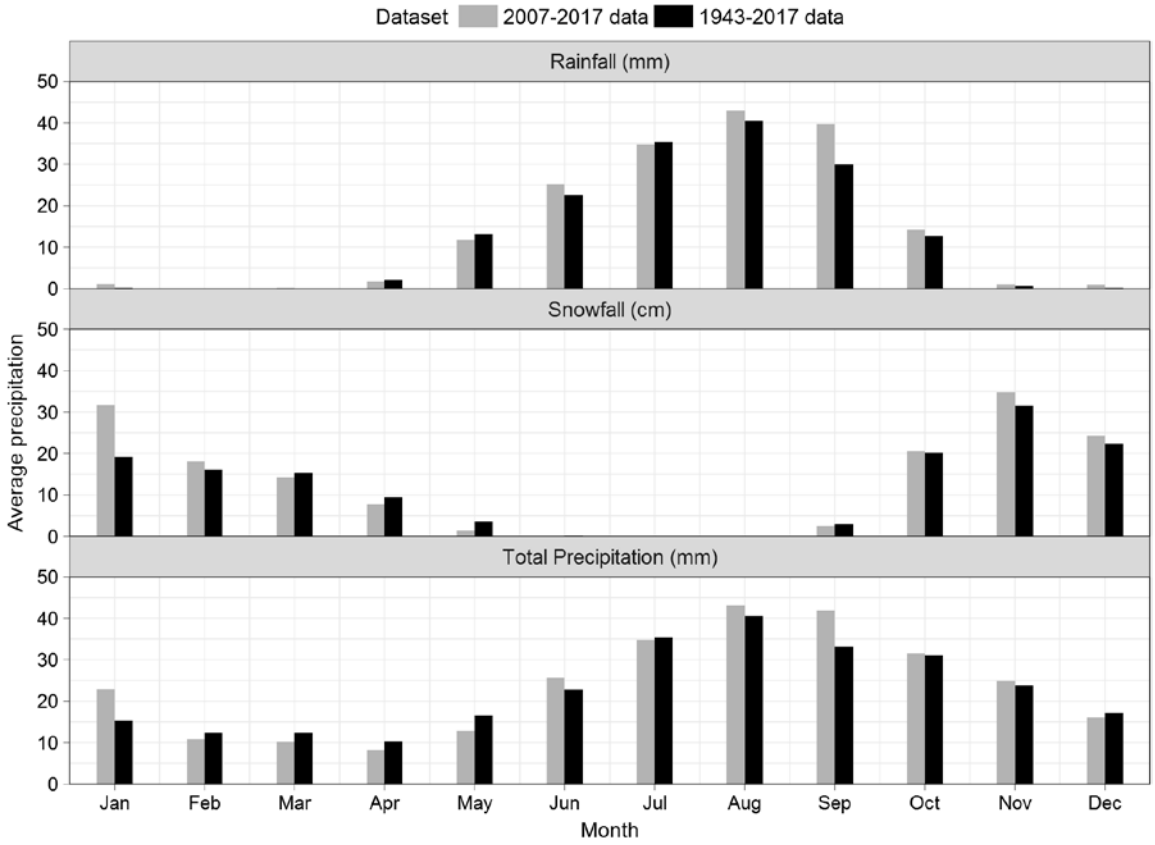
Data source: ECCC 2017a.

2.1.3 Precipitation and Evaporation

Yellowknife's long-term (1943 to 2017) mean annual snowfall is 140.5 cm, and mean annual rainfall is 157.7 mm. A maximum daily snowfall of 26.4 cm was recorded on 29 October 2008, and a maximum daily rainfall of 82.8 mm was recorded on 15 August 1973 (ECCC 2017a). Although the 2007 to 2017 mean precipitation (rainfall, snowfall, and total) is higher than the 1943 to 2017 long-term mean, the precipitation has in general followed the same trend (Table 2.1-1 and Figure 2.1-2). A snowfall peak can be observed in January and November for the long-term (1943 to 2017) and short-term (2007 to 2017) averages, while rainfall has historically peaked in August but in more recent years has shifted to a September peak (Kokelj et al. 2012).

The probable maximum precipitation (PMP) event for the Site has been estimated using the Hershfield statistical procedure described in Chapter 4 of the Manual for Estimation of Probable Maximum Precipitation by the World Meteorological Organization (WMO 2009). The PMP is defined as the theoretical greatest depth of precipitation for a given duration for a design watershed or a given storm area at a particular location at a particular time of year (WMO 2009). The estimated PMP for the Site, over a 24-hour period at a single point is 328 mm (Section 5.5).

Figure 2.1-2: Yellowknife Airport Monthly Mean Precipitation, 1943 to 2017 and 2007 to 2017

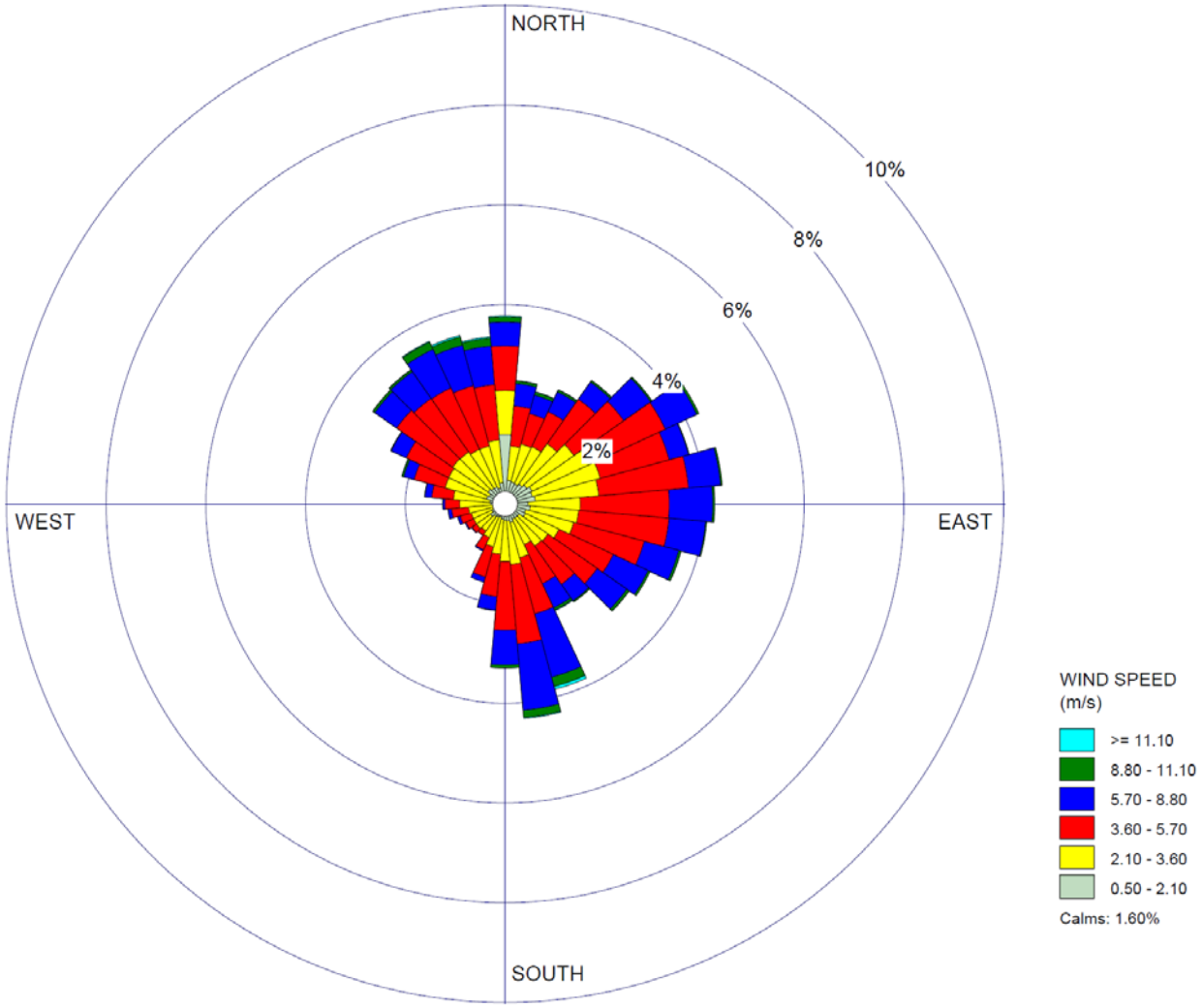


Date source: ECCC 2017a
mm = millimetre; cm = centimetre

2.1.4 Wind Speed and Direction

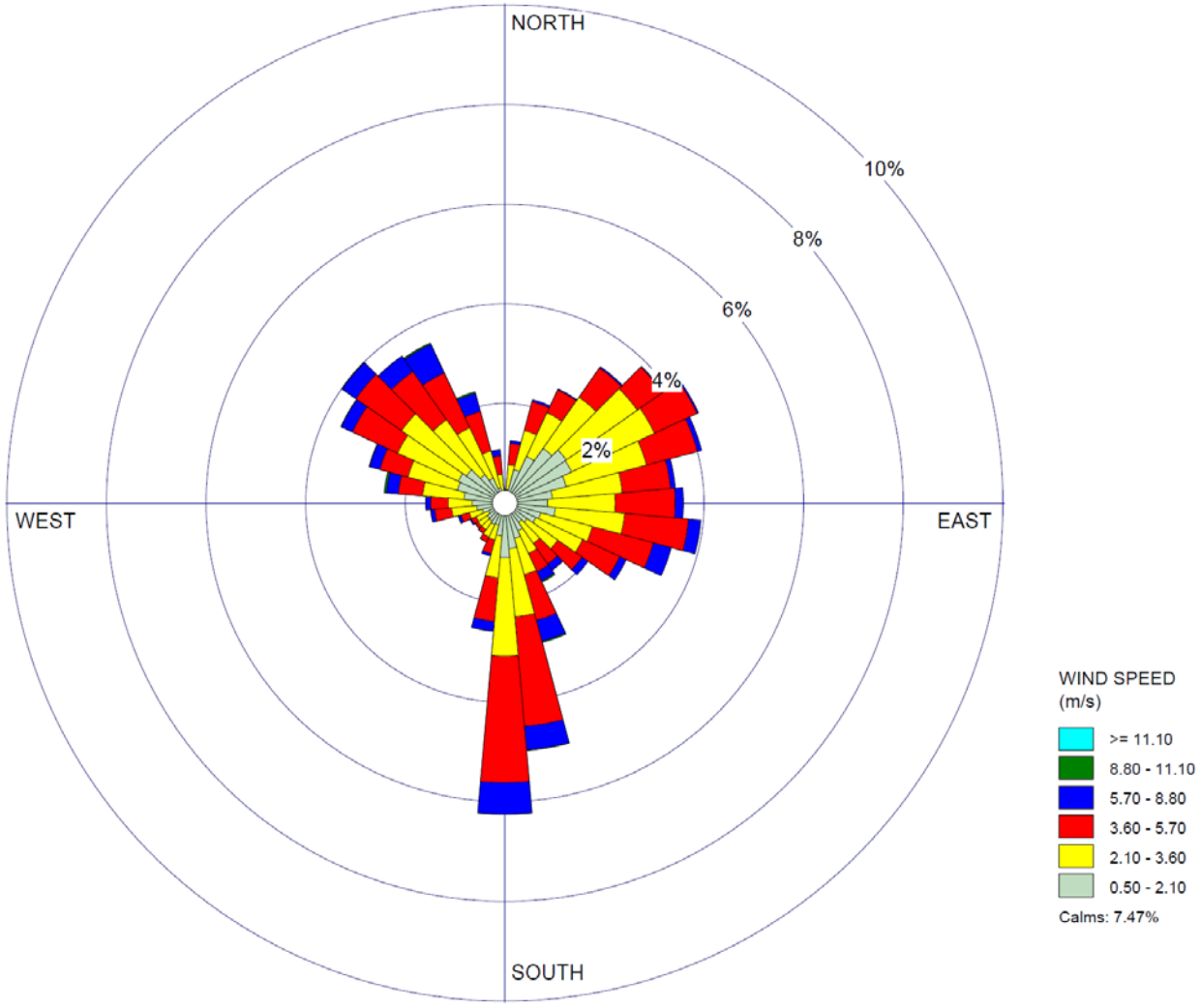
The mean wind speed recorded at the Yellowknife airport between 1981 and 2010 was 12.8 kilometres per hour (km/h) (ECCC 2017a). Yellowknife's monthly mean wind speed ranged from 10.7 km/h (January) to 14.3 km/h (October). In June, July, and August, the most frequent winds were southerly, while easterly winds dominated the rest of the year. Wind speeds reaching over 53 km/h were recorded on a mean of 1.8 d/yr only. Wind characteristics for the period of record from 2013 to 2017 for the Yellowknife airport are presented on a windrose in Figure 2.1-3. Between 2013 and 2017, winds have mostly blown from the east and rarely from the west or southwest and were typically low winds blowing at less than 5.7 metres per second (m/s) (Figure 2.1-3). Wind characteristics at the Yellowknife Airport were also summarized in the fugitive dust assessment (RWDI 2016) for the period of 1992 to 2012. Wind characteristics for Site are shown on the windrose in Figure 2.1-4. Between 2013 and 2017 wind conditions typically consisted of low wind speeds less than 5.7 m/s and mostly blew from the east, northwest and south, and rarely blew from the west and southwest (Figure 2.1-4).

Figure 2.1-3: Yellowknife Airport Windrose, 2013 to 2017



% = percent; m/s = metres per second.

Figure 2.1-4: Site Windrose, 2013 to 2017



% = percent; m/s = metres per second

2.1.5 Climate Trends

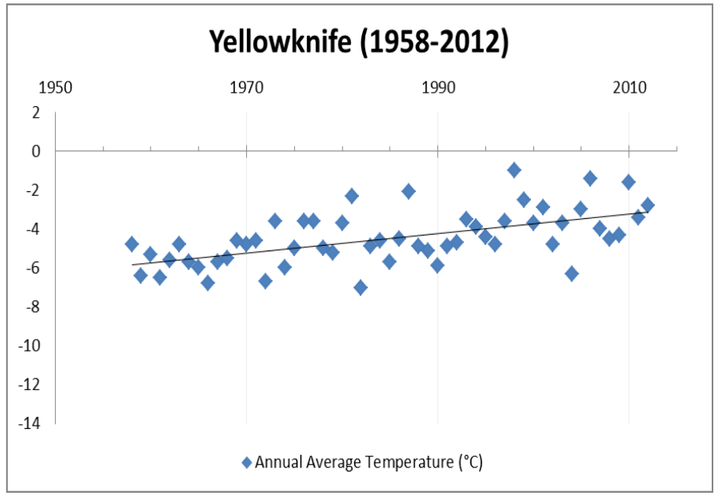
In addition to the summary of the range of climate measurements outlined above, a more detailed review of the changes in local climate in the Yellowknife area over time was conducted by the GNWT. This included an analysis of weather data recorded at the Yellowknife airport between 1958 and 2012 (GNWT 2015).

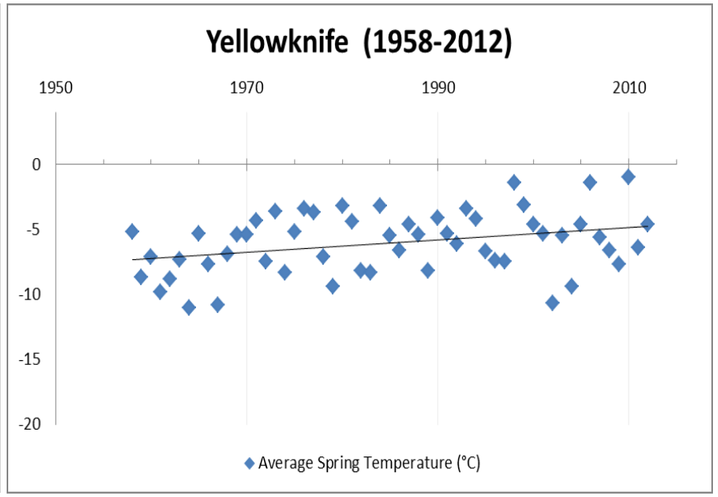
Temperature: temperature during each season has been rising, less so in the summer

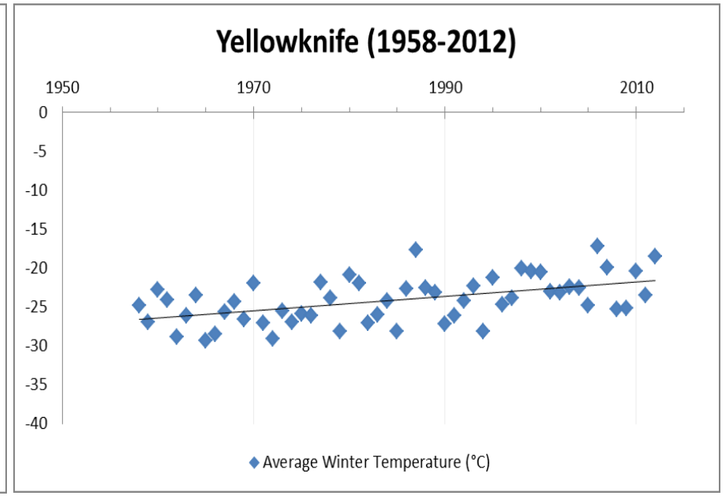
- an increase in the mean annual temperature of 2.0°C
- an increase in the mean winter temperatures of 2.9°C
- an increase in the mean spring temperatures of 2.7°C
- an increase in the mean summer temperature of 1.5°C
- an increase in the mean fall temperature of 2.9°C

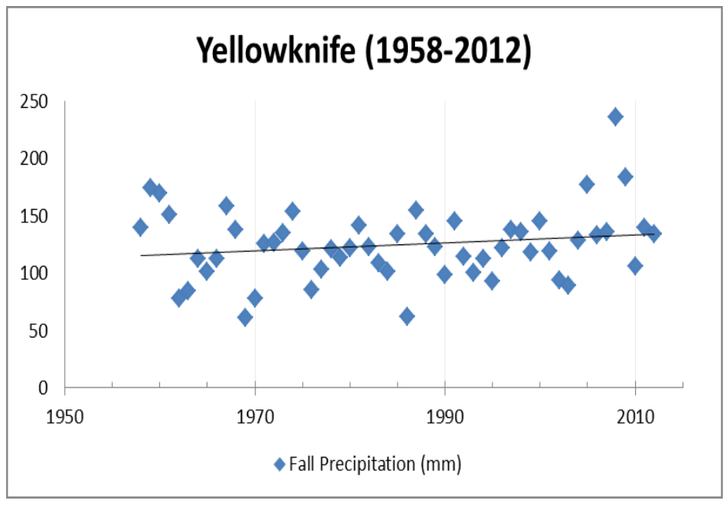
Precipitation: An increase in the mean winter, summer, and fall precipitation, a slight increase in the mean spring precipitation, as well as a small decline in winter precipitation was observed in Yellowknife from 1953 to 2012 (Figure 2.1-5). Declining snowfall when compared to increasing overall precipitation is indicative of warmer spring temperatures preventing snow from forming (GNWT 2015).

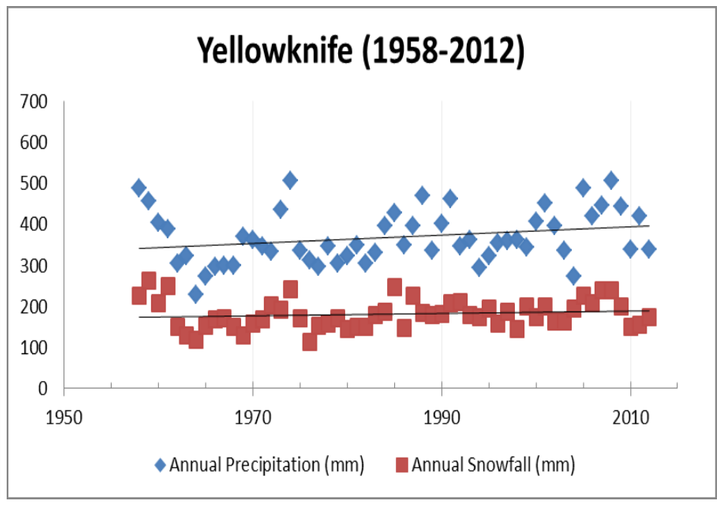
Figure 2.1-5: Selected Yellowknife Climate Trends, 1958 to 2012











Source: GNWT 2015

Future climate change may include warmer temperatures, leading to greater precipitation, greater evaporation, changes to the balance between snowfall and rainfall, and changes to the timing of freeze-up and spring freshet. The nature of the Baker Creek watershed means that increased precipitation may be offset to some extent by increased evaporation. Peak flows may also be affected by changes to the seasonal distributions of rainfall, snowfall, and snow melt. A further discussion of climate change relative to design of the CRP is provided in Section 5.0. The plan for Baker Creek is to widen and adjust it to be able to allow flood waters to pass down the creek (see Section 5.5).

2.1.6 Air Quality

Ambient air quality has been monitored intermittently at the Site (INAC and GNWT 2010) for many years, but a formal program, the Air Quality Monitoring Program (AQMP), began in 2014. In general, the objectives of the AQMP are to maintain compliance with established GMRP air quality criteria during remediation activities, and to assess the impacts to community air quality as a result of remediation activities. Additional activity-specific air quality monitoring is also completed as part of maintaining worker health and safety on site as well as to monitor for fugitive dust that may affect nearby land and water. Activity-specific air quality monitoring results may be used to validate the ambient air quality results, as required, but they are not incorporated into the general ambient air quality assessment.

The AQMP consists of two components (Figure 2.1-6):

1) **Fenceline stations**—nine stations located on the perimeter of the project boundary, which are monitored annually from May to early December.

2) **Community stations**—one station is located at the Great Slave Sailing Club, one station is located in Niven Lake in Yellowknife, and one station is located in the community of Ndilǫ, which are monitored year round.

Weekly air quality reports are sent to communities on the GMRP distribution list and are posted on the MVLWB Public Registry under the Water Licence MV2012L8-0010, which is related to the Site Stabilization Plan work (see Chapter 4 for details). In 2014, one GNWT community station (downtown Yellowknife) that is part of the National Air Pollution Surveillance program was included as part of the AQMP, but was subsequently removed when a new station was set up in the Niven Lake area in 2016-17. Data from the National Air Pollution Surveillance station is still be collected by the GNWT and is made available to the GMRP for comparison of results. A re-evaluation of refinement to the AQMP study design was completed in 2018 for improved efficiency and to be certain monitoring stations were independent of one another (AECOM 2019).

Suspended particulate matter, arsenic, and combustion emissions were selected as air quality indicators for the AQMP (INAC and GNWT 2010). Airborne particulate matter is made up of microscopic solid (e.g., arsenic, asbestos) and liquid particles that remain suspended in the air, and that come from windblown dust and combustion emissions. The size of the particles varies from 0.005 to 100 micrometres (µm) in diameter, and the various sizes can be subdivided into three fractions:

- total suspended particulate (TSP) matter consisting of all particles with a mean diameter <30 µm
- inhalable particulate matter (PM_{10}) with a mean diameter <10 µm
- fine particulate matter ($PM_{2.5}$) with and mean diameter <2.5 µm

The $PM_{2.5}$ and PM_{10} fractions are easily inhalable and can penetrate deep within the respiratory system, causing health concerns.

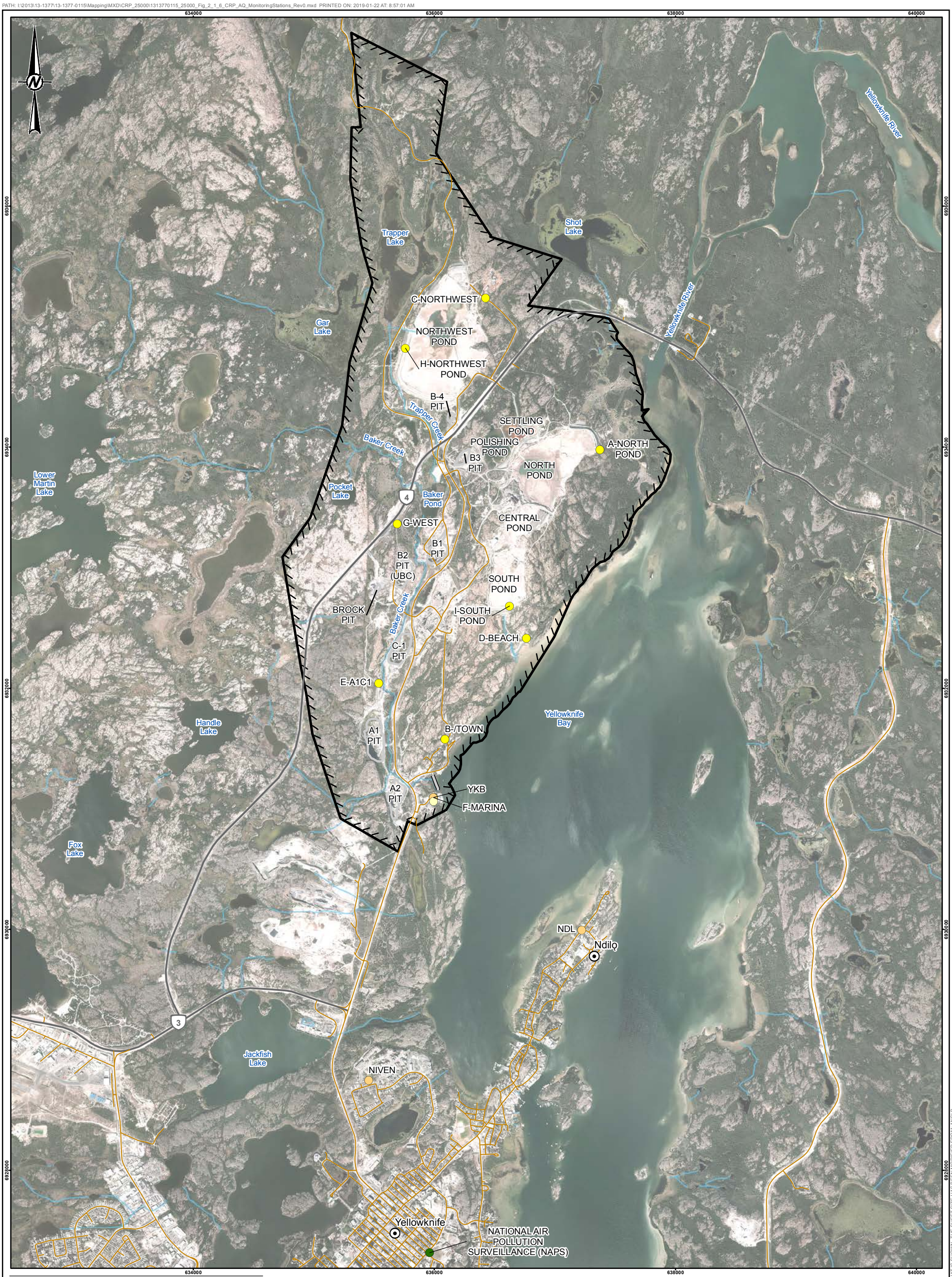
AQMP fenceline stations at the Site continuously monitor ambient air in real time, calculating 15-minute average concentrations of PM_{10} and TSP during the period when the fenceline is operational. The fenceline also calculates an integrated filter based on 24-hour concentrations of PM_{10}, TSP, and trace metals (antimony, arsenic, lead, nickel, and iron). The community stations monitor ambient air for $PM_{2.5}$ and PM_{10} on a continuous basis, averaged hourly as well as integrated sampling for TSP, PM_{10}, asbestos, trace metals (antimony, arsenic, lead, nickel, and iron) averaged over a 24-hour period (SLR 2015, 2017, 2018).

The GNWT ENR has developed a Guideline for Ambient Air Quality Standards (GNWT ENR 2011), which is based on the National Ambient Air Quality Objectives and Canada-wide Standards. This guideline was established under the GNWT's *Environmental Protection Act* and sets standards for ambient air quality throughout the NWT. For parameters that do not have applicable GNWT air quality criteria, results are compared to the Ontario Ambient Air Quality Criteria or toxicological reference values outlined by Health Canada (AECOM 2013).

In addition to monitoring air quality criteria for exceedances, some stations are compared to Site-specific Risk-Based Action Limits (RBALs). An action level is a contaminant concentration that when exceeded requires a response such as additional handheld sampling, immediate work procedure modification and/or work stoppage until the issue is resolved or elevated concentrations are reduced below the RBAL. RBAL for real-time fence line monitoring of PM_{10} for protection of the local air quality during remediation activities at Site were developed. The action levels were based on criteria for arsenic exposure outlined by Health Canada (AECOM 2013). A detailed list of the RBALs are outlined in the AQMP.

In general, the AQMP results show that during care and maintenance, the ambient air quality at the Giant Mine is similar to local conditions with some exceptions. Some fence line stations have exceeded TSP criteria and a few RBALs. The cause of this was attributed to smoke from regional forest fires and/or road dust generated from excavation or maintenance vehicle traffic on Site. TSP concentrations exceeding the RBAL measured in late fall/early winter months have been attributable to fog, snow, and sleet. The community stations have also recorded measurements of PM_{10} and $PM_{2.5}$ above air quality criteria and they also recorded multiple 24 h TSP and PM_{10} measurements above their respective standard, however, there have been no exceedances for arsenic level criteria (SLR 2015, 2017, 2018). The majority of particulate concentrations measured above the standards at the community stations were likely caused by smoke from regional forest fires during summer months and to dust from adjacent roads, measured during the spring before winter road sand was removed. On none of these occasions was the wind direction such that the sampling locations were consistently downward of the Site. Wind directions on these days placed the sampling locations either upwind or crosswind of the Site, or were variable throughout the sampling day (SLR 2015, 2017, 2018).

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LEGEND

- COMMUNITY

AIR QUALITY MONITORING STATIONS

- COMMUNITY MONITORING STATION
- GNWT MONITORING STATION
- SITE PERIMETER STATION
- BREAKWATER
- GIANT MINE PROJECT BOUNDARY
- HIGHWAY
- ROAD
- WATERCOURSE
- PIT BOUNDARY

0 500 1,000

1:30,000 METRES

REFERENCE(S)

HYDROLOGY AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-22
DESIGNED	JC
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

AIR QUALITY MONITORING STATIONS, GIANT MINE REMEDIATION PROJECT

REV. 0

FIGURE 2.1-6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

0 25mm

2.2 Physical

2.2.1 Topography

The Site consists of undulating topography, with a central valley containing Baker Creek and Trapper Creek (Figure 2.2-1; Figure 2.2-2; Golder 2009). Extensive areas of exposed bedrock are present on the higher ground, with surficial deposits in low-lying areas (INAC and GNWT 2010). The ridges on either side of Baker Creek are 10 to 20 m high and the slopes are bedrock controlled. There is thin soil on most of the ridge slopes. Mining activity in the Baker Creek valley has significantly altered the local topography, and portions of the Baker Creek channel have been relocated several times throughout the history of operations (Golder 2009; also see Section 5.5). The most recent realignment of Baker Creek (specifically Reach 4) occurred in 2006 (see Section 4 for more details). Deposition of tailings filled small valleys and existing lakes on portions of the site.

2.2.2 Bedrock Geology

The Giant Mine gold deposits occur within the Archean-aged Yellowknife Greenstone Belt, located in the southeast corner of the Slave Province and extending north from Great Slave Lake for a distance of over 50 km (Golder 2009). The greenstone belt is bounded to the west by younger granitic rocks of the Western Plutonic Complex and to the east by siliciclastic sedimentary rocks of the Burwash Formation.

The local bedrock is typically composed of basalt flows, which occur as both pillowed and massive units. The rounded, weathered, elongated outcrops are typically oriented northeast–southwest. Mafic volcanic rocks are bounded to the west by granodioritic plutonic rocks which are in fault contact, and to the east by sedimentary rocks along the shore of Yellowknife Bay.

The structural geology of the area is dominated by a series of major fault zones which influence the geomorphology of the area. The Site is bounded by a series of major Proterozoic faults (West Bay, Akaitcho, Townsite, Rudolph, and 3-12), which play an important role in terms of hydrogeology and geotechnical properties. Detailed information on each major fault can be found in the DAR (INAC and GNWT 2010; Figure 2.2-1). The fault system controls, to a degree, the geomorphological conditions at the Site, with the West Bay Fault creating a steep cliff line along the west side of the property. Minor structural features (e.g., fracture sets or shear zones) also play a role and create weaker zones that are followed by local creeks and erosional features.

No significant water flow has been reported from any of the faults (INAC and GNWT 2010). Information on rock mass quality and macroscopic transmissivity, as well as historical groundwater flow and quality, can be found in the DAR (INAC and GNWT 2010). Additional groundwater quality information can be found in Section 2.3.3.

2.2.3 Surficial Geology

The terrain conditions at the Site are shown in Figure 2.2-1 and consist of a combination of the following (Golder 2016a):

- **Developed Areas**—areas of the Site developed to support mining operations, including tailings ponds, open pits, mill/roaster area, TRP, Townsite, Marina, roadway network, and various laydown and material storage areas. Soil conditions typically consist of contaminated granular fill, underlain by native glaciolacustrine clays, silts, and or bedrock. These areas are typically void of vegetation.

- **Bedrock/Forest/Wetland Terrain**—consist of scrub forest, wetlands, and bedrock outcrops. These lands were not developed as part of the historical mining operations; however, were impacted by aerial dispersion of arsenic-rich roaster stack emissions, tailings releases, and/or the discharge of pond water from the TCAs.

A detailed discussion of the contaminated materials types present within the Developed Areas and the bedrock/forest/wetland terrain and the remedial strategies for each study area are provided in Section 5.4.

The Site lies within a zone of discontinuous permafrost, and the most prevalent soils in the area are glacial till. Organic deposits often overlie glaciolacustrine till, remnants of the approximately 80 m of water in Glacial Lake McConnell overlying the Yellowknife area approximately 10,000 years ago (Golder 2016a). Bedrock outcrops account for approximately 60% of the terrain at the Site, with peaty organic soils, scrub forest, and wetlands constituting the remainder of the terrain (Golder 2016a). These lands are typically poorly drained. Many of the outcrop areas have vegetation in depressions. The native soil consists of till and gravel deposits, overlain by glaciolacustrine clays and silts. Areas with peaty organic soils can be up to 1 m thick in some areas. Additional discussion of vegetation in the area is provided in Section 2.4.3.

Bedrock outcrops are predominant at higher elevations (Figure 2.2-1; Figure 2.2-2). The main portions of the outcrop typically consist of bare, smooth rock surfaces with crevasses that collect soil. Natural soil deposits typically extend to depths of 0.1 to 0.3 m within the narrow bedrock crevasses. Vegetation within the outcrop areas is limited to the outcrop crevasses and the lower lying areas between outcrops.

Vegetated or forested areas occur in lower lying areas between the outcrops. The subsurface soil conditions in the vegetated areas are likely to consist of organic deposits that are typically less than 0.5 m thick, underlain by glaciolacustrine clays and silts. These materials overlay glacial till, which is discontinuous and typically less than 2 m thick.

Wetlands occur in poorly drained areas between the outcrops. The wetlands are small, marshy areas located on the edges of ponds. The subsurface soil conditions in the wetlands likely consist of organic deposits that are typically over 1 m thick, underlain by glaciolacustrine clays and silts.

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LEGEND

- BREAKWATER
- CONTOUR (5 masl INTERVAL)
- GIANT MINE PROJECT BOUNDARY
- PROTEROZOIC FAULT LINE
- WATERCOURSE
- PIT BOUNDARY
- TCA POND

0 250 500

1:20,000 METRES

REFERENCE(S)

HYDROLOGY, TOPOGRAPHY, AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-22
DESIGNED	DP
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

SITE TOPOGRAPHY

REV. 0

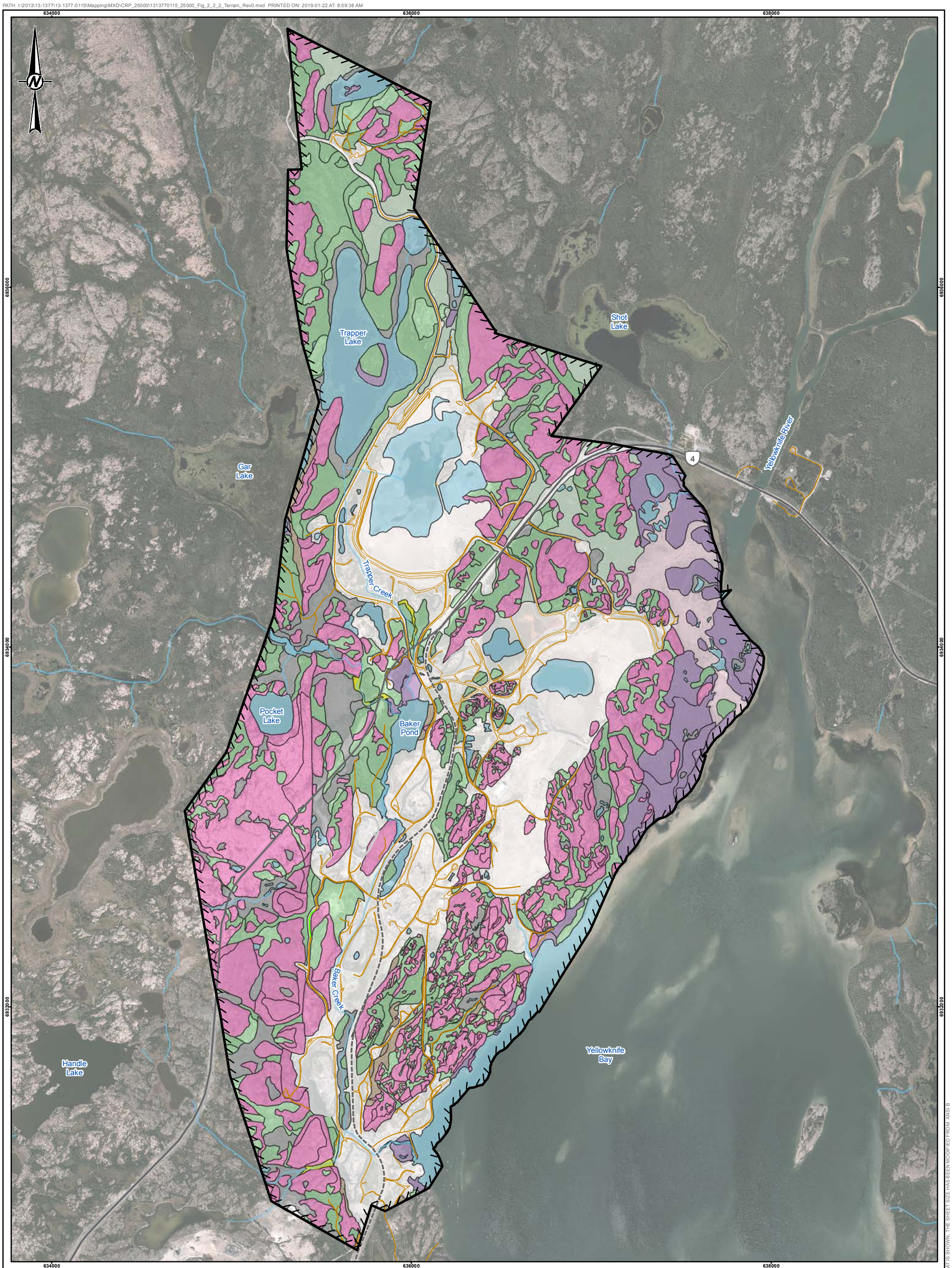
FIGURE 2.2-1

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LEGEND

- HIGHWAY
- GIANT MINE ACCESS ROAD
- ROAD
- PROJECT BOUNDARY
- WATERCOURSE
- PIT BOUNDARY
- TERRAIN POLYGON BOUNDARY (APPROXIMATE)

DOMINANT SURFICIAL MATERIAL

- BEDROCK
- DEVELOPED
- WATERBODY

FOREST TERRAIN

- MORAINAL (BLANKET)
- MORAINAL (THIN VENEER)
- MORAINAL (VENEER)

WETLAND TERRAIN

- COLLUVIUM
- TAILINGS
- FLUVIAL
- LACUSTRINE
- ORGANIC

0 500 1,000

1:20,000 METRES

NOTE(S)

TERRAIN CLASSIFICATION MAPPING GENERATED FROM LIDAR ANALYSIS.

REFERENCE(S)

HYDROLOGY AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-22
DESIGNED	SF
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

SITE TERRAIN MAP

REV. 0

FIGURE 2.2-2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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2.2.4 Permafrost

Permafrost is soil or rock that remains below 0°C throughout the year. Permafrost in the Yellowknife area was created after the withdrawal of Glacial Lake McConnell, which covered close to 15% of the present-day NWT, has been affected by climatic fluctuations in the last 4,000 years (Aspler 1987; Wolfe et al. 2016). In the present day, Yellowknife is within the extensive discontinuous permafrost zone, where permafrost underlies 50% to 90% of the land area, with permafrost ground temperatures close to 0°C (Morse et al. 2016; Wolfe et al. 2016). Permafrost in the area may exist under all major vegetation cover types, underlain by fine-grained sediments. In Yellowknife, permafrost occurrence dominates in areas where organic material accumulates (e.g., peat bogs), is widespread in areas dominated by silts and clays, is sporadic or absent in sands and gravels, and is absent where bedrock is exposed and acts as a heat source (Aspler 1987). Increased distance from exposed bedrock and overburden thickness (serving as insulation) show a direct relationship with permafrost thickness (Aspler 1987).

Permafrost is evident in some areas at Giant Mine. A maximum permafrost depth of 85 m was measured in the B Shaft area of the Site, in a location with 18 m of overburden (Bateman 1949), and permafrost at the Mill was reported down to 82 m (McDonald 1953). No permafrost was found in the upper levels of the B3 area that mostly consist of bedrock (Espley 1969), but it has been noted that the arsenic dust chambers that were constructed above 76 m were, at that time, located within permafrost. Evidence of ice lensing was found when re-aligning Reach 4 in 2006 (Chapter 4). Permafrost was noted at the bridge abutments when replacing the UBC Bridge in 2018.

Historical observations and ground temperature measurements (SRK 2005a, 2006; INAC and GNWT 2010) show that the thermal regime that existed at the Site has been disturbed by mining activities. A combination of underground activities, which introduced heat and removal of insulating layers of overburden exposed more bedrock that acted as a heat source (INAC and GNWT 2010).

2.2.5 Seismicity

The Site is in a region of low historical seismicity (INAC 2011). Between the years 1986 and 2011 (25 years), four earthquakes of magnitude 1 to 2, and 14 earthquakes of magnitude 1 to 4, were measured within radii of 300 km, centred at Yellowknife. The calculated peak ground acceleration of 0.036 g for the 2,475-year return period indicates a low level of seismic activity, and suggests that only minor seismic events could be expected over the long term of the GMRP (INAC 2011). The risk of occurrence of earthquakes of magnitude between 5 and 7.9 occurring within a 300 km radius from Yellowknife is rated as low to moderate and the anticipated events were predicted to have minimal structural impacts (INAC 2011).

2.2.6 Hydrology

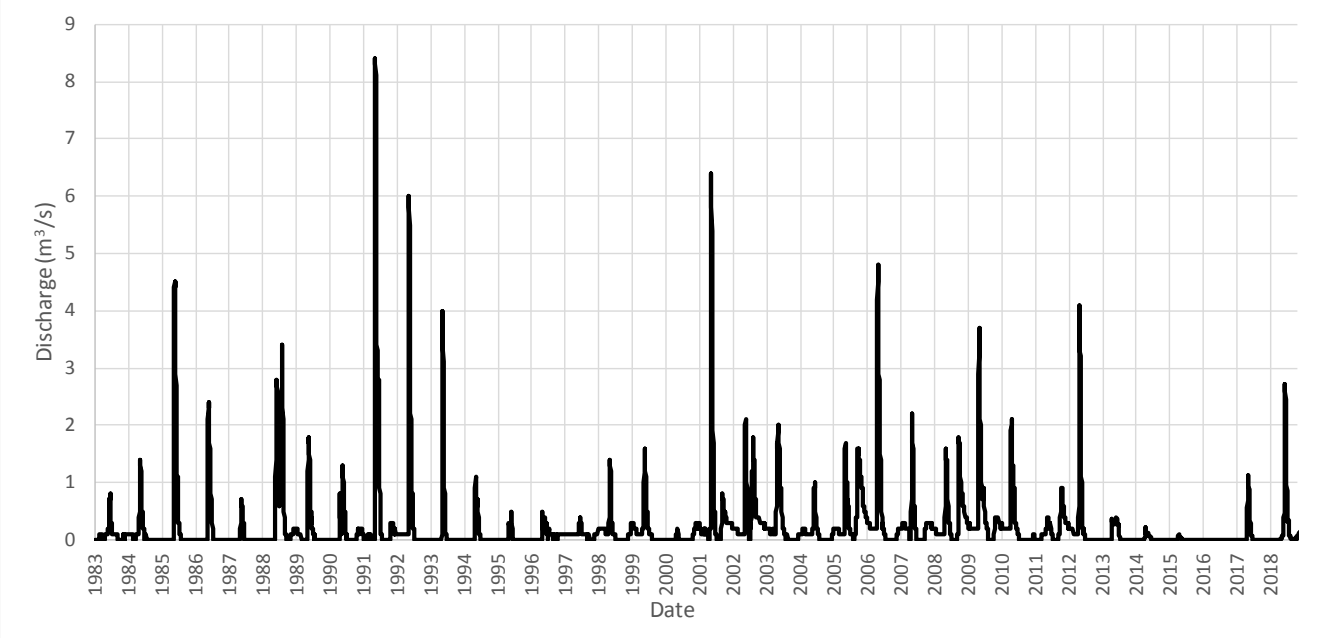
The regional surface hydrology tends to flow from north to south, towards Great Slave Lake (Wolfe et al. 2016). Poor hydrological drainage across the area is due partly to a low topographic gradient, a rectilinear bedrock fault-controlled drainage pattern, and the presence of numerous lakes and wetlands.

Baker Creek is the main hydrological feature at the Site (refer to Figure 2.0-1). Baker Creek originates at Duckfish Lake, located approximately 25 km northwest of the Site (Wight 1973). Baker Creek flows south and southeast from Duckfish Lake, through a series of wetland ponds and bedrock outcrops and into a marsh that is separated by a breakwater from Yellowknife Bay. The drainage area of Baker Creek is estimated at 121 km^2 (WSC 2017).

Baker Creek flows are variable throughout the year, and the stream downstream of Lower Martin Lake flows seasonally (Appendix 2B). In late summer, fall and winter, there are periods with no flow within the creek above the Site and through the Site (Figure 2.2-3). In contrast, Baker Creek downstream of the Site's treated effluent discharge flows continually in summer due to the inputs of treated effluent from July to September (Figure 2.2-4). Peak discharge historically occurred during spring freshet, with 76% of the Baker Creek annual stream flow in May and June compared to 8% between October and March. However, there has been a shift in the regional streamflow regime related to an increasing trend in September rainfall and, since 1997, the proportion of annual stream flow has changed to 50% in spring and 20% in fall/winter (Kokelj et al. 2012; Spence et al. 2015). Between 1983 and 2016, peak creek discharge volumes ranged from 0.011 cubic metres per second (m^3/s) in 2016 to 8.35 m^3/s in 1991 (WSC 2017), excluding treated effluent.

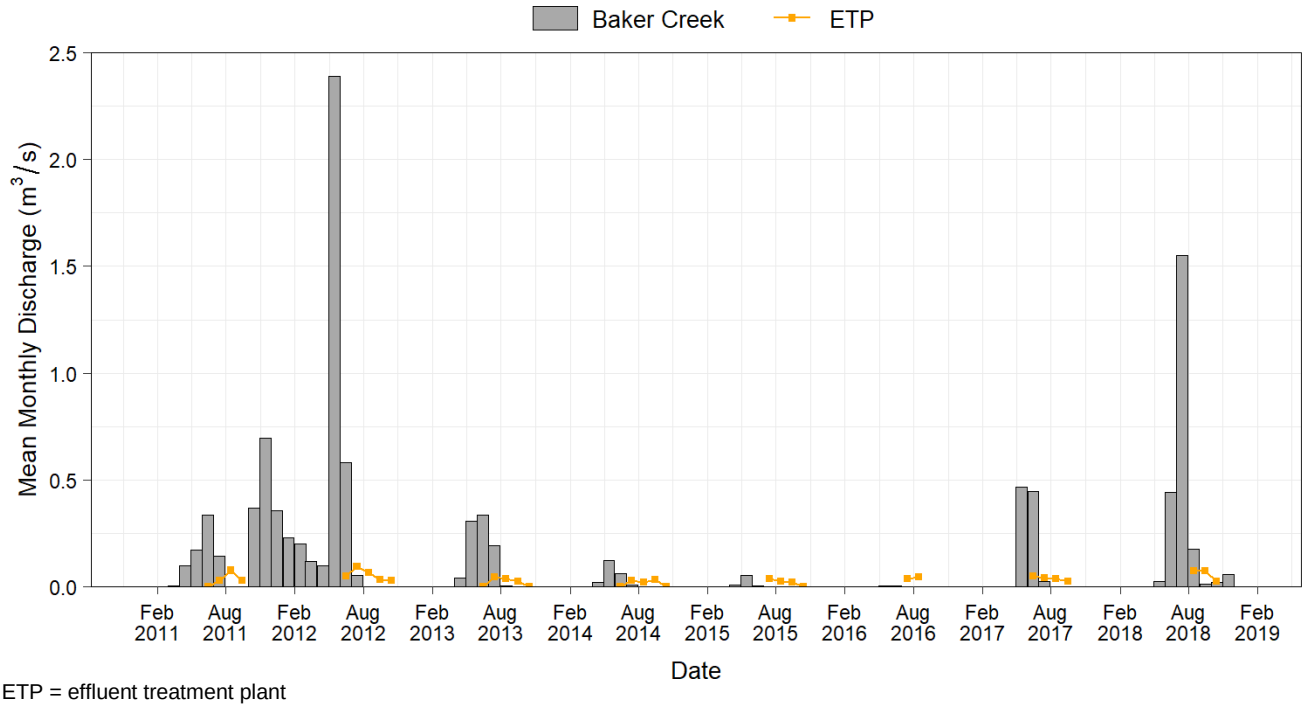
In general, surface runoff on the Site is controlled by outcropping bedrock on the southwest and southeast side of the project boundary (Figures 1.0-1, 2.2-1 and 2.2-2; Golder 2009). Trapper Creek and Baker Creek collect runoff and direct water flow eastward and southward through the property. Creation of the Northwest, South, Central, and North ponds and the Settling and Polishing ponds altered the direction of natural flow. Construction of the Northwest Pond required the relocation of Trapper Creek. Dam 11 at the South Pond has redirected the natural flow from the pond area, which was originally towards Yellowknife Bay; water in this area is now pumped, towards the north and Baker Creek. The open pits have small individual catchment areas that direct surface water underground; this water is pumped back to surface and treated at the ETP before being discharged into Baker Creek (see Section 5.5 as well as the Water Management and Monitoring Plan for details).

Figure 2.2-3: Baker Creek Hydrograph at Outlet of Martin Lake (Hydrometric Station 07SB013) 1983 to 2018



Source: Water Survey of Canada (2017), Hydrometric Station 07SB013 – 2017 and 2018 data not validated by Environment and Climate Change Canada when this report was prepared (Pippy 2018). m^3/s = cubic metres per second

Figure 2.2-4: Comparison of Flow in Baker Creek versus Treated Effluent from the Existing Effluent Treatment Plant



ETP = effluent treatment plant

2.2.7 Hydrogeology

Hydrogeological investigations conducted at the Site were described in the DAR (INAC and GNWT 2010) and specifically in Supporting Documents C1 to C6 to the DAR. Groundwater quality and hydraulic data supporting these investigations have been collected from a network of shallow and deep monitoring wells across the Site (see Section 2.3.4 below), as well as from the underground workings. Water levels and water samples from these monitoring wells have been collected to add establish existing conditions and to support future assessment of the effectiveness of ongoing remedial works and changes in hydrogeological regime.

Water level monitoring across the network of groundwater monitoring wells indicates that a shallow perched groundwater flow system may exist across portions of the Site, where the underlying deeper bedrock has been dewatered by the underground workings. Shallow groundwater (i.e., generally 1 to 20 metres below ground surface [mbgs]) on the eastern perimeter of the Site may be flowing towards Great Slave Lake.

The water level in the underground mine workings is presently maintained just below the 750 Level (750L). At this level, the partially dewatered mine acts as a hydraulic sink for the adjacent area, resulting in hydraulic gradients in the deep bedrock being directed towards the underground workings. Water within the mine pool is hydraulically contained by the associated pumping necessary to maintain the water level just below the 750L, keeping arsenic-affected water in the underground and preventing migration away from the mine workings through groundwater flow.

The bedrock surrounding the mine has a relatively low hydraulic conductivity. As such, while the underground minewater management system collects lateral groundwater inflow, a significant portion of the collected water and associated water quality is also from infiltration from surface water ponds and creeks and from recharge from precipitation (including snowmelt).

Hydrogeological investigations conducted at the Site were used to develop a numerical model to evaluate groundwater flow conditions near the Site (SRK 2005c). This model supported the interpretation that the underground mine presently acts as a hydraulic sink, containing the movement of arsenic-affected water in the underground mine workings. This model is presently being updated based on data collected from the monitoring network since the completion of the DAR.

2.2.8 Physical Structures

The condition and stability of the physical structures at the Site are monitored and inspected frequently. The Original TCA dams (i.e., Dam 1, Dam 2, Dam 3A to 3D, Dyke/Dam 4, Dyke/Dam 5, Dyke 6, Dams 7 to 12, splitter dyke, and containment berm), the Northwest TCA dams (i.e., Dams 21A to 21D, Dams 11A and 22B), and other dams (i.e., B2 Dam and M&M Dam) (see Figure 2.0-1) are inspected annually by a geotechnical engineer (see Chapter 5.6 and 5.12 for details). The tailings dams and tailings contained in the TCA are also inspected twice daily by Site staff during inspections of the overall Site. In addition, bridges, roads, pit walls, creek slumps, and creek water management structures are inspected daily by Site staff. The temperature of the Arsenic Chamber 10 is monitored continuously with temperature sensors. Details of inspections and monitoring are discussed in Chapter 5. Associated management and monitoring plans have been submitted to the MVLWB under separate cover.

2.3 Chemical

2.3.1 Soil Chemistry

Gold mined at Giant Mine was associated with ore rich in arsenopyrite (FeAsS). Roasting of the ore was carried out to improve the efficiency of the cyanide gold extraction process. This roasting process converted arsenic and sulphur to gas phase arsenic trioxide (As_2O_3) and sulphur dioxide (SO_2), which were discharged directly to the atmosphere during the initial two years of operation (1949 to 1950). Emission controls were optimized between 1951 and 1954, and were in place until 1999, when the roaster ceased operations. Efforts to capture roaster stack emissions were made and the arsenic-rich dust was stored in stopes and purpose built underground chambers. As a result of historical roaster stack emissions, impairment of shallow soil quality, vegetation, sediment, and surface water has been recorded within the adjacent bedrock/forest/wetland terrain and waterways (Golder 2017b; Section 5.4, Section 5.5). Contaminated soils at the Site are present in the following two locations: Developed Areas and Bedrock/forest/wetland terrain (refer to Section 2.2.3 for a summary of each location and Section 5.4 for more detail).

Mining operations created mineralized granular fill material, which was used for development along with re-grading and maintenance of the Developed Areas. This fill contains elevated arsenic concentrations exceeding the industrial soil quality guideline for total arsenic of 340 mg/kg (GNWT ENR 2003). The deposition/blending of contaminated granular fill with shallow surficial soils resulted in widespread arsenic contamination within the Developed Areas. In addition, fine-grained glacial till beneath the contaminated granular fill also typically contains elevated arsenic concentrations exceeding the industrial soil quality guideline for total arsenic. These arsenic impacts are associated with migrating/leaching from the above contaminated granular fill. Petroleum hydrocarbon

(PHC)-contaminated soils also occur on Site as a result of historical spills or improper maintenance of multiple aboveground storage tanks and underground storage tanks. The areas of PHC impacts within the Developed Areas typically coincide with areas of arsenic-contaminated soils.

University-based research conducted between 2008 and 2011 (Wrye 2008; Bromstad 2011; Bromstad et al. 2017) identified shallow arsenic contamination across bedrock/forest/wetland terrain at the Site. This research concluded that elevated concentrations of arsenic in shallow soils were significantly higher than those that could be explained through natural processes. In response to this, an initial regional soil sampling program was conducted in 2013 (Golder 2016a). Results of the initial regional soil sampling program identified 14 sample stations located in the bedrock/forest/wetland terrain where the concentrations of total arsenic were greater than the industrial soil quality guideline of 340 milligrams per kilogram (mg/kg). Eleven soil samples, collected from the upper 0.10 m, contained detectable concentrations of arsenite (As[III]), which ranged from 0.15 to 3.95 mg/kg, and 20 soil samples, collected from the upper 0.10 m, contained detectable concentrations of arsenate (As[V]) ranging from 13.5 to 1,063 mg/kg. Both of these forms of arsenic confirm the presence of arsenic-rich roaster stack emissions within the upper 0.10 m of soil within the bedrock/forest/wetland terrain. The results of this program triggered the requirement to complete a more comprehensive regional soil sampling assessment.

A follow-up regional soil quality assessment was completed in 2015 (Golder 2016a). The purpose of the follow-up regional soil sampling program was to characterize the concentration and distribution of arsenic in shallow soils across the bedrock/forest/wetland terrain. At the conclusion of this assessment, it was recognized that the operation of the former roaster has resulted in the widespread distribution of arsenic rich roaster stack emissions and that the soil quality impairment within shallow soil located in the bedrock/forest/wetland terrain was abundant. Key findings from the regional soil quality assessments are as follows:

- Bedrock terrain within the vicinity of the mill and former roaster area exhibits significant variability with respect to arsenic concentrations in shallow soil. Selected soil samples located within close proximity to the former roaster (approximately 250 m) displayed some of the highest recorded arsenic concentrations at the Site (20,800 mg/kg). Within the bedrock terrain, the highest arsenic concentrations are typically recorded in soil samples collected from the upper 0.05 to 0.10 m. However, it should be noted that the contaminated soil is restricted to the crevasses within the bedrock terrain, which typically account for between 1% and 15% of the bedrock surface area.
- With increasing distance from the former roaster stack, a decreasing trend in arsenic concentrations within shallow soil was measured. This is consistent with recent studies, which have estimated that the aerial extent of roaster stack emissions from these initial two years of operation may extend 20 to 30 km from the historical roaster stack (Jamieson et al. 2017).
- The highest concentrations of arsenic within shallow soil outside the immediate vicinity of the former roaster were observed to the west, south, and southeast. This is consistent with dominant historical wind directions and supports an airborne deposition method.
- Although soil within wetland and forest terrain, typically contains elevated concentrations of arsenic, these concentrations are significantly less than those within the bedrock terrain and are restricted to shallow depths. Samples collected from these terrain types generally displayed decreasing concentrations with depth.

2.3.2 Sediment Chemistry

Throughout the operational history of the Site, a variety of sources of environmental impairment have affected sediment quality in Baker Creek and parts of Yellowknife Bay, including the shoreline from the mouth of Baker Creek up to the Foreshore Tailings Area (Golder 2017e). The key sources of sediment impairment include 1) effluent derived from TCAs, 2) minewater discharged from the underground, 3) tailings releases, 4) historical mill/roaster operational process upsets, and 5) aerial emissions from the roaster stack. Further details on these key sources of sediment impairment are provided in Section 5.4. These sources have resulted in elevated concentrations of antimony, arsenic, cadmium, chromium, copper, lead, mercury, and zinc in sediment throughout portions of Baker Creek and Baker Pond and Yellowknife Bay (referred to as nearshore sediment) (Golder 2017e,f).

Comparison of available sediment data to applicable Canadian Council of Ministers of the Environment (CCME) sediment quality guidelines (CCME 2002) presented in Golder 2017f indicate that concentrations of metals in shallow sediments from Baker Creek Reaches 0 and 1 and along the nearshore sediment within Yellowknife Bay were higher than nearby reference sediments and, where probable effect levels were available, higher than potential toxicity benchmarks. Due to arsenic concentrations most consistently exceeding the probable effect level by the highest magnitude, arsenic is the primary sediment contaminant of concern for sediment within Baker Creek and out beyond the breakwater to the surrounding area in Yellowknife Bay (i.e., nearshore sediment) (Stantec 2014). Copper and lead only occasionally exceed probable effect level values in some sediments from locations monitored within Baker Creak and immediately beyond the breakwater in Yellowknife Bay, as well as the adjacent wetland area.

The distribution of total arsenic in sediments along the shoreline from Baker Creek to the Foreshore Tailings Area ranged from 7.4 to 1,860 mg/kg in 2016 (Golder 2017b). The concentrations of arsenic were highest near the Foreshore Tailings Area and mouth of Baker Creek. Refer to CIRNAC and GNWT (2019b) for figures depicting arsenic concentrations in sediment throughout Baker Creek and Yellowknife Bay and Appendix 5.4-A for a summary of sediment chemistry.

Further out into Yellowknife Bay, sediment has been studied for many years (INAC and GNWT 2010), but recent studies with lower analytical detection limits and new collection techniques have provided updated information. This includes sediment studies conducted adjacent to Site and out into Yellowknife Bay by Queen's University, GNWT, and ECCC (Andrade 2006; Galloway et al. 2015; Chetelat et al. 2018). Sediment core samples taken from depths thought to represent pre-mining conditions suggest the background concentrations in the area were lower (approximately 5 mg/kg) than estimated in the early 2000s (RSSI 2002). These studies showed similar patterns of elevated metal concentrations closest to the Site but that the extent of Site influence likely from aerial deposition was widespread in Yellowknife Bay toward Dettah. These studies will help inform future monitoring activities and the choice of reference areas for comparison to Giant Mine before and after reclamation.

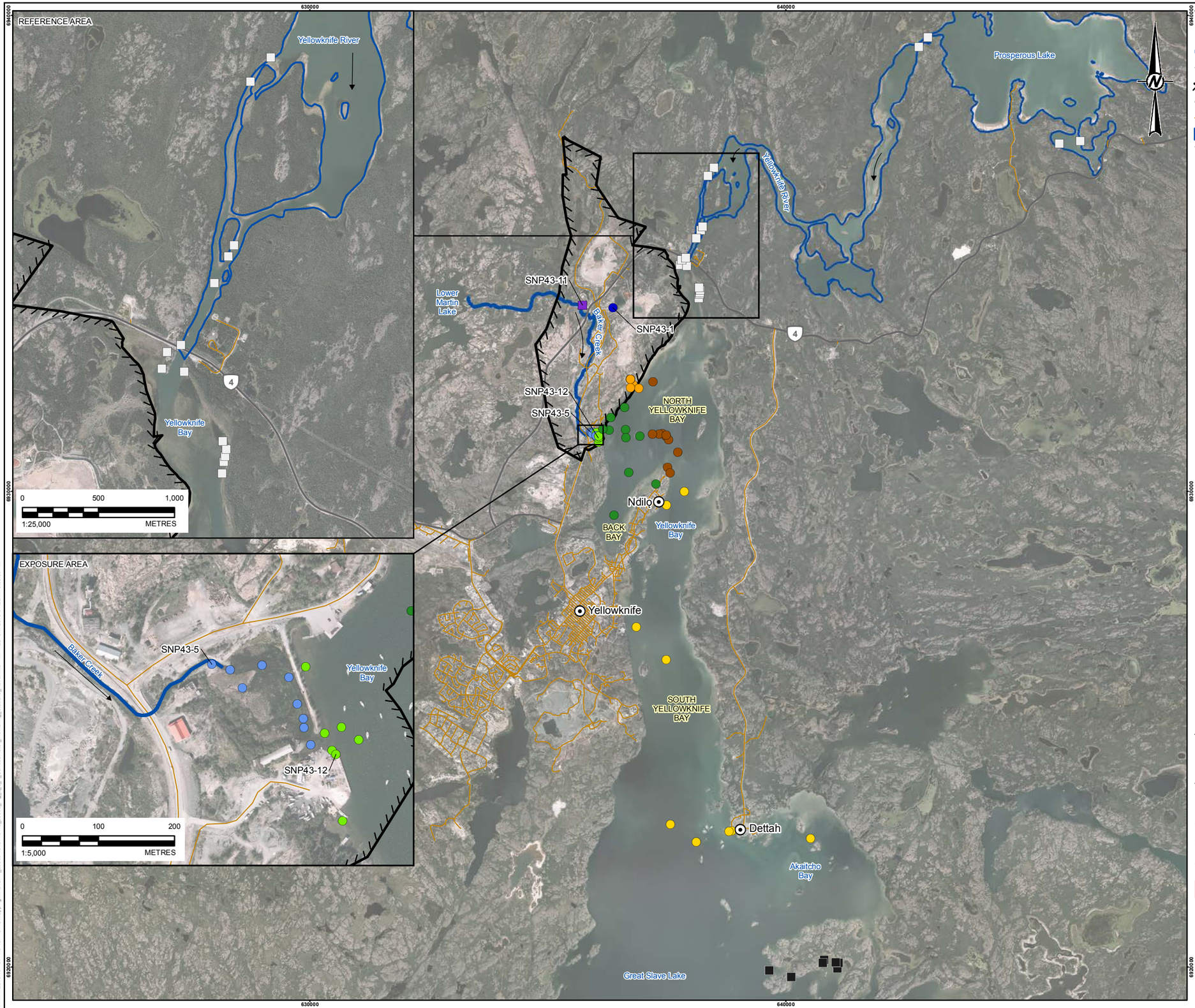
2.3.3 Water Quality

An extensive water quality monitoring program is currently on-going on site and includes surface water, groundwater, minewater as well as off-site surface water in Yellowknife Bay and the Yellowknife River. Figure 2.3-1 provides an overview of existing station locations; further details related to each station is provided in the Effluent Quality Criteria Report (CIRNAC and GNWT 2019a).

2.3.3.1 Surface Water

Surface water monitoring in relation to the Site is currently completed as follows (Figure 2.3-1):

- **Surveillance Network Program (SNP)**—Although Water Licence N1L2-0043 (MVLWB 1998) has expired, the SNP program associated with this licence is still completed annually. Most sampling is completed only during the open water season with the exception of one station (SNP 43-21 – Akaitcho Shaft; see Section 2.3.3.2), which is sampled year-round.
- **Metal and Diamond Mining Effluent Regulations (MDMER)/Environmental Effects Monitoring (EEM)**—Every year water quality in the receiving environment (i.e., downstream of the discharge in Baker Creek) as well as at an upstream reference station is monitored monthly during the period of treated effluent discharge. Two of these stations overlap with the SNP program. Additional water quality sampling is completed in Baker Creek, Yellowknife Bay and the Yellowknife River as part of the EEM biological monitoring program.
- **Operational Monitoring Program (OMP)**—Water quality at twenty additional stations around the Site is monitored annually during the open water season. The OMP includes seepage monitoring from the TCAs, runoff monitoring from various locations around the Site, and additional samples collected from the ETP and associated ponds for operational purposes (i.e., non-regulatory).



LEGEND

- COMMUNITY
- BAKER CREEK
- DIRECTION OF FLOW
- GIANT MINE PROJECT BOUNDARY
- HIGHWAY
- ROAD
- YELLOWKNIFE RIVER AND PROSPEROUS LAKE

WATER QUALITY SAMPLING LOCATION GROUP

- ETP EFFLUENT
- BAKER CREEK BEHIND BREAKWATER
- YELLOWKNIFE BAY NEAR BREAKWATER
- BACK BAY/YELLOWKNIFE BAY
- NORTH YELLOWKNIFE BAY
- SOUTH YELLOWKNIFE BAY
- FORESHORE TAILINGS
- UPSTREAM BAKER CREEK
- YELLOWKNIFE RIVER
- HORSESHOE ISLAND BAY

0 2 4
1:80,000 KILOMETRES

REFERENCE(S)

HYDROLOGY AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. SAMPLING LOCATION DATA OBTAINED FROM GIANT MINE REMEDIATION PROJECT EFFLUENT QUALITY REPORT, CIRNAC AND GNWT 2019.
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROJECT

Giant Mine Remediation Project

TITLE

GIANT MINE SURFACE WATER MONITORING STATIONS

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-22
DESIGNED	LH
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

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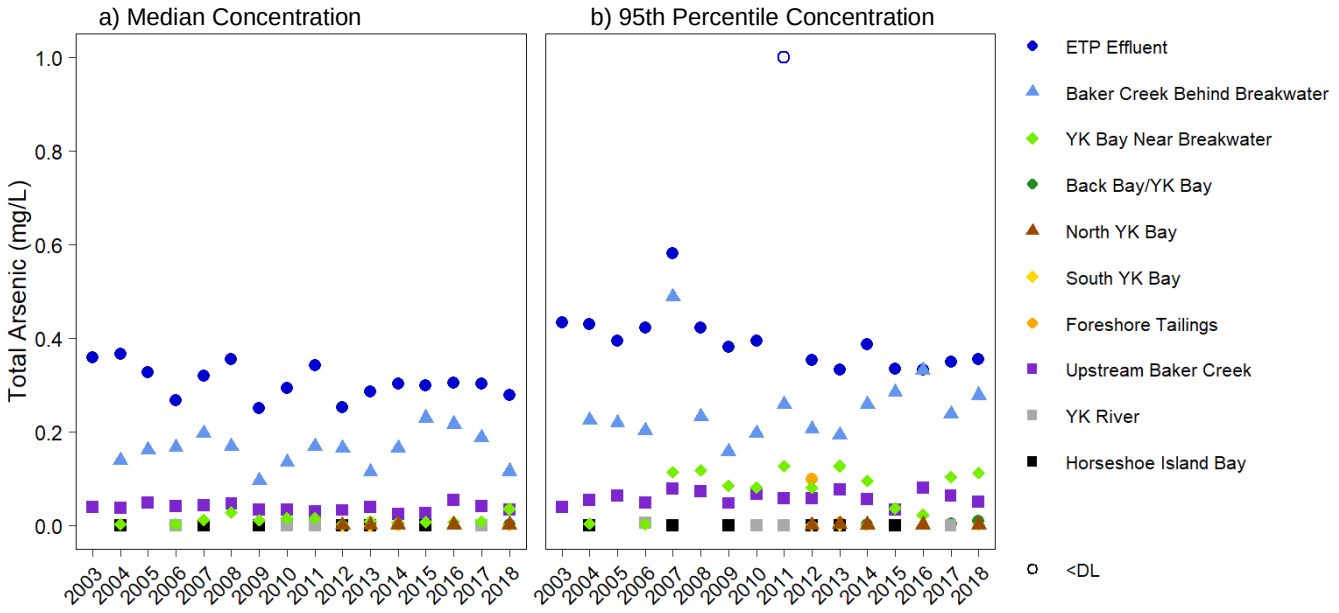
FIGURE 2.3-1

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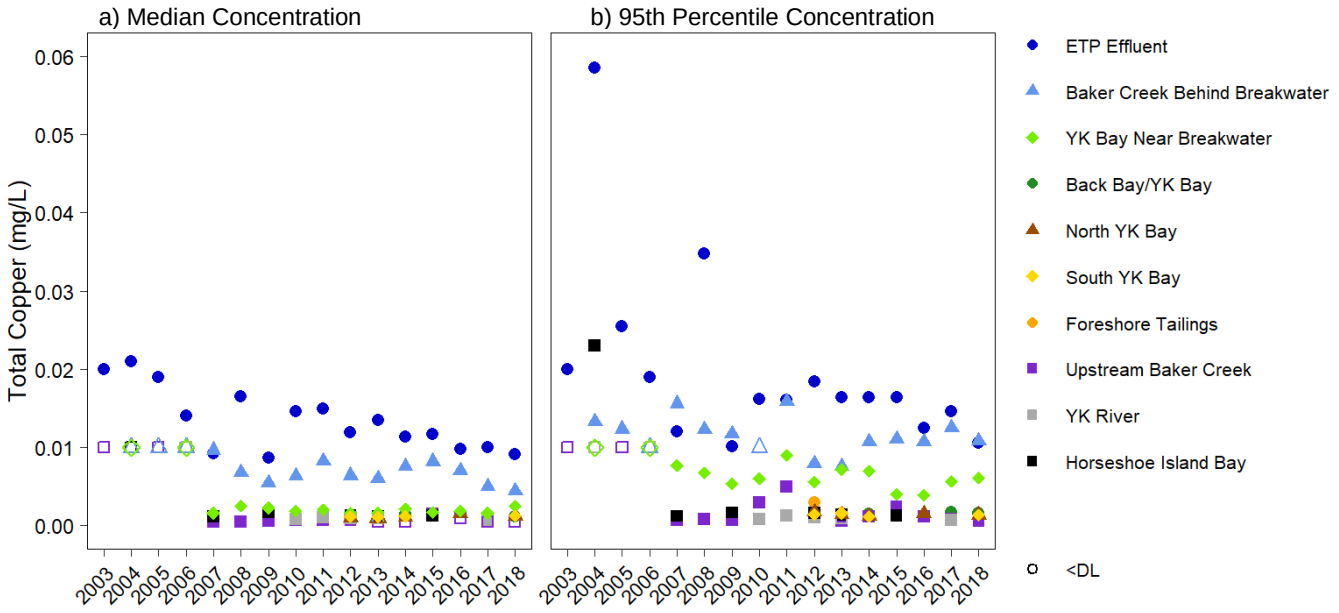
When treated effluent is not present, Baker Creek is generally clear, with a moderate pH and low concentrations of metals and nutrients (see Appendix 2C, Upstream Baker Creek). One exception is total arsenic which enters the Site at concentrations above reference (SNP 43-11 on Figure 2.3-1). In Baker Creek during effluent discharge, the concentrations of metals (e.g., arsenic and copper), as well as TDS and its constituent anions (e.g., chloride and sulphate) that are elevated above reference and relevant water quality guidelines (Figures 2.3-2 and 2.3-3; Appendix 2C, Golder 2017f) are monitored. Contaminants in the water of Baker Creek historically have generally decreased with time as water treatment plant (WTP) practices became more rigorous and lower volumes of effluent were released (Golder 2016b). For example, arsenic concentrations at the mouth of Baker Creek reported by Falk et al. (1973) of 12.6 mg/L, prior to construction and operation of the Effluent Treatment Plant in 1981, which was substantially higher than arsenic concentrations observed between 2011 and 2016, which were below the mean metal mining regulation discharge limit of 0.5 mg/L.

A spatial trend is evident for most, but not all, contaminants (Figures 2.3-2 and 2.3-3). Generally, the highest contaminant concentrations are present in the treated effluent and Baker Creek mouth (Reach 0), with decreasing contaminant concentrations present in Back Bay and reference areas. This pattern is typical of increasing dilution with distance from the source (i.e., from the effluent discharge point). For instance, TDS concentrations increased over time and a corresponding typical dilution spatial pattern exists: the concentrations in the treated effluent and the Baker Creek (Mouth) area are elevated and those in Back Bay are similar to TDS concentrations in reference areas and upstream Baker Creek (Figure 2.3-3). Refer to Appendix 2D for detailed water quality results.

Figure 2.3-2: Total Arsenic and Copper Concentrations, 2011 to 2018

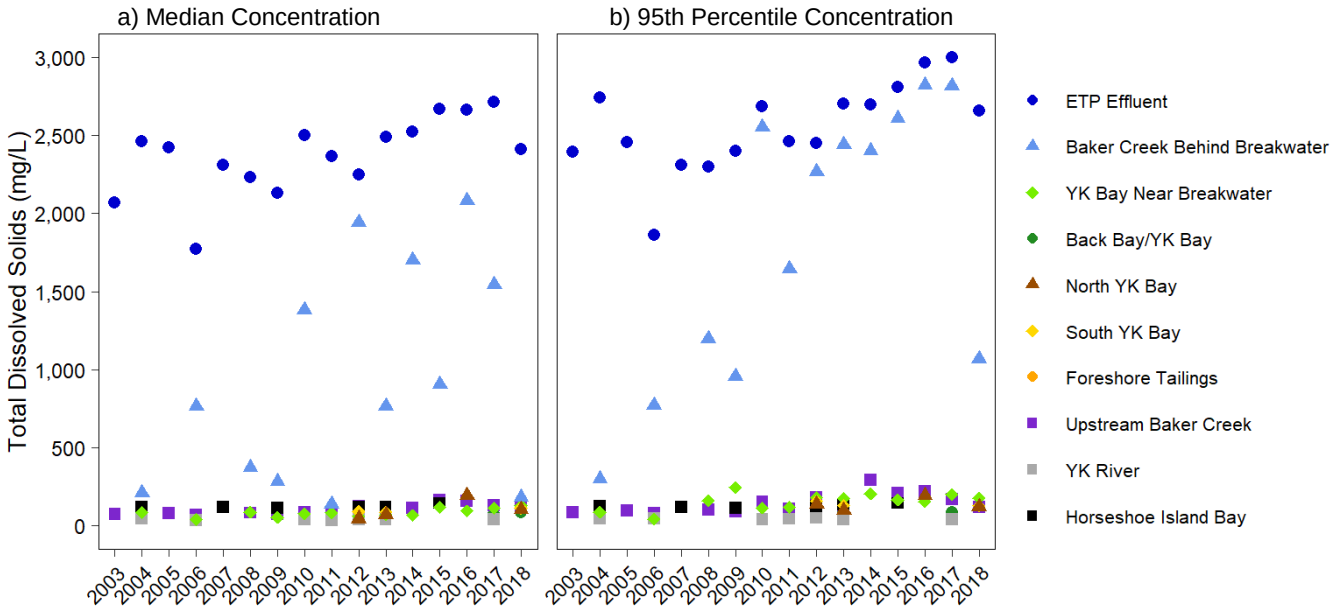


Note: Non-detectable values exist for total arsenic at higher values than are shown (e.g., at 1 mg/L).
ETP = effluent treatment plant; YK = Yellowknife; mg/L = milligrams per litre



ETP = effluent treatment plant; YK = Yellowknife; mg/L = milligrams per litre

Figure 2.3-3: Total Dissolved Solids Concentrations, 2011 to 2018



ETP = effluent treatment plant; YK = Yellowknife; mg/L = milligrams per litre

Seepage: Seepage from dams is collected and pumped back to the TCAs; further information on the seepage quantity and capture is found in Section 5.5. In general, seepage quality is similar to minewater quality (see Section 2.3.3.3) with elevated concentrations of metals, chloride and sulphate. In recent years, dry conditions meant seepage to the sumps was limited. Updated chemistry for the sumps is provided in the appendices to the Effluent Quality Criteria report (CIRNAC and GNWT 2019a).

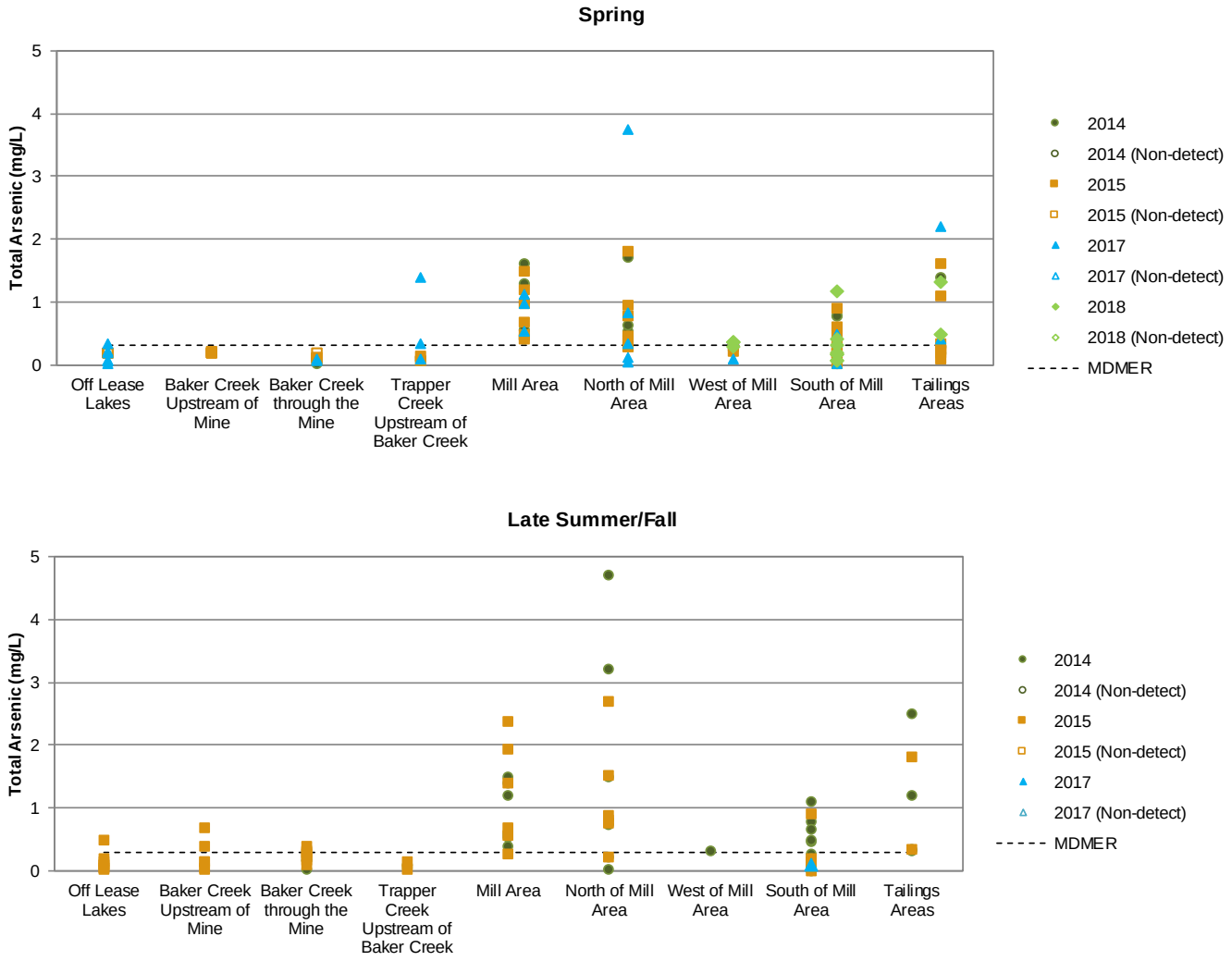
Runoff: Much of the surface runoff is collected on Site and treated (refer to the Water Management and Monitoring Plan and Section 5.5). Surface runoff water quality was monitored in recent years (2014, 2015, 2017 and spring 2018) and the patterns are generally characterized as follows (Golder 2016d):

- Runoff is generally neutral pH, moderately to well oxygenated, and highly conductive.
- Runoff on Site as both ponded water and flowing water contains elevated concentrations of metals, ions, and nutrients. The signature of runoff was found to be similar to minewater and treated effluent in terms of the presence of chlorides, metals, and nitrate.
- The highest concentrations of metals and ions were measured in runoff from near the Mill area.
- Runoff samples contained concentrations exceeding applicable aquatic life guidelines for arsenic, antimony, copper, lead, nickel, zinc, chloride, nitrate and nitrite.
- Sulphate and chloride concentrations were elevated in most samples.
- Approximately 98% of the inorganic arsenic concentrations being transported by runoff consists of As(V). Accordingly, very low concentrations of As(III) are being transported by runoff into the waterbodies at the Site.

- Fall water quality was found to generally contain higher concentrations of metals and ions than the spring freshet, presumably because spring freshet waters dilute base flow waters.

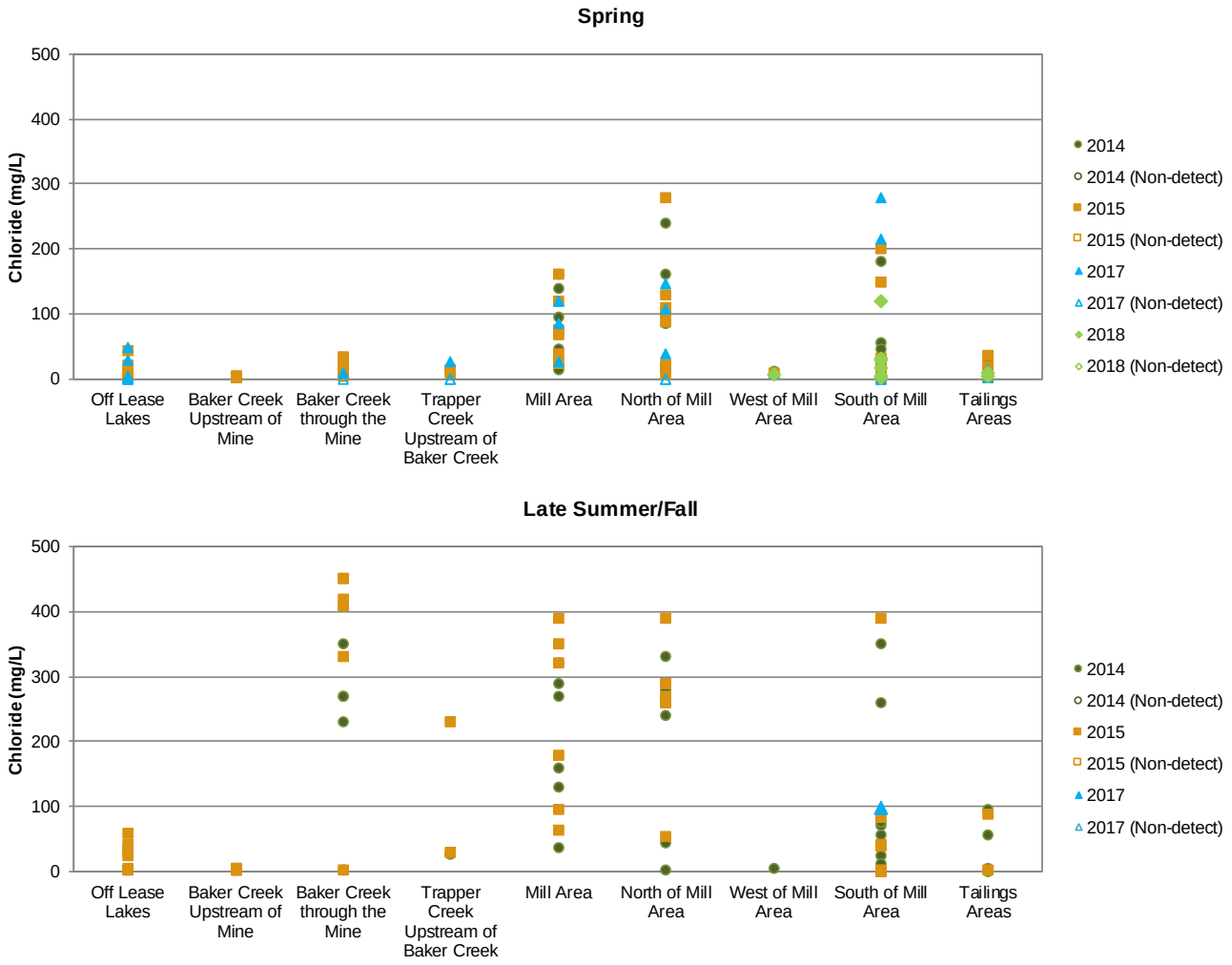
Plots for key parameters (arsenic and chloride) in runoff samples are provided in Figure 2.3-4 and Figure 2.3-5.

Figure 2.3-4: Concentrations of Arsenic in Surface Runoff



mg/L = milligrams per litre; MDMER = Metal and Diamond Mining Effluent Regulations

Figure 2.3-5: Concentrations of Chloride in Surface Runoff



mg/L = milligrams per litre

2.3.3.2 Groundwater

A groundwater monitoring network was developed between 2000 and 2016 to evaluate groundwater flow conditions and groundwater quality across the Site (Figure 2.3-6). Shallow and deep groundwater was characterized intermittently from 2000 to 2012; monitoring was re-established in 2017. This monitoring well network is presently being re-evaluated to identify new groundwater well locations, select SNP stations for the Water Licence application, and identify on-going groundwater well locations for the OMP. These wells include the following:

- Four shallow standpipe monitoring wells located within and near the Northwest TCA. These wells were installed in 2000 to characterize the groundwater regime within and downgradient of the Northwest TCA. The wells extend between 10 and 26 mbgs and are generally screened in bedrock, except for one well that is screened within the tailings (Golder 2001).

- Six shallow monitoring wells located in/near the Foreshore tailings area along Yellowknife Bay. These wells were installed in 2001 to characterize the groundwater quality within and below the tailings. These wells extend between 2 and 12 mbgs and are screened in the tailings and/or underlying bedrock (Golder 2002).
- Thirteen shallow monitoring wells located within the Calcine Pond. These wells are wells were installed in 2004 to characterize groundwater quality directly in the Calcine Pond and the potential dissolved arsenic concentrations in groundwater that could enter Baker Creek. The Calcine Pond wells extend between 3.9 and 14.3 mbgs and are screened in the calcine or the natural sediments underlying the calcines (INAC 2004).
- Four shallow monitoring wells located within the former Mill Pond and the Roaster Complex area. These wells were also installed in 2004 and were intended to assess the quality of water that could potentially flow from the mill/roaster area to the former alignment of Baker in Reach 4 (see Appendix 2A). These wells extend between 3.3 and 5.6 mbgs and are screened in the natural clay containing some sand and gravel (INAC 2004).
- Ten shallow monitoring wells located within the South, Central, and North TCAs (installed in 2016) and two well installed to the northeast of the North TCA (in 2000). The wells are screened between 7 and 33 mbgs and are completed within the tailings and/or natural soil present below the tailings (Golder 2001, 2017i). These wells are used to monitoring groundwater quality within and/or down-gradient of the TCAs.
- Fourteen multi-port wells located outside the underground mine workings. These wells were installed between 2002 and 2004 and were intended to monitor the baseline groundwater quality in bedrock surrounding the dewatered mine. Each well has between five and 12 sampling zones and sampling depths at these well locations vary between 12 and 181 mbgs (SRK 2002b, 2005d).

Groundwater quality has historically been monitored as documented in groundwater quality reports for the Site (Golder 2012, 2013, 2017h, 2018b; SRK 2004, 2005d, 2007, 2008, 2009, 2011). Although monitored for a broader set of parameters, arsenic has been selected as a general indicator of groundwater quality for the GMRP. Arsenic in groundwater is generally derived from the bedrock and/or infiltration from surface sources (such as the TCAs). Figures 2.3-7 and 2.3-8 presents a summary of the dissolved arsenic concentrations (including the minimum, maximum, average and highlighting the latest measurement) measured in groundwater in the shallow and in the deep multi-port wells across the monitoring well network between 2000 and 2017. The dissolved arsenic concentrations in the shallow wells are generally highest when measured in tailings and lowest in the overburden or the bedrock. The highest arsenic concentrations in the deep multi-port wells have been recorded at S-DIAND-002, which is located to the southwest of the South Pond TCA. The dissolved arsenic concentrations in the deep multi-port wells vary between the different sampling zones for a well, but are consistent over time for each zone.

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636000 638000

6934000 6932000

Trapper Lake
Shot Lake
Gar Lake
Yellowknife River
Trapper Creek
Baker Creek
Pocket Lake
Baker Pond
Yellowknife Bay

MW00-03A/B
S-DIAND-022
NORTHWEST TCA
MW00-01
MW00-02
B4 PIT
S-2224
MW00-04A/B
SETTLING POND
NP-SD-03
NP-SD-08
NP-SD-04
POLISHING POND
S-DIAND-021
S-1860
B3 PIT
NP-SD-07
NORTH TCA
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S-DIAND-018A/B
CP-SD-01
S-DIAND-013A/B
B1 PIT
B2 PIT (UBC)
BROCK PIT
SP-SD-06
SOUTH TCA
S-DIAND-011A/B
S-DIAND-008
S-1956
SP-SD-02
S-DIAND-012
S-DIAND-002
S-1954
MW01-1A/B/C
MW01-2A/B/C
C1 PIT
S-1857
S-1955
S-DIAND-024
A1 PIT
S-1859
S-DIAND-001
A2 PIT

LEGEND

WELL MATERIAL TYPE
- BEDROCK
- OVERBURDEN
- TAILINGS

2017 WELL STATUS
- **S-DIAND-001** FUNCTIONING WELL
- S-DIAND-020 WELL NOT FUNCTIONAL

GROUNDWATER AREAS
- NORTHWEST TCA
- FORESHORE TAILINGS
- CALCINE POND
- MILL POND AND ROASTER COMPLEX
- NORTH, CENTRAL, AND SOUTH TCA
- MULTI-PORT MONITORING WELL

- PIT BOUNDARY
- HIGHWAY
- ROAD
- BAKER CREEK
- WATERCOURSE

0 250 500
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REFERENCE(S)

HYDROLOGY AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

PROJECT

Giant Mine Remediation Project

TITLE

GIANT MINE GROUNDWATER MONITORING STATIONS

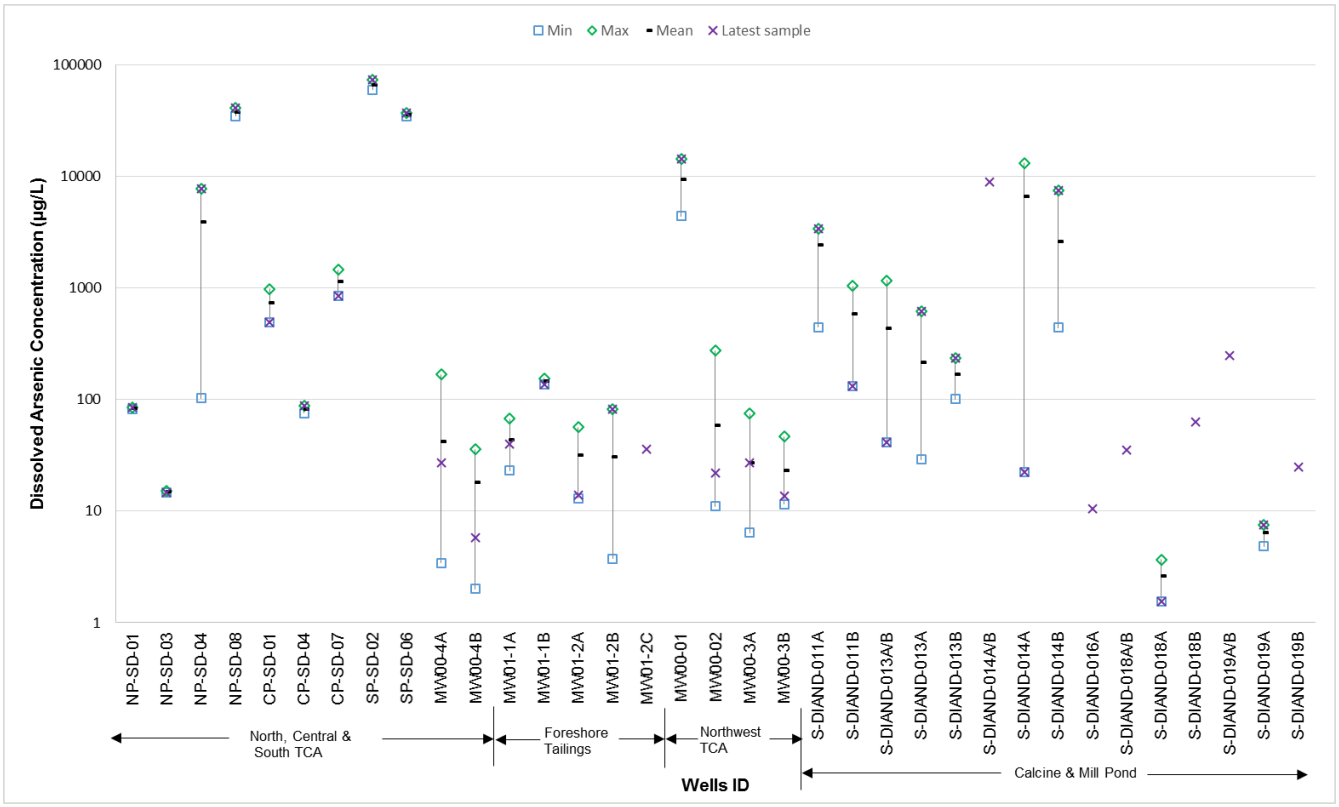
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DESIGNED	LH
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

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FIGURE 2.3-6

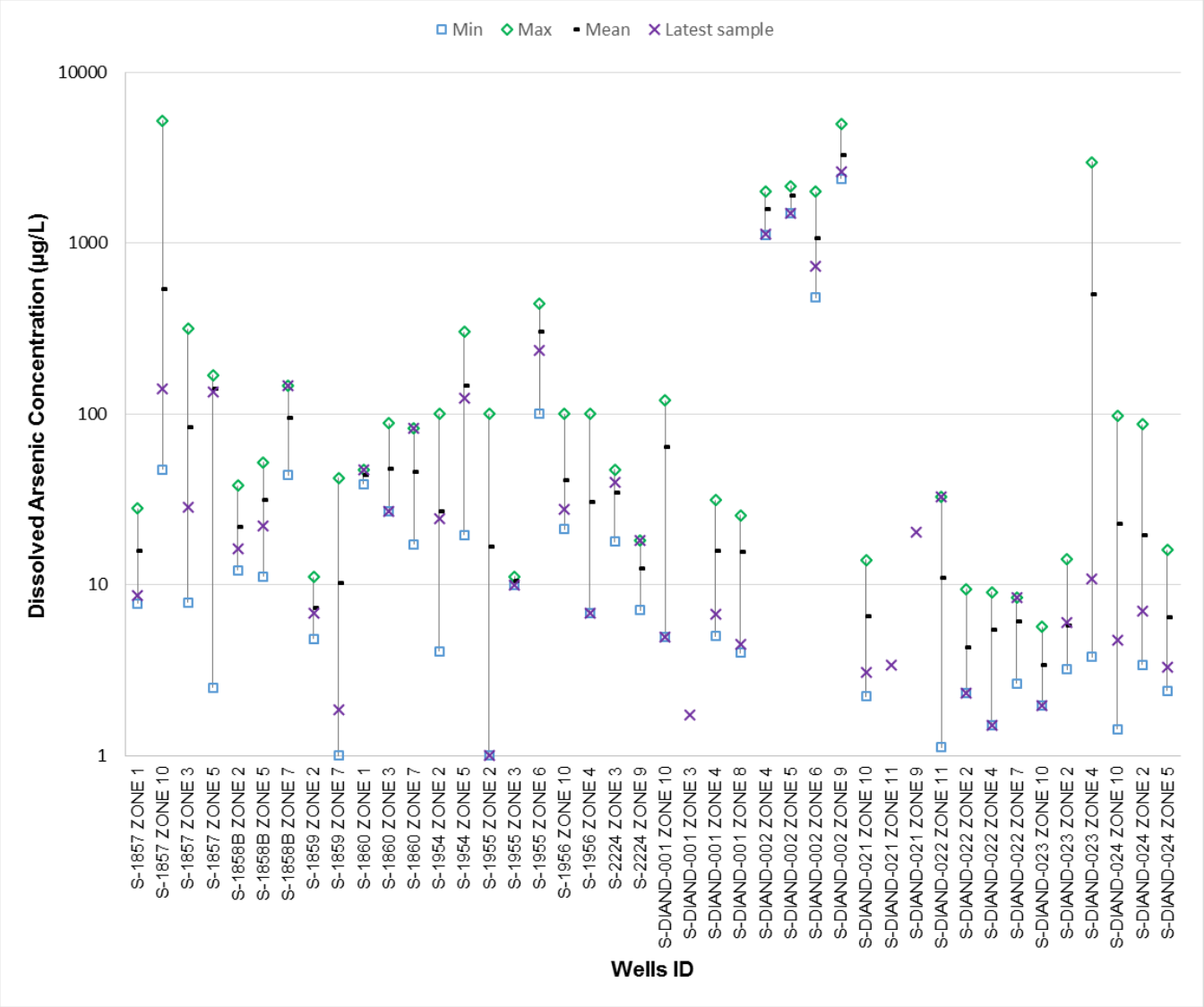
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Figure 2.3-7: Shallow Wells 2000 to 2017 Dissolved Arsenic Compilation



Note: Latest sample = fall 2017.

Figure 2.3-8: Multi-port Wells Historical and 2017 Dissolved Arsenic Compilation



Note: Latest sample = fall 2017.

2.3.3.3 Minewater

Minewater consists of water that flows into the underground mine structures. It includes water infiltrating from Baker Creek, seepage from the surface, and from the shallow and deep groundwater aquifers and the mine pool. Minewater from the underground workings is pumped year-round, as required, to the surface into the Northwest Pond to maintain the water level in the underground mine areas at an elevation below the 750L, which is well below the arsenic storage chambers (Golder 2017g; see Section 5.1 for detailed maps of the underground; see Figure 3.3-2 for a cross section of the underground).

Minewater is monitored in two main locations: the Akaitcho area at the northern end of the Site at station SNP 43-21; and in a central area known as the C Shaft (Figure 2.3-6; Figure 3.3-2). As part of the OMP, minewater is also monitored at five bulkheads and two sumps underground. Water from behind the bulkheads is sampled to determine bulkhead performance; specifically, the monitoring tests for increases in arsenic concentrations as an indication of an increase of water seepage into the bulkhead. The underground sumps are sampled for contaminants such that water can be used for localized drilling programs.

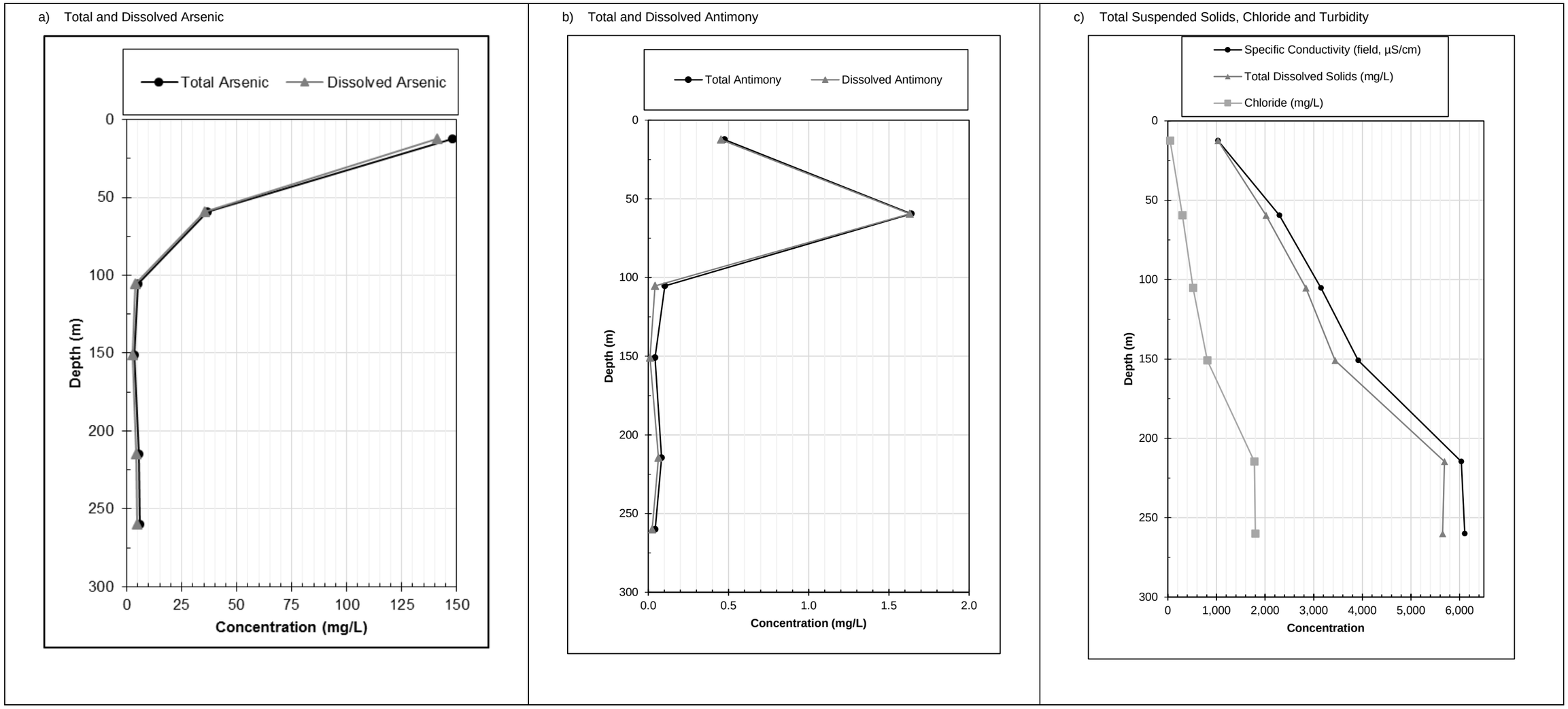
SNP 43-21 is monitored weekly, year-round. Minewater quality in the Akaitcho area (SNP 43-21) was documented in SRK (2005b, 2009), Stantec (2014), and AECOM (2016). C Shaft monitoring through a well or underground occurred in the early 2000s and was discontinued in 2007 when the area became difficult to access and the lower levels of the shaft were blocked (INAC and GNWT 2010). Sampling of the C Shaft area via the underground mine working level 750L recommenced in 2017. In October 2017, the C Shaft at the Giant Mine was successfully sampled for minewater at multiple elevations in the C Shaft excavation void (C Shaft void) to determine if the minewater pool chemistry and level of stratification (Golder 2018a).

Minewater in the Akaitcho area is generally neutral to slightly alkaline with elevated concentrations of metals, ions, and nutrients. Total metals that consistently exceed CCME Water Quality Guidelines for the Protection of Aquatic Life (CCME 1999) include aluminum, antimony, arsenic, cadmium, chromium, copper, iron, lead, nickel, silver, thallium, and zinc. Minewater quality samples from the C Shaft void collected in 2017 confirmed that the minewater within the shaft is stratified and exhibited the following patterns (Golder 2018a):

- Specific conductivity and total dissolved solids (TDS) generally increased with sample depth up to the 1,500L (260 m from the 750L), where concentrations appear to stabilize (Figure 2.3-9).
- Total suspended solids and turbidity were similar in samples collected from just below the 750L (12.4 m from 750L) and at the 950L (59.5 m from 750L), and then increased with deeper sampling depths (Figure 2.3-9).
- Concentrations for major ions generally increased with sample depth up to the 1,500L (214.6 m from 750L), where concentrations appear to stabilize. Exceptions to this include carbonate, fluoride, and hydroxide, for which the concentrations were measured below the detection limit.
- Nitrate, total phosphorus and orthophosphate concentrations decreased between the samples collected just below the 750L (12.4 m from 750L) and the 950L (59.5 m from 750L), and then stabilized at the lower values at deeper sampling depths.
- Concentrations of the following dissolved and total metals generally decreased with depth: aluminum, antimony, arsenic, and selenium (Figure 2.3-9).
- Concentrations of the following dissolved and total metals generally increased with depth: barium, iron, rubidium, and strontium.

Concentration of total cyanide in the sample collected just below the 750L (12.4 m from 750L) was higher in comparison to samples collected at deeper depths.

Figure 2.3-9: Minewater quality below Mine Level 750, C Shaft Void, October 2017



2.3.3.4 Treated Effluent

Minewater and Site runoff that is stored in the Northwest Pond is seasonally treated in the ETP (Golder 2017g; refer to the Water Management and Monitoring Plan). Treated effluent is discharged into Baker Pond during open-water conditions, usually over a two- to three-month period between July and September. In the lower reaches of Baker Creek, treated effluent releases form a high proportion of flows in summer (i.e., up to 100%) because the flow from upper Baker Creek typically ceases in August and September. The final discharge point for the Site is SNP 43-1 (Figure 2.3-6). During periods of discharge, sampling at SNP 43-1 is completed as required under the MDMER and per monitoring requirements outlined under the former Water Licence (MVLWB 1998).

A summary of the treated effluent characterization from 2011 to 2018 is provided in Appendix 2C. This sampling has been done annually since 2003, and detailed results have been submitted to ECCC as part of the annual MDMER/EEM reports. Refer to Appendix 2D for the 2017 Annual MMER report.

Treated effluent from the Site was circumneutral to slightly alkaline with moderately high specific conductivity with annual field-measured means ranging from 2,721 to 3,359 µS/cm (Appendix 2C, ETP Effluent). Concentrations of total dissolved solids, chloride, and arsenic in treated effluent have increased since 2011, while concentrations of antimony and nickel have decreased. Sulphate and copper concentrations have remained relatively consistent (Appendix 2C, ETP Effluent). The Site is consistently in compliance with the historical water licence limits and the MDMER with few upset conditions (AANDC 2012, 2013, 2014, 2015; Golder 2016c, 2017f).

2.3.4 Acid Rock Drainage

Acid rock drainage is described as the outflow of acidic water that forms when certain minerals are exposed to air and water (INAC and GNWT 2010). Waste rock at the Site is generally not considered acid generating (Golder 2001). Royal Oak Mines Inc. (1994) and Golder (2001) investigated the acid rock drainage potential in the pit wall rock. Of the samples collected, 85% were acid-consuming. Any acid produced by discrete acid-generating sections of rock with high sulphide concentration would be neutralized by the large percentage of carbonate minerals within the ore zone lithology. Updates to the geochemistry of borrow locations are planned (see Section 5.7).

2.4 Terrestrial Environment

This section summarizes the available information on the vegetation and wildlife of the Site and immediately surrounding environment. This summary, therefore, describes what is known about the terrestrial environment, as it currently exists in an otherwise disturbed area.

2.4.1 Fragmentation, and Invasive and Artificially Supported Species

As noted at the start of Chapter 2, the YKDFN report that the Site and the Wı̨ìlı̨ìdeh area were used for hunting moose, trapping furbearers and fishing, to access caribou hunting areas, fishing, collecting medicine plants and berries, and as a staging area while travelling (YKDFNLEC 2005; INAC and GNWT 2010). Today, the Site lies within Yellowknife city limits and is bound to the east by Yellowknife Bay, to the southwest by the City of Yellowknife landfill, and to the south by the City of Yellowknife, with Highway 4 intersecting through the western portion of the project boundary. These features likely tend to isolate the Site from the surrounding forest through limited connectivity and small habitat patch size, making it difficult for wildlife to re-establish or to use and travel through the area as they would have in the past.

Further, there are species present that are either supported at artificially high densities or only present because of the City of Yellowknife and the landfill. Each of these species has the potential to disrupt the natural avian and mammalian wildlife communities at the Site. Specifically, the Site area is home to high numbers of ravens (*Corvus corvax*) due to proximity to the city and the landfill. A population of magpie (*Pica pica*) has established in Yellowknife over the past 20 years, an invasive species that is not otherwise present in the area. Both raven and magpie are known nest predators that may limit activity in the area by other migratory birds. Ptarmigan (*Lagopus muta*) are present in unusually high numbers, due to feeding by residents of Yellowknife. Coyotes (*Canis latrans*) den near the Site and forage near the city but are not otherwise found in the Yellowknife area. Red fox (*Vulpes vulpes*) have also been observed around the Site and have been observed foraging within city limits. These predatory species may have a density-independent relationship with the environment at the Site, where their population is sustained at artificially high levels due to the city, and exert a disproportional effect on prey populations. Likewise, the influence of human use of the surrounding area for walking, snowmobiling, cycling, and hunting will also exert an influence and limit the likelihood that the area would reflect wildlife use in undisturbed areas even if the Site were not present.

2.4.2 Species of Concern

The intent of the *Species at Risk Act* (Government of Canada 2002) and the *Species at Risk (NWT) Act* (GNWT 2009) is to protect species at risk from becoming extirpated or extinct. While the former was enacted by the Government of Canada, the latter was enacted by the GNWT and applies only to wild animals and plants managed by the GNWT (2016). As the *Species at Risk (NWT) Act* is implemented, the NWT Species at Risk Committee will make further assessments, and the Conference of Management Authorities will prepare the List of Species At Risk, providing legal protection for these species and possibly leading to changes in the species at risk considered for the Site.

For the purposes of this document, species may be considered of concern as a result of either their national or territorial status. Best practices for species of concern include considering species that may not yet have formal protection (i.e., are considered at risk by the Committee for the Status of Endangered Wildlife in Canada but are not yet listed under the *Species at Risk [NWT] Act* or the federal *Species at Risk Act*).

There are 12 wildlife species of concern with ranges that are known to overlap or likely overlap with the Site, including one mammal, one insect, and ten birds (Table 2.4-1). Of these species, the barn swallow, common nighthawk, and horned grebe have been observed on Site (Cygnus 2004; Golder 2015b, 2016g). No plant species at risk are present in the Yellowknife region (GNWT 2016). In the case of migratory birds, only those birds that breed or winter near the Site were included; other species that may migrate through the area (such as the peregrine falcon) were not included.

Table 2.4-1: Species of Concern Possibly Occurring at Giant Mine

Common Name	Latin Name	NWT List of Species at Risk Status	NWT Species at Risk Committee Assessment	COSEWIC Status	Federal Species at Risk Act Status
Wolverine	*Gulo gulo*	Not at risk	No status	Special concern	Under consideration
Bank Swallow	*Riparia riparia*	Not applicable	Not applicable	Threatened	Under consideration
Barn Swallow	*Hirundo rustica*	Not applicable	Not applicable	Threatened	Under consideration
Common Nighthawk	*Chordeiles minor*	Not applicable	Not applicable	Threatened	Threatened
Horned Grebe	*Podiceps auritus*	Not applicable	Not applicable	Special concern	Under consideration

Table 2.4-1: Species of Concern Possibly Occurring at Giant Mine

Common Name	Latin Name	NWT List of Species at Risk Status	NWT Species at Risk Committee Assessment	COSEWIC Status	Federal Species at Risk Act Status
Olive-Sided Flycatcher	*Contopus cooperi*	Not applicable	Not applicable	Threatened	Threatened
Red-Necked Phalarope	*Phalaropus lobatus*	Not applicable	Not applicable	Special concern	Under consideration
Rusty Blackbird	*Euphagus carolinus*	Not assessed	No status	Special concern	Special concern
Short-Eared Owl	*Asio flammeus*	Not assessed	No status	Special concern	Special concern
Yellow Rail	*Coturnicops noveboracensis*	Not applicable	Not applicable	Special concern	Special concern
Yellow-Banded Bumble Bee	*Bombus terricola*	Not assessed	No status	Special concern	Under consideration
Shortjaw Cisco [(a)]	*Coregonus zenithicus*	Not applicable	Not applicable	Threatened	Threatened

Source: GNWT 2016. (a) An aquatic species is noted here for the sake of completeness on overall species of concern from COSEWIC.
Note: The *Species at Risk (NWT) Act* does not cover species already included in the *Migratory Bird Convention Act*.
NWT = Northwest Territories; COSEWIC = Committee on the Status of Endangered Wildlife in Canada.

2.4.3 Vegetation

Vegetation communities were described by Jacques Whitford Environmental Ltd. (Jacques Whitford 2003), while a land cover classification using similar communities was completed by Golder (2016e). Ecological investigations at the Site included surveys of terrestrial and aquatic vegetation (Jacques Whitford 2003). In addition to identifying the most common plant species, plant communities were categorized into nine groups (Table 2.4-2), largely defined by drainage.

Using an automated supervised classification approach based on available LiDAR data from the Site, a classification of approximately 15 km^2 area including the Site property and surrounding forest was prepared (Golder 2016e). The classification included uplands with forest, exposed bedrock, disturbance, and regenerating developed areas. Lowland portions of the study area were dominated by peat bogs, lakes, streams, and accompanying shoreline vegetation.

Table 2.4-2: Plant Communities at Giant Mine

Plant Community	Description	Dominant Species
Upland rock outcrop	Lack of soil; vegetation in crevices of exposed bedrock	Low shrubs, herbs, mosses and lichens, bearberry, juniper, grasses
Upland scrub forest	Shallow soils with less moisture and nutrient retention than mesic forest	Paper birch, some white spruce, common juniper, prickly rose, Labrador tea and green alder, bearberry, toadflax
Upland mesic forest	Found on the deepest soils between rocky outcrops; retention of moisture gives diverse community	White spruce, paper birch, willow, Labrador tea and green alder, rushes, horsetail, goldenrod, glow moss
Wetland cattail	Shorelines of larger lakes, small water-filled depressions within meadow community	Cattail, some sedges
Wetland sedge	Found in isolated depressions in rock outcrops	Water sedge, common horsetail
Riparian shrub	Seasonally flooded banks of Baker Creek	Willow, bog birch, sweet gale, prickly rose, shrubby cinquefoil, horsetail, raspberry, scouring rush, Canada blue-joint

Table 2.4-2: Plant Communities at Giant Mine

Plant Community	Description	Dominant Species
Disturbed meadow	Ecologically similar to mesic forest community; may be mesic forest that has been logged	Hair grass, dwarf scouring rush, common horsetail, slender wheatgrass, foxtail barley, glow moss
Disturbed vegetated	Sparse revegetation	Pioneer species including foxtail barley, rough hair grass yarrow, red clover, dandelion, lamb's quarters, common horsetail, dock
Disturbed unvegetated	No vegetation; dry tailings ponds, open pits, roads	n/a

Source: Jacques Whitford 2003.
n/a = not applicable

2.4.4 Terrestrial Wildlife

As described above, wildlife is present at both the Site and the surrounding forest, but the local ecosystem is likely affected not only by the Site, but by the highway, landfill and city, and the boundary with Yellowknife Bay.

To understand wildlife use of the Site in winter, surveys were completed in 2016 (Golder 2016f). Surveys included winter track counts (in developed areas of the Site and in bedrock/forest/wetland terrain within and surrounding the Site), deployment of remote cameras, and observations of wildlife and wildlife signs. The results provided a summary of species or species groups present, and their relative activity levels (Table 2.4-3). In addition, remote cameras and direct observations detected red fox, snowshoe hare (*Lepus americanus*), ptarmigan, lynx (*Lynx canadensis*), coyote, and wolf (*Canis lupus*).

Table 2.4-3: Winter Track Count Observations, Giant Mine 2016

Species	Single Track	Trail	Network
Coyote	39	2	0
Snowshoe hare	130	5	5
Wolf	10	0	0
Small mammal groups (e.g., mice, voles or shrews)	37	1	0
Red fox	65	9	1
Raven	2	0	0
Ermine	2	0	0
Marten	3	0	0
Least weasel	10	0	0
Red squirrel	77	2	0
Ptarmigan	314	2	2

Source: Golder 2016f.
Note: Trail = packed path with more than one set of tracks; Network = multiple tracks and trails in proximity.

2.4.5 Birds

Yellowknife is located in Nesting Zone C8, where bird nesting extends from 9 May through 13 August (ECCC 2016). At present, the primary risks to birds from the Site include the potential for the inadvertent harming, killing, disturbance, or destruction of migratory birds, nests, and eggs (referred to as incidental take [ECCC 2017b]) through nesting on existing above-ground infrastructure; the operation of machinery and vehicles; and the removal of habitat. No authorizations or permits allow the incidental take of migratory birds or their nests and eggs. A secondary risk to birds is the presence of contaminants, particularly at tailings ponds.

Bird surveys were completed to understand use of the Site area by both staging migrants and locally breeding birds (Cygnus 2004). The most abundant species included scaup, widgeon, bufflehead, and canvasback. Use of the area by both migrating and breeding loons, grebes, shorebirds, waterfowl, gulls, and terns was also documented. A full species list is presented in the *Giant Mine Migratory Bird Survey* (Cygnus 2004).

Survey results suggested that TCAs and associated waterbodies are not used extensively by waterfowl. Use of these areas by ducks is largely restricted to the spring and fall migration periods when TCAs appear to thaw sooner and freeze later than nearby waterbodies. Both the Foreshore Tailings Area and Northwest TCA are gathering sites for gulls and terns; the latter site is also a breeding area (Cygnus 2004). These areas are contaminated and will be remediated to reduce exposure of wildlife to contaminants (see Section 5.6).

To build upon the documented use of the Site by birds during the nesting season (Cygnus 2004), surveys were completed to document roosting and nesting activity at the Site, identify possible risks to these birds, and suggest mitigation to reduce risks to birds and avoid delays to Site closure activities (Golder 2015b). A summary of the bird groups identified at the Site, their seasonal presence, habitat preferences, and protecting legislation is presented in Table 2.4-4. These and subsequent surveys have detected nesting by barn swallow, and horned grebe, both species of concern, as well as raven, Eastern phoebe, and other species (Golder 2016g).

Table 2.4-4: Observed and Expected Bird Species Groups at the Site and Protecting Legislation

Species Group	Regulations	Number of Species (range)	Habitats	Seasonal Distribution
Waterfowl (ducks, geese, swans)	MBCA, NWT *Wildlife Act*	20–25	Wetlands, riparian areas, and developed areas	April–October
Upland game birds (grouse, ptarmigan)	NWT *Wildlife Act*	2–4	Uplands, wetlands, and developed areas	Year round
Loons and grebes	MBCA, NWT *Wildlife Act*, SARA	5–7	Wetlands and developed areas	May–October
Raptors (hawks, eagles, falcons)	NWT *Wildlife Act*, SARA	6–9	Uplands, wetlands, and developed areas	April–October
Waterbirds (cranes, rails, coots, herons)	MBCA, NWT *Wildlife Act*, SARA	5–6	Wetlands and riparian areas	April–September
Shorebirds	MBCA, NWT *Wildlife Act*, SARA	10–20	Wetlands, riparian areas, and developed areas	May–September
Gulls and terns	MBCA, NWT *Wildlife Act*	6–8	Wetlands and developed areas	April–October
Owls and nightjars	NWT *Wildlife Act*, SARA	2–4	Uplands, wetlands, riparian areas, and developed areas	Year round

Table 2.4-4: Observed and Expected Bird Species Groups at the Site and Protecting Legislation

Species Group	Regulations	Number of Species (range)	Habitats	Seasonal Distribution
Woodpeckers	MBCA, NWT *Wildlife Act*	2–4	Uplands, wetlands, riparian areas, and developed areas	Year round
Songbirds (except corvids and some blackbirds)	MBCA, NWT *Wildlife Act*, SARA	35–40	Uplands, wetlands, riparian areas, and developed areas	May–October

Source: Derived from Golder 2015b.

MBCA = *Migratory Bird Convention Act*; NWT = Northwest Territories; SARA = federal *Species at Risk Act*

2.5 Aquatic Environment

Historically, Baker Creek was a fish resource for Indigenous communities (Appendix 2B). There still exist several species of value to sport and Indigenous fishers, although it is thought that Walleye were previously more abundant. The creek offers important spawning and rearing opportunities for key prey species, such as shiners and sculpins.

The final 2 km of the lower reaches of Baker Creek flow through the Site (Figures 1.0-1 and 2.5-1). The sections of the lower portion of Baker Creek that pass through the Site were labelled Reach 0 to Reach 6 for mine-planning purposes (Figure 2.5-1); Reach 7 is immediately upstream of the Site and is labelled as such for ease of reference to areas upstream of the Site. Detailed habitat maps for Reach 0 through Reach 6 can be found in the *Baker Creek Revised Ecosystem Synthesis Report* (Appendix 2B).

2.5.1 Fish and Fish Habitat

Baker Creek primarily consists of lotic habitat with water depths and substrate types varying along its length. Water depths within the creek vary from a few centimetres to approximately 2.3 m. At the mouth of Baker Creek, where it flows into Yellowknife Bay, a large marsh area is located on the west bank of the bay, which supports predominantly *Equisetum* spp. (horsetail) and a smaller patch of *Potamogeton* spp. (pondweed). To the east of the marsh area, the water from Baker Creek flows along the breakwater and into the main body of Yellowknife Bay. The substrates in this area are dominated by fine material (i.e., silt and sand) and are representative of a depositional area. Past studies have documented the presence of a variety of fish species in both Baker Creek and Yellowknife Bay (Tables 2.5-1 and 2.5-2). On the basis of the limited studies occurring during later mining activities in the 1990s to 2012, 12 species of fish were documented in the creek: Northern Pike, Arctic Grayling, Lake Chub, Ninespine Stickleback, Emerald Shiner, Spottail Shiner, Trout Perch, White Sucker, Burbot, Longnose Sucker, Slimy Sculpin, and Lake Whitefish (Appendix 2B). Limited reports also suggest Walleye may be seen in the area but none have been captured.

Table 2.5-1: Description of Baker Creek Reaches – Fish Use and Habitat

Baker Creek Reach	Description	Notable Fish Species Present	Type of Habitat	Fish use of Reach
Reach 6 (Baker Pond)	• Pond • Riffle habitat below waterfall • Waterfall at top of Reach (restricts upstream migration)	• Northern Pike • Arctic Grayling • Longnose Sucker • Lake Whitefish (potential overwintering) • Cisco (potential overwintering)	• Well-vegetated pond • Area of riffle	• Highly productive during spring/summer • Suitable for rearing, feeding, and spawning of numerous species • Northern Pike likely spawn in creek. • Documented spawning of Arctic Grayling and Longnose Sucker near riffle habitat • Limited overwintering
Reach 5	• Wetland areas • Meandering	• Northern Pike (abundant) including young-of-the-year	• Select spawning areas • Important nursery for Northern Pike	• Feeding, rearing, and migratory area • Some spawning in reach speculated (no spawning or eggs documented) • Also, bird and muskrat habitat
Reach 4	• Flat/riffle • 2006 habitat reconstruction in Reach • Relatively uncontaminated	• Arctic Grayling • Longnose Sucker	• Sediment-free substrate • Critical nursery area for Arctic Grayling young-of-the-year	• Principal spawning location for Arctic Grayling and Longnose Sucker in system
Reach 3	• Swift current with riffles and pools. Narrow deep channels with no aquatic vegetation	• Arctic Grayling incl. young-of-the-year in June, just prior to out migration • Longnose Sucker	• Riffles/Pool	• Limited spawning Arctic Graying and Longnose Sucker • Resident fish • Migration
Reach 2 & Reach 1 (Upper)	• Riffle/glide section in Reach 2 • Culvert in upper Reach 1 likely impassable for small-bodied fish	• Northern Pike • Arctic Grayling • Longnose Sucker	• Riffle/glide • Extensive natural riparian stream cover	• Migration for large-bodied • Out migration from Lower Martin only for small bodied fish • Some spawning by Arctic Grayling • Seasonal resident habitat for Northern Pike
Reach 1 (Lower)	• 250 m long • Flat/riffle • Plunge pool at lower end	• Slimy Sculpin • Longnose Sucker • Spottail Shiner • Ninespine Stickleback • Arctic Grayling	• Riffle habitat • Marsh	• Feeding and migration • Spawning and nursery for noted key fish species present • Spring “refugium” in plunge pool due to warmer temperatures • Spawning and nursery area
Reach 0	• 200 m long • Flat • No riparian zone	• Northern Pike • Slimy Sculpin • Arctic Grayling • Longnose Sucker • Numerous cyprinid (minnow) species	• Productive marsh • Abundant submerged and emergent vegetation • Migration corridor • Fish resident area	• Richest area of use by fish (thousands of fish in spring) • Multiple life stages present • Migrating, spawning, rearing, and feeding • Key forage species use for spawning and rearing documented

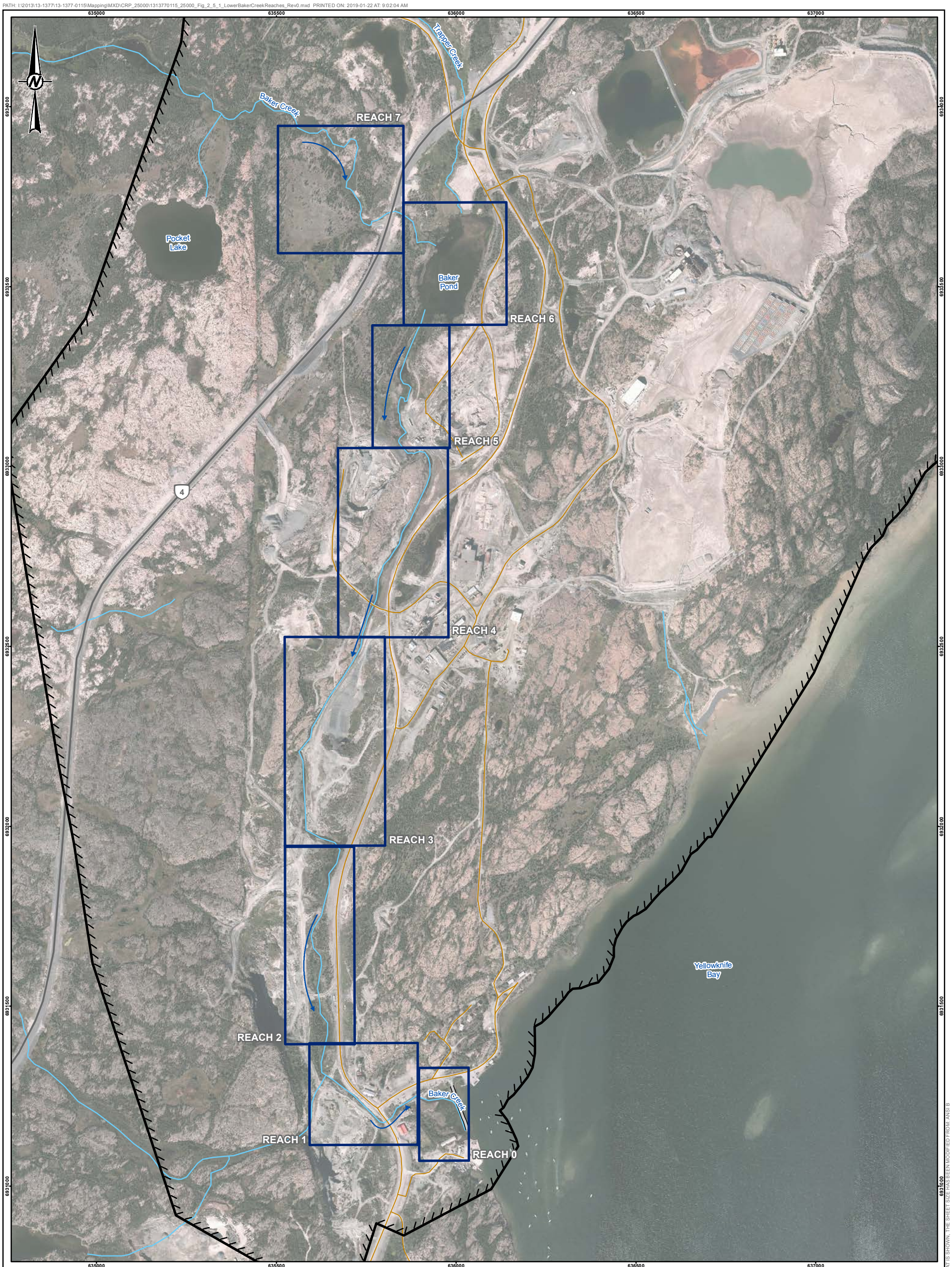
Lower Baker Creek is fragmented by natural and artificial barriers (Appendix 2B). The system can be organized into seven reaches with the project boundary (Figure 2.5-1), with three distinct areas:

- the mouth of the creek below the former Highway 4 culvert, which is composed of Reach 0 and the lower portion of Reach 1 (i.e., the mouth)
- above the former Highway 4 culvert, a section containing reaches within the Site including the upper portion of Reach 1 upstream to Reach 6 below the waterfall (i.e., within the project boundary)
- above the Reach 6 waterfall (i.e., above the project boundary).

Of the six reaches on the Site, Reaches 5 through Reach 0 collectively, provide spring, summer, and possibly fall habitat. These reaches have multiple uses to fish including spawning, rearing, feeding, and through migration. Resident species live in these reaches, though depths are shallow and overwintering habitat is not available. Reach 6 is well vegetated with a riffle area and is highly productive during spring and summer months. Up migration is not possible past Reach 6 due to the waterfall at the upper end of the reach, but some down migration does take place. The depth of Baker pond in Reach 6 may allow for limited overwintering for a wide variety of species, including species such as Lake Whitefish and Cisco.

Overall, since the implementation of better mining practices in the late 1990s and with the Site beginning closure and reclamation, improvements in the Baker Creek aquatic ecosystem have been documented (Appendix 2B). At this time, the creek may be characterized as contaminated and altered, but exhibiting signs of a system in recovery. Remediation options will likely have to account for the dichotomous nature of the creek—contaminated but with resilient aquatic species.

PATH: I:\2013\13-1377\13-1377-0115\Mapping\MXD\CRP_25000\1313770115_25000_Fig_2_5_1_LowerBakerCreekReaches_Rev0.mxd PRINTED ON: 2019-01-22 AT: 9:02:04 AM



LEGEND

- BREAKWATER
- DIRECTION OF FLOW
- GIANT MINE PROJECT BOUNDARY
- HIGHWAY
- ROAD
- WATERCOURSE
- REACH EXTENT

0 250 500

1:10,000 METRES

REFERENCE(S)

HYDROLOGY AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-22
DESIGNED	TD
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

AERIAL VIEW OF THE LOWER REACHES OF BAKER CREEK THROUGH GIANT MINE

REV. 0

FIGURE 2.5-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0

Table 2.5-2: Fish Species Documented in Baker Creek and Yellowknife Bay

Common Name	Scientific Name	Documented Presence in Study Area
Walleye	*Stizostedion vitreum*	• anglers have observed Walleye in the creek, and Traditional Knowledge from the YKDFN indicated that Walleye used to spawn in the creek (YKDFN 1997) • field staff of the GMRP Team reported seeing Walleye near the breakwater in August 2003 • Walleye were not captured in late 2006 or spring 2007 sampling in the creek as part of the Baker Creek Reach 4 project
Burbot	*Lota lota*	• captured in Upper Baker Creek and at the mouth during 2004 Phase 1 EEM program (Golder 2005) • captured in Baker Creek during the Phase 2 and 3 EEM programs (Golder 2008, 2011a)
Longnose Sucker	*Catostomus catostomus*	• captured near mouth of creek and in middle of creek (Dillon 1998; DFO unpublished 1996 data) • captured downstream of culvert and observed in Reach 4 during the 2008, 2009, 2010, and 2011 fish monitoring programs (Golder 2010, 2011b,c) • captured in Baker Creek during the Phase 2 and 3 EEM programs (Golder 2008, 2011a)
White Sucker	*Catostomus commersoni*	• captured near mouth of creek (Dillon 1998; DFO unpublished 1996 data) • captured downstream of culvert and observed in Reach 4 during 2008 Reach 4 Fish Monitoring Program (Golder 2010)
Northern Pike	*Esox lucius*	• captured in mouth and numerous reaches of the creek (Dillon 1998, DFO unpublished 1996 data) • captured in Baker Creek during the Phase 1, 2, and 3 EEM programs (Golder 2005, 2008, 2011a) • captured downstream of culvert and observed in Reach 4 during the 2008, 2009, 2010, and 2011 fish monitoring programs (Golder 2010, 2011b,c)
Lake Whitefish	*Coregonus clupeaformis*	• captured at mouth (Jackson et al. 1996) • captured in Baker Creek during 2004 Phase 1 EEM program (Golder 2005) • captured downstream of culvert and observed in Reach 4 during 2008 Reach 4 Fish Monitoring Program (Golder 2010) • captured in Reach 6 pond during the Overflow Fish Monitoring Program in 2011 (Golder 2011c)
Lake Cisco (Cisco)	*Coregonus artedi*	• captured in Mill Pond (Golder unpublished data memorandum to CIRNAC) • captured in Reach 6 pond during the Overflow Fish Monitoring Program in 2011 (Golder 2011c)
Arctic Grayling	*Thymallus arcticus*	• captured at mouth (DFO unpublished 1996 data) • observed in creek by numerous anglers in spring • captured downstream of culvert and observed in Reach 4 during the 2008, 2009, 2010, and 2011 fish monitoring programs (Golder 2010, 2011b,c)
Lake Chub	*Couesius plumbeus*	• captured at mouth (DFO unpublished 1996 data) • observed downstream of culvert during 2008 Reach 4 Fish Monitoring Program (Golder 2010)
Slimy Sculpin	*Cottus cognatus*	• captured at mouth (DFO unpublished 1996 data) • captured in upper reaches of creek (Moore et al. 1978) • captured in Baker Creek during the Phase 1, 2 and 3 EEM programs (Golder 2005, 2008, 2011a) • observed downstream of culvert during 2008 and 2011 fish monitoring program (Golder 2010, 2011c)
Ninespine Stickleback	*Pungitius pungitius*	• captured at mouth (DFO unpublished 1996 data) • captured in upper reaches of creek (Moore et al. 1978) • captured in Baker Creek during the Phase 1, 2, and 3 EEM programs (Golder 2005, 2008, 2011a) • captured downstream of culvert and observed in Reach 4 during the 2008, 2009, 2010, and 2011 fish monitoring programs (Golder 2010, 2011b,c)
Emerald Shiner	*Notropis atherinoides*	• captured at mouth (DFO unpublished 1996 data) • observed downstream of culvert during 2008 Reach 4 Fish Monitoring Program (Golder 2010)
Spottail Shiner	*Notropis hudsonius*	• captured at mouth (DFO unpublished 1996 data) • captured in Baker Creek and the Phase 1, 2 and 3 EEM programs (Golder 2005, 2008, 2011a) • observed downstream of culvert during 2008 Reach 4 Fish Monitoring Program (Golder 2010)
Trout Perch	*Percopsis omiscomaycus*	• captured in creek at unknown location (DFO unpublished data 1994 data, reported in Dillon 1998) • captured in Baker Creek during the Phase 1 EEM program (Golder 2005) • captured downstream of culvert during recent fish monitoring program (Golder 2010, 2011b,c)
Unidentified sucker spp.	*Catostomus spp.*	• juvenile unidentifiable sucker species were captured in Baker Creek during the Phase 2 and 3 EEM programs (Golder 2008, 2011a)

Source: Golder 2016b. YKDFN = Yellowknives Dene First Nation; GMRP = Giant Mine Remediation Project; EEM = Environmental Effects Monitoring; DFO = Fisheries and Oceans Canada

2.5.2 Benthic Invertebrate Community

Prior to the implementation of effluent treatment in the 1980s, benthic invertebrates were virtually absent from Baker Creek, presumably due to elevated contaminant concentrations (Appendix 2B). Falk et al. (1973) documented the absence of invertebrates at four sampling stations within Baker Creek. Moore et al. (1978) documented that Baker Creek was largely devoid of fauna downstream of the Site, although oligochaetes were present in very low numbers (<100 individuals/m^2).

Dillon Consulting Limited (Dillon 2002) documented benthic invertebrate recolonization within Baker Creek in July 2002. Dipteran larvae (e.g., Simuliidae and Chironomidae, "flies"), Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) nymphs and larvae were observed in Baker Creek at locations upstream of the Site; Diptera larvae were the most abundant taxa. Ephemeroptera, Plecoptera, and Trichoptera (EPT) were absent from locations downstream of the Site (i.e., areas exposed to treated effluent), but oligochaetes, ostracods, and dipteran larvae were present. Invertebrate tissue collected at Baker Creek stations located downstream of the Site contained arsenic concentrations that were approximately three times higher than tissues collected at upstream stations (Dillon 2002).

Benthic invertebrates have been studied numerous times since mining ceased. As part of the EEM program which studies the effects of treated effluent on aquatic life, benthic invertebrate communities were sampled in 2004, 2006, and 2010. Artificial substrates deployed in depositional areas were used to minimize habitat variation among sampling stations and areas. These substrates were also used to minimize the influence of potential confounding factors, particularly the potential effects of historical sediment contamination, in the assessment of the potential effects of the effluent discharge on benthos in the exposure areas. Results from these surveys were comparable (Golder 2005, 2008, 2011b). The Bray-Curtis Index, which notes how different two sites are from each other, was the only consistent effect observed among sampling areas for each of the three EEM phases; further review showed differences in community composition in Baker Creek compared to the reference area in terms of both a reduced proportion of pollution-sensitive mayflies in the near-field area and differences in community structure.

The most recent assessment of benthic invertebrate communities in Baker Creek on Site was completed in 2011 (Golder 2013a). It was done to inform the evaluation of Baker Creek remediation options. In the 2011 assessment, benthic communities associated with both depositional and erosional habitats in Baker Creek were sampled and compared to reference stations in the Yellowknife River. Natural bottom substrates were sampled in 2011; artificial substrates were not used in this study

Depositional: No obvious differences between benthic communities in depositional areas of Baker Creek and the Yellowknife River were documented with one exception. Six mayfly taxa were identified from depositional stations in the Yellowknife River, but were only sporadically present in Baker Creek, which suggests a potential negative effect on mayflies, consistent with the known sensitivity of mayflies to metals. Other observations from the 2011 study include the following:

- Neither total density nor richness showed spatial trends along Reaches 0 and 1 in Baker Creek, and there were no apparent differences in density or richness between Baker Creek and a reference area (Yellowknife River).
- Benthic communities in depositional areas were dominated by a few taxa.

- Relative densities of major benthic taxonomic groups in depositional areas were variable among stations in Reaches 0 and 1. The proportion of Diptera (flies) progressively increased with distance downstream from 39% at the furthest upstream station in Reach 1 to 82% at station the furthest downstream station in Reach 0. Diptera accounted for 42 to 68% of the benthic invertebrate communities in depositional areas of the Yellowknife River.

The assessment was confounded to an extent by habitat differences between Baker Creek and the Yellowknife River and by historical sediment contamination within Baker Creek, such that these differences could not be conclusively attributed to treated effluent exposure in Baker Creek.

Erosional: Erosional communities were also sampled and the following was observed:

- Both total density and richness were consistently lower at Reach 0 and 1 stations in Baker Creek compared to stations in the Yellowknife River.
- Benthic communities in erosional areas were also dominated by a few taxa.
- Relative densities of major benthic taxonomic groups in erosional areas were similar among stations in Reaches 0 and 1, but Baker Creek communities differed from Yellowknife River communities. The benthic invertebrate communities within Baker Creek were dominated by Diptera (90% to 98%). In contrast, Diptera accounted for 37% to 46% of the benthic invertebrate community in the Yellowknife River. EPT occurred at higher relative densities (11% to 33%) at the Yellowknife River stations, whereas this group accounted for less than 4% of the community in Baker Creek. The observed differences are consistent with the expected negative effect of elevated concentrations of mine-related contaminants in stream water and sediments in Baker Creek.
- In terms of community composition, thirty taxa were unique to the Yellowknife River stations. In comparison, 14 taxa were unique to Reaches 0 and 1 in Baker Creek. Seventeen EPT taxa were identified from erosional stations in the Yellowknife River, but were only sporadically present in lower Baker Creek, which suggests a potential negative effect on EPT taxa in lower Baker Creek, consistent with the known sensitivity of EPT taxa to metals.
- Multivariate analysis, which compares the entire communities rather than individual variables, identified clear differences in community structure between Baker Creek and the Yellowknife River. Nevertheless, habitat variation among stations and between Baker Creek and the Yellowknife River remained a potential confounding factor that might have accounted for some of the observed differences in community structure.

2.5.3 Aquatic Birds and Wildlife

Aquatic birds and wildlife (e.g., muskrats and beavers) use Baker Creek. There are no consistent historical data documenting stream use by aquatic birds and wildlife, so trends cannot be determined but their presence is noted annually (Appendix 2B).

2.5.4 Human Health and Ecological Risk Assessment

In January of 2018, the Government of Canada finalized the report on the Giant Mine Human Health and Ecological Risk Assessment (HHERA). This HHERA is available in Appendix 2E. A HHERA is a scientific process used to describe and estimate the likelihood of potential risks (i.e., adverse health effects) to humans and wildlife and plants resulting from exposure to environmental contaminants (e.g., arsenic).

The objective of the HHERA was to quantify the likely change in exposure and risk for people in the area as well as wildlife at the Site from exposure to arsenic and other contaminants of concern associated with the GMRP. Current and predictive assessments of future conditions after remediation and 100 years into the future were evaluated. Communities of Ndilǫ, Yellowknife and Dettah were included in the HHERA, with specific considerations for Latham Island, Long Lake campground, and Ingraham Trail.

Sample types that were reviewed during the HHERA included water quality, sediment quality, terrestrial soil quality, aquatic and terrestrial vegetation, fish tissue, and some bird and mammal tissue (Table 2.5-3). Potential ways people might be exposed to arsenic and other contaminants that were considered included soil and dust, drinking water, wading in sediments, as well as eating country foods and medicinal plants from the local area. The HHERA also incorporated information on how much local country foods residents eat and where they got the food through dietary surveys. Information on arsenic concentrations from samples of country foods collected by local residents was used in the HHERA. The report also considered how much grocery store food is eaten.

The significance of water and sediment and soil chemistries in relation to wildlife and human health is outlined in detail in the HHERA (Appendix 2E). The human health risks of cancer associated with arsenic and other contaminants from past releases and existing conditions are low to very low, consistent with risks of a full body CT Scan or getting dental X-rays. These risks will remain low to very low once the remediation is complete.

The Ecological Risk Assessment found that the clean-up will improve environmental conditions on the Site; however, there could still be risks to small animals (e.g., mice, voles) on the Site. In Yellowknife Bay, low risks to small insects in the sediments were found, but these conditions are anticipated to slowly improve over time (Appendix 2E).

Table 2.5-3: Overview of Samples Considered in Human Health and Ecological Risk Assessment

Sample Type	Sample Origin	Number of Samples Analyzed
Surface water quality	Baker Creek	57
	Back Bay	49
	Yellowknife Bay	69
Sediment quality	Baker Creek	47
	Back Bay	85
	Yellowknife Bay	108
Aquatic vegetation	Baker Creek	14
	Yellowknife Bay	4
	Regionally	41
Fish tissue	Lake whitefish	186 muscle 206 liver 165 kidney
	Northern pike	83 muscle 85 liver
Benthic Invertebrates	Baker Creek	11 samples + EEM samples
Terrestrial soils	Site and Yellowknife area	600 samples [(a)]
Terrestrial vegetation	Site, Yellowknife area, and Dettah	74 garden vegetables, moss lichen, and mushroom samples 17 berry samples 38 medicinal plants/Labrador tea

(a) Soil samples were from nine separate studies conducted from 1987 to 2003.

CHAPTER 3
Project Description

3 PROJECT DESCRIPTION

This chapter provides an overview of the Giant Mine including a brief summary of site location and access (Section 3.1) and main project elements (Section 3.2). Also included is Giant Mine site history (Section 3.3) from pre-mining land use, through to early exploration history, industrial history, the arsenic trioxide management history, and the historical impacts of mining on Indigenous people and affected parties. This chapter concludes with a description of the remediation plan—the project description (Section 3.4). This project description is an overview with details on closure and reclamation activities described in Chapter 5 for each of the project components.

3.1 Location and Access

As noted in Chapter 2, the Site is located approximately 5 km north of the Yellowknife city centre, at Longitude 114°21'W and Latitude 62°31'N (Figures 1.0-1 and 2.0-1). Access to the Site is from local roads branching from the Northwest Territories Territorial Highway 4 (also known as the Ingraham Trail; Figure 1.0-1). Roads within the Site are shown in Figure 2.0-1. In 2013, Highway 4 was relocated west to bypass the majority of the Site; however, it still bisects the Site. The new highway alignment parallels the Site and then crosses Baker Creek above Reach 7 and runs adjacent to the Northwest Pond on the Site. Vee Lake Road, which is another publicly accessible road that terminates at Vee Lake, crosses through the Site beside the Northwest Pond and connects to Highway 4 at the south end of the road (Figure 2.0-1). The remaining segment of road entering site is now used as the access road to the Site.

The Site is closed to the public for safety reasons. This is indicated by signs posted along public access routes. The main gate to the Site is on the access road just north of the turnoff to the abandoned Townsite and City of Yellowknife Boat Launch. Entrances where gates are not practical have signage, boulders, or temporary fencing placed across the road to prevent access. Access roads can be opened to allow vehicles into the property as required. Access to the Townsite is limited to the Marina (operated by the Great Slave Sailing Club and City of Yellowknife public boat launch). The Marina and the public boat launch are within the project boundary but on land leased to the City of Yellowknife; neither of these areas are controlled or operated by the GMRP. The Marina is privately operated and maintained by the Great Slave Sailing Club and provides moorage for approximately 40 boats during the open water season as well as on-site dry dock storage during the off season.

3.2 Main Project Elements

In brief, the Site consists of the following components:

- an underground mine with numerous underground workings, including arsenic trioxide storage areas in stopes and purpose-built chambers
- eight abandoned open pits
- Two TCAs and associated rockfill dams
- Baker Creek, which originates northwest of the Site, flows through the Site and drains some areas of the Site, and then flows into Yellowknife Bay of Great Slave Lake
- a seasonally operated ETP

- various buildings and Site infrastructure elements, including a TRP (out of service since 1990), a mill site complex (which includes the area where the roaster stood and several warehouses), and a former Townsite

The planned closure and reclamation activities for these main project elements are described in Section 3.4.

3.3 Giant Mine Site History

To give context for the closure and reclamation effort, a brief history of key parts of the mining operation is provided below, identifying the historical events that contributed to the existing conditions. The content of this subsection addresses the Site's history, starting from the pre-industrial period, to the operational phase, and eventual transfer of the Site to the Government of Canada (INAC and GNWT 2010).

3.3.1 Pre-mining Land Use

Before the development of mines and the settlement of what is now known as the city of Yellowknife, the land was used by various Indigenous groups, including the forebears of the modern Akaitcho, Tłı̨chǫ, and Métis. These people travelled and camped in the area, while harvesting food from the land and Great Slave Lake. The earliest written records of the area make reference to a semi-permanent fishing camp located across Yellowknife Bay, in the area now known as Dettah. The Yellowknives Dene continue to reside in the communities of Dettah and Ndilǫ, as well as Yellowknife. The NSMA members reside in Yellowknife and other NWT communities. A pre-mining aerial photograph of the Giant Mine and Yellowknife area pre-mining is shown in Figure 3.3-1.

Historically, Indigenous peoples throughout the region would reside in a given area for several months, depending on the season and access to traditional food. The Yellowknife area is within the winter range of the Bathurst caribou herd. In general, the caribou moved into the region in the late fall and remained until early spring when they migrated north for the calving season. From early winter to late spring, Indigenous groups would harvest caribou, moose, and other resident species. In addition to hunting, the surrounding land and waters were used for fishing and trapping, as well as the collection of plant species that formed a relatively small but important part of their diets (e.g., blueberries, cranberries, and cloudberries).

The Traditional Knowledge Report prepared by the YKFDN Land and Environmental Committee (YKDFNLEC 2005) contains a high-level overview of historical Dene use of the Site and surrounding environments. An updated Traditional Knowledge study, which was led by YKDFN, began in 2018, and the results of this work will be available later in 2019.

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Shot Lake

Trapper Lake

Moose Lake

Gar Lake

Yellowknife River

Trapper Creek

Oran Lake

Muir Lake

Jo-Jo Lake

Bow Lake

Pocket Lake

Joe Lake

Baker Creek

Handle Lake

Yellowknife Bay

636000

638000

LEGEND

GIANT MINE PROJECT BOUNDARY

WATERCOURSES

ORIGINAL AND CURRENT

ORIGINAL

WATERBODIES

ORIGINAL

0 250 500

1:15,000 METRES

REFERENCE(S)

HYDROLOGY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. HISTORIC AIR PHOTOS CAPTURED JULY JULY 13, 1945 (A8666-74) AND JULY 22, 1945 (A8668-71), OBTAINED FROM THE NATIONAL AIR PHOTO LIBRARY, LIBRARY AND INFORMATION SERVICES.
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-22
DESIGNED	DP
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

AERIAL VIEW OF GIANT MINE PRIOR TO MINE DEVLEOPMENT, 1945

REV. 0

FIGURE 3.3-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
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3.3.2 Early Exploration History

Gold was thought to be first discovered by in the Great Slave Lake region in 1896. According to Yellowknives Dene First Nations history, an Elder named Liza Crookedhand found a large gold-bearing rock while picking berries with two other women on the northwest shores of Yellowknife Bay, the area that would later become the site of the Giant Mine. She brought the rock back to her camp on the Yellowknife River. When a prospector noticed the rock at Crookedhand's camp, he traded it for a stovepipe and details about where the rock was found (see more in YKDFNLEC 2005). It was thought that the gold deposit was then explored by prospectors in the area at least as early as 1900, but it was not until the 1930s, with the advent of aircraft travel in the far North, that significant mineral development began. The first mine to open in the present-day Northwest Territories was the Port Radium Mine on Great Bear Lake in 1933.

The Port Radium development stimulated mineral exploration throughout the North. The first non-Indigenous use of the Yellowknife area appears to have been as a semi-permanent float plane base to serve airborne explorers prospecting the surrounding area. However, it was not long before gold discoveries were made in the immediate vicinity. Numerous claims were staked around Yellowknife in the 1930s, leading to the opening of the Con Mine in 1938 and the first large-scale gold production in the area. The development of the Giant Mine commenced in 1945.

3.3.3 Industrial History

This section, adapted from the DAR (INAC and GNWT 2010), is based primarily on information obtained from a review of monthly operational reports to the mining company Board of Directors, which are stored in the archives of the Prince of Wales Northern Heritage Centre. Additional information was obtained from published papers (Grogan 1953; McDonald 1953; Pitcher 1953; Mortimer and Tait 1959; Foster 1963), from Royal Oak Mines Inc. (1998), and from selected correspondence in files located at the Site. The specifics are outlined here in Chapter 3, and a brief summary relative to the lessons learned with mining over time is included in Chapter 4. A summary of the industrial history relevant to the technical aspects of the closure activities is found in Table 3.3-1. This table also includes a summary of closure and reclamation activities carried out up to 2018.

Table 3.3-1: Summary of Project History and Key Activities

Year	Mine Activities	Ownership	Key Regulatory/Permitting Relevant to Closure Planning
Pre-mining Site History			
Before 1900	Land used by various Indigenous peoples including the forbears of the modern Akaitcho, Tłı̨chǫ, and Métis. Caribou hunting, fishing, and trapping		
Early 1900	Gold found and exploration begins		
1935	Staking claim	Burwash Yellowknife Mines Ltd. stakes 21 claims, including the future Giant Mine	
1937	Mine ownership	Giant Yellowknife Gold Mines Ltd. is incorporated	
1943	New mine management	Frobisher Exploration Company Ltd. (Frobisher; owned by Ventures Ltd.) takes over the mine management control	
Mining and Processing			
1945	Underground development of the mine starts	Frobisher (owned by Ventures Ltd.)	
1948	Ore processing and tailings deposition begin		
	Tailings is deposited in the Back Bay portion of Yellowknife Bay (Foreshore Tailings Area)		
1949	Airborne arsenic emissions are produced. Surface disposal of arsenic trioxide occurs		
1949–1951	Airborne arsenic releases are estimated at 7,500 kg/d		The Department of National Health and Welfare evaluates safe disposal options of arsenic trioxide (1950)
1951	Roaster calcine and flotation tailings are deposited in Bow Lake (current North Pond)		Giant Yellowknife Gold Mines Ltd. initiates first studies into arsenic in surrounding environment, leading to revised operations
	Cold Cottrell Electrostatic Precipitator is installed, which leads to the collection of arsenic trioxide dust as a waste by-product		
	Arsenic trioxide is pumped into storage chambers near the arsenic recovery plant in a permafrost zone (from 100–250 ft below surface)		
1955	Dam 1 construction starts as Bow Lake reaches capacity		
1957	Control of arsenic in the mine effluent begins with a precipitation circuit		
1958	Dracco baghouse filtering system is installed to control arsenic trioxide dust and calcine		
1959	Airborne arsenic releases are estimated at 200–300 kg/d		
Early 1960's	Construction of Dam 1, Dam 2, and Dam 3 create the current North, Settling, and Polishing ponds areas		
1962	Arsenic trioxide disposal is switched, placed into early ore production stopes	Frobisher merges with Falconbridge Nickle Mines Ltd. (Falconbridge)	
Late 1960's	Construction of Dams 4 and 5 begins, closing off the south end of the area now known as the Central Pond	Falconbridge	
1967	A new water treatment circuit is commissioned		
1973			The Mine Inspector expresses concern regarding the potential for arsenic pollution from the mine, particularly possible impacts from flooding in the case of a proposed 1975 shut-down.
1974	Open pit mining starts with the excavation of A1 Pit. A total of 8 pits were mined.		
1976			All ore production stopes suitable for arsenic trioxide disposal are filled. Excavation of purpose-built chambers commences, starting with Chamber 9.
1977			The Canadian Public Health Association task force on arsenic is established, to assess the effects of arsenic emissions on the population of Yellowknife. It recommends that underground storage of the arsenic trioxide dust at the mine should continue, pursuant to requirements specified by the Mining Inspection Branch.
1978	New Water Licence conditions imposed		In 1978, as a condition of a new Water Licence, the mine owner was required to improve the quality of effluent released to the environment.
1981	A new tailings effluent treatment plant starts operations		After conducting pilot testing in collaboration with Environment Canada, a new tailings effluent treatment plant started operating in August 1981

Table 3.3-1: Summary of Project History and Key Activities

Year	Mine Activities	Ownership	Key Regulatory/Permitting Relevant to Closure Planning
1983	Baker Creek is diverted to allow the excavation of C1 Pit		
	Dam 11 is constructed and the South Pond is created		
1984	Gold recovery from tailings effluent with carbon adsorption begins		
1985			The NWT Water Board approves the treatment and discharge of minewater directly to Baker Creek via the mill (this option was never implemented)
1986		Pamour Inc. (controlled by Giant Resources Ltd.) purchases the mine (Giant Yellowknife Gold Mines Ltd.)	
1987	The Northwest Pond is created by the construction of Dams 21 and 22, intended to serve as an impoundment for tailings recovered from the North and Central ponds and those processed in the tailings retreatment plant, as well as new tailings from conventional ore processing		
1990	Open pit mining ceases		
1991		Royal Oak Mines Inc. is formed by consolidating the assets of Pamour and Royal Oak Resources.	
1997	A minewater treatment circuit is installed in the mill, allowing the treated water to be used in the mill process and reducing the consumption of fresh water		
End of Roaster Operations			
1999	No further processing of ore takes place at the mine and the roaster no longer operates	Royal Oak Mines Inc. goes into receivership and transfers control of the property to CIRNAC that in turn sells to Miramar Giant Mine Ltd.	CIRNAC indemnifies Miramar Giant Mine Ltd. for existing environmental liabilities at the Site
	Miramar Giant Mine exploits the deposit, and trucks the ore off site to the local Con Mine for processing	Miramar Giant Mine Ltd.	The GNWT indemnifies CIRNAC for certain liabilities associated with the surface features or components of the mine
	Minewater is pumped to the South, North, and Northwest ponds for storage, and then treated in the existing water treatment plant prior to discharge to Baker Creek during the summer months		Under the terms of a reclamation security agreement with CIRNAC, Miramar Giant Mine Ltd. continues to operate the mine in environmental compliance under Water Licence N1L20043 (MVLWB 2003)
2001			An Abandonment and Restoration Plan is submitted to the MVLWB by Miramar Giant Mine Ltd. The plan leaves several questions open, stating that they would be answered by the Arsenic Trioxide Project Description
2003			Water Licence is obtained for instream modification of Baker Creek (MV2002L2-0020) for removal of instream barriers, at the request of Fisheries and Oceans Canada
2004	Mining operations ceased		2002–2004: Consultation, public and expert engagement on final closure option for the arsenic trioxide
	Minewater is only pumped to the Northwest Pond before being treated and released		
Care and Maintenance Phase – Progressive Closure			
2005	Mine enters care and maintenance	The Giant Mine becomes “orphaned and abandoned” as Miramar Giant Mine Ltd. is assigned into bankruptcy. Surface land lease is returned to the GNWT. The Site comes under control of CIRNAC and the GNWT.	Water Licence N1L20043 expired December 2005
		CIRNAC and Public Services and Procurement Canada enter into a contract arrangement for care and maintenance of the site. Det’on Cho/Nuna Joint Venture is awarded the care and maintenance contract.	
2006	Realignment of Reach 4 of Baker Creek		Conducted under *Fisheries Act* Authorization YK-06-0063 (see Chapter 4 for more details)
2007	Ongoing care and maintenance, monitoring, and engineering	CIRNAC	*Giant Mine Remediation Plan* (SRK/Senes 2007) submitted by the GNWT and CIRNAC to address the underground arsenic trioxide dust and surface decommissioning, cleanup and reclamation is submitted along with a Water Licence application to the MVLWB, original Water Licence Application MV2007L8-0031
2009 to 2015	Freeze Optimization Study: to provide additional information to develop an optimum ground freezing process for the frozen block method including power requirements, rate of freezing, pipe diameter, drilling requirements, and more accurate cost estimates. Freeze plant installed in 2009 and study began in 2011		
2010	Ongoing care and maintenance, monitoring, and engineering		City of Yellowknife refers project to EA under of *Mackenzie Valley Resource Management Act*, citing potential adverse environmental impact within municipal boundaries. The MVEIRB initiates EA (EA0809-001). The DAR submitted by INAC (now CIRNAC) and GNWT (2010)
2011	Conveyor deconstruction		Icing event in Baker Creek Reach 7 leads to sediment release (Spill #NT-159); Inspector issues Letter of Direction
2012	Construction work is performed on Baker Creek to address historical tailings deposit in Jo-Jo Lake		Giant Mine Remediation Project Team applies to MVLWB for Water Licence for urgent work on site (Site Stabilization Plan)

Table 3.3-1: Summary of Project History and Key Activities

Year	Mine Activities	Ownership	Key Regulatory/Permitting Relevant to Closure Planning
2013	• Pillar stabilization of non-arsenic stope complexes B118, B306, B310, and A370 and the two arsenic stopes B208 and B212/B213/B214 by tight filling starts. • Deconstruction of the Roaster Complex starts		MVLWB issues Water Licence MV2012L8-0010 in March 2013 for Site Stabilization MVEIRB issues *Report of Environmental Assessment and Reasons for Decision – Giant Mine Remediation Project* (MVEIRB 2013) approving the project and establishing measures to be followed.
2015	• Pillar stabilization work is completed • Roaster deconstruction is completed • C Shaft headframe deconstruction starts • Interim underground stabilization of arsenic stopes (B208 and B212/B213/B214) and non-arsenic stopes (B118, B306, B310, and A370). • Rock buttress stabilization works on C1 Pit wall is completed		Giant Mine Remediation Project Environmental Agreement between the Canadian Government, GNWT, Yellowknives Dene First Nation, City of Yellowknife, Alternatives North, and North Slave Métis Alliance establishes an independent oversight body
2016	• A Shaft headframe deconstruction is completed • Removal and capping of abandoned underground arsenic distribution piping		Surface Design Engagement process takes place, presenting remediation options and collecting input from participants MVLWB issues Land Use Permit MV2016S0016 for advanced underground Site Stabilization Plan
2017	• Electrical upgrades to B3 Substation • Underground communication system replacement • Fencing and signage • Underground electrical upgrades • Underground chutes and head cover repair		Water Licence MV2012L8-0010 amended and extended to January 2020 Land Use Permit MV2016S0016 amended MVLWB issues Water Licence MV2017L8-0006 and Land Use Permit MV2017X0030 for repair of existing UBC Bridge
2018/2019	• The non-arsenic stope complex C509 is backfilled • UBC Bridge replacement		Water Licence MV2012L8-0010 amended

NWT = Northwest Territories; GNWT = Government of the Northwest Territories; CIRNAC = Crown-Indigenous Relations and Northern Affairs Canada; INAC = Indigenous and Northern Affairs Canada; MVLWB = Mackenzie Valley Land and Water Board; MVEIRB = Mackenzie Valley Environmental Impact Review Board; EA = Environmental Assessment

3.3.3.1 Mine Ownership

The original 21 mineral claims on which the Site is located were staked by Burwash Yellowknife Mines Ltd. (Burwash) in 1935. Exploration of the property continued until 1944, at which time the decision was made to develop a mine. Giant Yellowknife Gold Mines Ltd. was incorporated in August 1937, as a joint subsidiary of Bear Exploration and Radium Ltd. and Yellowknife Gold Mines Ltd., after the latter acquired the assets of Burwash.

During the early 1940s, Giant Yellowknife Gold Mines Ltd. and Frobisher Exploration Company Ltd. (Frobisher) examined the possible geological relationship between the Con Mine and the Giant Mine via the West Bay fault offset. As a result of this work, Frobisher, which was owned by a company called Ventures Ltd., optioned the remaining treasury shares of Giant Yellowknife Gold Mines Ltd. in July 1943 and took over management control. Ventures Ltd. remained the property owner until 1962, when it merged with Falconbridge Nickel Mines Ltd.

Ownership changed again in 1986 when Pamour Inc. (Pamour), controlled by Giant Resources Ltd. of Sydney, Australia, bought Giant Yellowknife Gold Mines Ltd. Pamour was subsequently bought out by Royal Oak Resources Ltd. in 1990. In the following year, Royal Oak Mines Inc. was formed to consolidate the assets of Pamour and Royal Oak Resources.

Royal Oak Mines Inc. continued operations at the Site until 1999, when it went into receivership. A court-appointed receiver transferred control of the property to CIRNAC in December 1999. Immediately, Miramar Giant Mine Ltd. (a subsidiary of Miramar Mining Corporation) purchased the Site from CIRNAC. Under the terms of the purchase agreement, CIRNAC indemnified Miramar Giant Mine Ltd. for existing environmental liabilities at the Site. Concurrently, the GNWT indemnified CIRNAC for certain liabilities associated with the surface features or components of the mine. Additionally, under the terms of a reclamation security agreement with CIRNAC, Miramar Giant Mine Ltd. continued to operate the Site in environmental compliance. Miramar Giant Mine Ltd. mined ore from the Site on a greatly reduced scale until July 2004. The ore was trucked to Con Mine, which was owned and operated by Miramar Con Mine Ltd. and located on the south side of Yellowknife. No further processing of ore took place at the Giant Mine, and the roaster did not operate after 1999.

When mining ceased in July 2004, Miramar Giant Mine Ltd. gave CIRNAC notice that it would terminate its obligations under the reclamation security agreement on 7 January 2005. An extension of time was negotiated to allow CIRNAC, together with PSPC, to enter into a contract arrangement for care and maintenance of the site. Following a competitive bidding process, Det'on Cho/Nuna Joint Venture was awarded the care and maintenance contract, with work commencing on 1 July 2005.

The Giant Mine became "orphaned and abandoned" when Miramar Giant Mine Ltd. was assigned into bankruptcy by the Northwest Territories court. The trustee managing the bankruptcy surrendered the mineral rights to CIRNAC and, because the Giant Mine is on Commissioner's land, the surface land reserve was returned to the GNWT. Mineral rights have since been withdrawn.

3.3.3.2 Mine Development

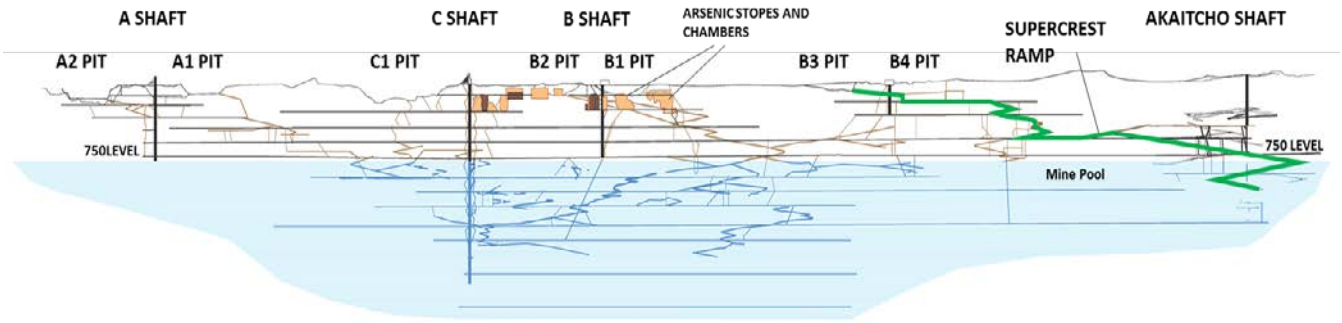
Underground mine development began in 1945 with the sinking of A Shaft (Figure 3.3-2), which was developed to provide access for exploration drilling and to allow development of the East Zone ore body. While the shaft was being developed, surface drilling identified high-grade ore further up the Baker Creek valley. A decision was made to develop the high-grade ore body first, and B Shaft was sunk in 1946 for this purpose. At the same time, the nearby C Shaft collar was excavated and stabilized prior to mill construction, in anticipation of future development of the South and Central ore zones.

C Shaft was sunk in 1949 and by 1953 it was connected to A Shaft and B Shaft via the 750L. Once C Shaft was connected to the major workings, it became the production shaft through which ore was hoisted to surface; A Shaft and B Shaft were used primarily as service and ventilation openings.

Three mining methods were initially employed: cut and fill, shrinkage, and open stoping. The selection of mining method for a particular stope was largely dictated by the shape, size, and angle of the ore block. Shrinkage and open stoping were used exclusively until October 1950, at which time cut and fill became the preferred mining method. In addition to development waste rock, natural gravel excavated on surface was used as stope fill until 1957, at which time mill tailings became the main backfill material. A new tailings backfill preparation plant was commissioned in 1967, and backfilling operations continued until 1978.

Known economic ore reserves were practically depleted by the early 1970s. To keep the operations going while additional reserves were found, open pit mining began in 1974, with the excavation of A1 Pit, and continued through the 1980s with the development of the pits including B1 (1976), B2 (1981), A2(1984), and B3 (1987). Baker Creek was diverted in 1983 to allow the excavation of C1 Pit. A total of eight pits were developed until open pit mining ceased in 1990. After that, ore was exclusively extracted from underground workings (Figure 3.3-2).

Figure 3.3-2: Underground and Pit Areas of the Giant Mine



3.3.3.3 Ore Processing

Giant Mine ore has a complex mineralogy as described further in Section 3.3.4. Most of the gold occurs as extremely fine-grained particles that are “refractory,” i.e., encased within larger grains of sulphide minerals, principally arsenopyrite and pyrite. An oxidation process is required to convert the dense sulphide grains into porous structures and expose the gold to cyanide leaching solutions. Roasting was the only efficient oxidation process available when the Giant Mine was developed. An ore processing system was designed to concentrate the gold-bearing sulphide minerals using froth flotation, and then roasting the sulphide concentrate in preparation for cyanide leaching.

Ore processing operations began on 12 May 1948 with circuits for ore crushing, grinding, froth flotation, and mercury amalgamation. Initially, the flotation concentrates were stockpiled to await the completion of the roaster facility. Some free gold (i.e., gold not encased within sulphides) was recovered by mercury amalgamation during the period before the first roaster began operation.

An Edwards-type multiple-hearth roaster, built by Allis-Chalmers, began operation in January 1949. The roaster calcine (oxidized product) was leached with cyanide solution. The gold was recovered from solution by precipitation onto zinc, and the zinc-gold product was smelted in a furnace to produce gold bullion. Gold was

recovered using both mercury amalgamation and cyanidation methods until 1959, at which time amalgamation was discontinued.

The Allis-Chalmers roaster had a low capacity and was difficult to operate. Variations in feed rate and sulphide concentration caused major problems. The roaster frequently had to be shut down and cleaned out. The temperatures at the exit point from the roaster were low enough that arsenic vapour condensed, forming arsenic trioxide deposits that tended to plug the dust collector. Arsenic trioxide condensation also created difficulties in the roaster emission stack, where dust build-up caused operating problems. Similar difficulties were experienced with the calcine cyclone collectors.

Soon after roasting operations began, fluo-solids roasters were introduced to the market. Testing of Giant Mine ore with the new roaster technology demonstrated that the best gold recovery could be achieved using a two-stage roast, in which arsenic was eliminated in the first stage under reducing conditions, followed by an oxidation stage at a higher temperature. A two-stage fluo-solids roaster (known as the No. 1 Dorrco roaster) was commissioned and put into operation in May 1952, when mill tonnage was increased from 425 imperial tons/d to 700 imperial tons/d. The No. 1 Dorrco initially operated in parallel with the original Allis-Chalmers roaster. The company experimented with the No. 1 Dorrco for a couple of years in an effort to obtain a good compromise between gold extraction and electrostatic precipitator efficiency. This experimentation ended in 1954, when the roaster was operated to optimize extraction, and arsenic dust collection was addressed as a separate issue.

Mill tonnage was increased again in 1958, to 1,000 imperial tons/d. At the same time, the ore being mined became increasingly refractory. To cope with both of these changes, a new fluo-solids roaster (known as the No. 2 Dorrco) went into operation in November 1958, replacing the two other roasters. After an initial optimization period, the No. 2 Dorrco proved to be a much more efficient and reliable roaster. The No. 2 Dorrco roaster remained in operation until ore processing ceased at the end of 1999.

3.3.3.4 Tailings and Water Management

Tailings disposal began in 1948 with discharge of flotation tailings directly into Yellowknife Bay. The tailings remaining from this disposal, on the shore and under shallow water, are known today as the Foreshore Tailings Area. This tailings disposal practice was stopped in late 1950 and beginning in February 1951, roaster calcine and flotation tailings were deposited in Bow Lake, located in the area of the current North Pond. The deposited tailings gradually consumed the storage capacity of the natural lake basin, and dams were required to prevent discharge of tailings into Baker Creek and Yellowknife Bay. Dam construction began in 1955 with Dam 1, and continued through the early 1960s with Dams 2 and 3. Together these dams formed the North Pond, as well as the original tailings disposal area (Bow Lake) now underlying the Settling and Polishing ponds (Figure 3.3-1). Construction of Dams 4 and 5 began in the late 1960s, closing off the south end of the area now known as the Central Pond.

Records of dam construction in the 1950s and 1960s are limited and informal, suggesting the dam designs and construction were likely undertaken by mine and company staff. The first documented engineering of tailings dams began in the mid-1970s, with designs for raising Dams 1, 2, and 3 (Geocon 1975). Dam 6 was constructed in 1976, as a simple rockfill structure separating the North and Central ponds. Dam 7 was built in the same year to contain seepage from Dams 4 and 5 on the Central Pond. Dams 9, 10, and 11 were constructed in 1983, and further raised in 1984, to create additional tailings storage capacity. The construction of Dam 11 created the South Pond, on the downstream side of Dams 4 and 5. The Original TCA (North, Central, South, Settling, and Polishing ponds) is retained by a series of dams numbered Dam 1 to Dam 12.

The Northwest Pond was created in 1987 to serve as an impoundment for tailings recovered from the North and Central ponds as well as new tailings from conventional ore processing. When the Northwest Pond was built, the naming convention for the dams changed and the dams were numbered Dam 21 and 22. Tailings were reprocessed in the TRP from 1988 to 1990 to recover gold. The relocation of tailings from the old storage area was discontinued in 1990 when the TRP shut down, while the deposition of new tailings in the Northwest Pond continued until milling operations ceased in 1999.

A storage pond was built in 1969 to store excess roaster calcine for summer re-processing in a kiln plant. The Calcine Pond was located northwest of B1 Pit, in an area now covered with soil. Most of the calcine was removed, but some residual calcine remains in the pond.

Control of arsenic in the mine effluent apparently began in 1957, when Site records indicate that a precipitation circuit was put into service, but details of the treatment and its effects are not known. A new water treatment circuit was commissioned in June 1967, which used lime to precipitate arsenic from the mill tailings stream before it was discharged to the active tailings pond. The precipitated arsenic was co-disposed with mill tailings in the active tailings pond, and the concentration of dissolved arsenic in the mine effluent was reduced.

In 1978, as a condition of a new Water Licence, the Giant Mine owner was required to improve the quality of effluent released to the environment. After conducting pilot testing in collaboration with Environment Canada, a new tailings effluent treatment plant started operating in August 1981; note that up until this time, water pumped from the mine was discharged directly to Baker Creek near C Shaft without treatment. The new plant treated clear water decanted from the tailings ponds and destroyed cyanide by alkaline chlorination. It also precipitated arsenic and some heavy metals through the addition of ferric iron and lime. Gold recovery from tailings effluent with carbon adsorption began in 1984. The chlorination stage of the treatment process was replaced by hydrogen peroxide oxidation in 1990.

The Water Licence requirements led to the storing minewater in the tailings ponds prior to treatment. The addition of minewater to the tailings ponds significantly reduced the available tailings storage capacity. To help manage this problem, in 1985 the NWT Water Board approved the treatment and discharge of minewater directly to Baker Creek via the mill, but this option was never implemented. In 1997, a minewater treatment circuit was installed in the mill, allowing the treated water to be used in the mill process and reducing the consumption of fresh water.

Since 1999, when the processing of ore at the site was discontinued, minewater was pumped to the South, Central, North, and Northwest ponds for storage, and then treated in the existing WTP prior to discharge to Baker Creek during the summer months. Since 2004, minewater from the underground has been pumped to the Northwest Pond before being treated and released. Detailed Site water movements are captured in the Water Management and Monitoring Plan and minewater pumping is outlined in Section 5.1.

3.3.4 Arsenic Trioxide Management History

This section has been adapted from the DAR (INAC and GNWT 2010).

Most of the gold in Giant Mine ore is encased within larger grains of sulphide minerals, principally arsenopyrite and pyrite (Section 3.3.3.3). The roasting process, used to oxidize the sulphide minerals and expose the gold prior to cyanide leaching, produced two major off-gases: sulphur dioxide and arsenic vapour. Initially, the roaster off-gases were vented directly to the atmosphere, with no recovery of arsenic, but gas cleaning equipment was installed in 1951, which lead to the production and disposal of arsenic trioxide dust as a waste by-product and to lower arsenic trioxide emissions.

3.3.4.1 Arsenic Fume Management

At the start of roasting operations in 1949, off-gas management was limited to the provision of a stack for release of gases and particulates to the atmosphere. The operation initially had problems handling the fumes, as they regularly entered the roaster building and numerous worker health problems were reported.

The first study of the effects of arsenic pollution in the Yellowknife area was initiated in May 1949. The results of this study, along with occupational health concerns and roaster operating problems associated with arsenic trioxide condensation, led Giant Mine management to the conclusion that arsenic fume emissions needed to be controlled. For this purpose, an electrostatic precipitator (ESP), also known as the “Cottrell Precipitator,” was commissioned in October 1951, and the first large-scale arsenic trioxide collection program began. The ESP initially operated as a “cold” unit, in which the inlet gas temperature was low enough that the arsenic was present as particulate arsenic trioxide and was recovered from the gas by attraction to charged electrodes, along with very fine gold-bearing calcine dust carried over from the roaster.

The efficiency of the cold ESP dropped dramatically when the first fluo-solids roaster (the No. 1 Dorrco) was installed in May 1952. The fumes from the new roaster had an acid deficiency, which reduced the electrostatic charge on the dust particles and reduced the ESP collection efficiency. The new roaster also produced a greater load of fine calcine dust in the off-gas. The calcine dust not only overloaded the ESP, leading to higher arsenic trioxide emissions, but also resulted in significant loss of gold.

In an effort to recover the calcine dust separately from the arsenic trioxide, a second ESP was installed in February 1955. This “hot” unit operated above the temperature at which arsenic trioxide would condense, and was placed in front of the cold ESP. The system of passing roaster off-gas through the hot ESP first, where calcine dust was recovered, and then through the cold ESP, where condensed arsenic trioxide was recovered, worked quite well. However, the collection efficiency of the cold ESP decreased further due to the additional removal of acid in the hot ESP. Sulphuric acid and water vapour were added to the roaster off-gas in an attempt to increase the acidity in the fumes entering the cold ESP, with limited success. Eventually, both ESPs were operated as cold units to improve the arsenic collection efficiency while additional research was undertaken.

When the second fluo-solids roaster (the No. 2 Dorrco) was commissioned in 1958, and the mill feed was increased to 1,000 imperial tons/d, a baghouse filtering system (known as the “Dracco Baghouse”) was installed to handle the added arsenic trioxide burden. The baghouse began operating in November 1958, as the sole dust collection device in the system. Once the new roaster was operating efficiently, one ESP was put on-stream as a hot unit to remove fine calcine dust in advance of the baghouse. After much experimentation aimed at optimizing the operation of the roaster and dust collection system, which was finally completed in 1963, the original cold ESP

was converted to a hot unit and was put in parallel operation with the other hot ESP. This system, consisting of two hot ESPs operating in parallel, followed by a baghouse, was used until roasting operations ceased in 1999.

3.3.4.2 Arsenic Trioxide Dust Disposal

The scale of arsenic trioxide dust formation and the resulting problems were not anticipated during the initial development of the Giant Mine. When dust build-up in the stack became a problem, the material was periodically cleaned out and, according to mine records, was disposed of "in a suitable area in the North of the property." According to the records, surface disposal of arsenic trioxide dust occurred in July 1949 and February 1950, but the disposal location is not recorded in any of the documents reviewed.

With the first arsenic trioxide dust collection equipment scheduled to be on-line in 1951, the mine operators sought options for storing the dust. Initial investigations focused on the sand plain west of the Yellowknife airport, and on Veronica Lake (now known as Pocket Lake) northwest of the process plant. The sand plain option was abandoned due to a high water table, and the Department of National Health and Welfare (the responsible regulatory authority) would not consider the Veronica Lake option until more information was available. The time restrictions were such that sufficient environmental data for the proposed disposal area could not be collected before the arsenic trioxide recovery plant went into operation.

Other options being explored at the time included storage in tanks on surface and underground storage. In a letter dated 21 July 1950, the Department of National Health and Welfare stated that it regarded the use of concrete vats on surface as the safest method of storage. However, it also stated that it did not want to cause the mining companies unnecessary expense and, therefore, would agree to other storage proposals provided certain criteria were met. The criteria were that the storage would last indefinitely and that a large capacity could be obtained at an economic cost.

Surface storage methods that were considered included wood, steel, and concrete tanks. Wood and steel failed to meet the requirement of an indefinite life span. Concrete tanks were long lasting, but the required storage capacity was such that a continuous construction program would be required to keep up with the anticipated dust production. It was felt that the amount of form lumber, steel, and cement required would result in an excessively high cost.

An area of ground near the new arsenic recovery plant was selected as a potential underground arsenic disposal area and was tested for ground stability and the presence of permafrost. Although it is not stated explicitly in the documents available from that time, it is clear that permafrost was to be the principal means by which the arsenic storage areas were to be kept dry in order to prevent the dissolution of arsenic in groundwater. Testing of the ground was conducted by drilling exploratory holes from the 250L and from surface. From this drilling, it was determined that permafrost was present from above the 100L to below the 250L; that is, from 100 feet below surface to more than 250 feet below surface. Temperatures in two holes at the 250L were -0.5°C and -0.4°C. The drilling program also showed that there was not excessive fracturing in the rock.

In February 1951, the Mine Manager sent a letter to the federal Department of Resources and Development, in which all the storage options were reviewed, and permission was requested to use underground storage for the arsenic trioxide dust. In the letter, the Mine Manager stated that the proposed storage area was located in permafrost and further noted that while active mining tended to thaw the surrounding walls, frozen conditions returned within a few hours after work was completed. Ice conditions in the closest working stope (B208) were presented as supporting evidence.

The first arsenic storage chambers were located close to the arsenic recovery plant, in the strata from 100 feet through 250 feet below surface, identified as the permafrost zone. This area contained low-grade ore and was mined for gold recovery. Arsenic trioxide disposal began in this area in October 1951 and continued until 1962, by which time five storage chambers had been excavated and there was little space left for new excavations located close to the baghouse, in permafrost ground. The dust was transported pneumatically from the roaster into the underground chambers.

Arsenic trioxide disposal then switched to the early ore production stopes that met the storage criteria, and were now empty, beginning with the B208 stope. Mined-out stopes had the advantage of requiring less preparation time than purpose-built dust storage chambers and, therefore, had a lower development cost. In applying for approval to use the mined-out stopes B208, B212, B213, and B214, the mine company emphasized that these areas were dry and located in the same horizon as the existing disposal stopes. Ice crystals were observed in B208, but not in B212. To counter the argument that the warm dust would make any permafrost recede, freezing air was to be circulated in all arsenic storage stopes during the winter months to maintain permafrost in the surface crown pillar, thereby preventing water inflows to the stopes.

In 1966, while considering a proposal for the development of new storage capacity, CIRNAC mining inspectors recognized that permafrost had receded in mine areas that were well ventilated. CIRNAC questioned whether permafrost was still present at the upper stope level, noting that the proposed new storage area close to C Shaft was located under Baker Creek, and some of the insulating material had been removed by earlier development. CIRNAC agreed that the mined-out C212 stope appeared to be a suitable area for arsenic trioxide disposal (it was within the permafrost zone), but requested that rock temperature data be collected to verify that the stope was in permafrost. CIRNAC objected to the disposal of the dust in stopes located below the lower level of the permafrost zone. Although the mine claimed that these stopes were dry, CIRNAC questioned whether they would remain dry if the permafrost in the surface bedrock and overburden became fragmented.

In a memorandum of May 1973, the Mine Inspector expressed concern regarding the potential for arsenic pollution from the Giant Mine if it were to be flooded after a shut-down proposed for 1975 and permafrost was not present. The Mine Inspector presented evidence of permafrost thawing in other mine workings to depths of at least 50 feet, and clearly questioned the continued presence of a permafrost zone at the Giant Mine. He recommended that the mine should not be allowed to flood until the extent and permanency of the permafrost was established through a long-term rock temperature monitoring program. Such a program was not established until the mid-1990s, when temperature measurement devices were installed in several new drill holes.

In 1977, the Canadian Public Health Association (CPHA 1977) Task Force on Arsenic was established to assess the effects of arsenic emissions on the population of Yellowknife. The terms of reference for the Task Force included the review of existing data, the identification of any additional data required, and the task of ensuring that such data were obtained. The Task Force was to recommend any remedial action required to address the issue. The Task Force report, published in December 1977, examined the potential effects in the Yellowknife population of arsenic exposure from soil, water, food, and air, as well as occupational exposure (CPHA 1977). The report made recommendations on issues ranging from food hygiene practices to industrial emissions control measures. With respect to arsenic trioxide management, the report recommended that underground storage of the arsenic trioxide dust at the Giant Mine should continue, pursuant to requirements specified by the Mining Inspection Branch.

By the end of the 1970, there was strong observational evidence that permafrost in the arsenic storage areas was receding and the movement of groundwater in these areas was increasing. The loss of originally present permafrost may have been caused by the progressive development of mine workings near the storage areas and the movement of warm ventilation air. This would have been accelerated by the development of open pits in the area, which removed insulating overburden from the surface.

All former production stopes suitable for arsenic trioxide disposal were filled by 1976. During the 1970s, greater emphasis was placed on maximizing the amount of dust storage in existing stopes to avoid developing new storage areas. Older storage stopes were “topped up” as the dust consolidated over time. The possibility of mechanically compacting the material before it was placed in the stopes was investigated. It was also anticipated that future production of dust could be sold, and the mine investigated the purification of arsenic trioxide for sale, which began in 1981. More efficient use of existing storage space did not stop the development of new storage. A new purpose-built chamber, Chamber 9, had to be rapidly excavated in 1976 to keep up with dust production.

Raw arsenic trioxide dust from the baghouse was sold to Koppers, a manufacturer of pesticides located in Georgia, USA, from 1981 to 1986. The amount of dust sold was less than the ongoing dust production, and underground storage continued throughout the 1980s with the development of Chamber 10, near C Shaft, and later Chambers 11 and 12 in a new area adjacent to B2 Pit. A downturn in the arsenic trioxide market, and introduction of stricter waste disposal regulations in the USA in the mid-1980s, led to the termination of sales of low-grade arsenic trioxide dust produced by the baghouse.

At this point, it became clear that the arsenic trioxide baghouse dust could only be sold in the future if it were purified; this would require a new process. This option was actively pursued and investigated by the mine owner in the late 1980s, culminating in the detailed feasibility study of an upgrading project, known as the WAROX Project (named after the acronym for the registered trade name White ARsenic OXide). The WAROX Project would use a fuming process to purify dust from the underground storage areas to greater than 95% arsenic trioxide and recover gold from the fuming residue. Interest in implementing the project was lost when the property was sold to Royal Oak Resources in 1990. Chambers 14 and 15 were excavated for arsenic trioxide disposal in the 1990s. Chamber 15 had not been commissioned by the time on-site ore processing ceased in October 1999 and remains empty to this day.

Until the 1980s, the standard procedure in the development of dust storage areas was to cut off the ventilation of warm air and to blow cold air through the chamber or stope during the winter prior to first use to re-establish the permafrost. It was concluded that permafrost was in place if ice or frost was visible on the walls. From the mid-1980s onward, the criteria for selecting suitable areas for development of storage chambers no longer included the presence of permafrost. An area was considered suitable if the rock was competent, the area could be effectively sealed off from other mine workings, and the excavation was generally dry before dust storage commenced. The last four chambers (11, 12, 14, and 15) were excavated partially above the elevation of the original permafrost zone. In the minutes of a meeting held in December 1995, the Mine Captain noted that in the regular inspections he conducted since 1986, ice was never observed in any of the arsenic chambers or stopes.

All of the underground excavations used for storage of arsenic trioxide dust are listed in Table 3.3-2, along with the year of their commissioning. The excavations are identified either as purpose-built chambers or mined-out stopes.

Table 3.3-2: Underground Arsenic Trioxide Dust Storage Excavations

Excavation Identification	Excavation Type	Year of Commissioning
B230	Chamber	1951
B233	Chamber	1952
B234	Chamber	1956
B235	Chamber	1958
B236	Chamber	1958
B208	Stope	1962
B212 / B213 / B214	Stopes	1965
C212	Stope	1973
9	Chamber	1976
10	Chamber	1982
11	Chamber	1986
12	Chamber	1988
14	Chamber	1995
15	Chamber	Not used for arsenic trioxide dust storage during production mining; proposed for storage of arsenic-contaminated material during remediation

Source: Adapted from INAC and GNWT 2010.
Note: Map and further information is located in Section 5.1

Between 1949 and 1999 ore was processed at the Roaster Complex, was located in the present day core infrastructure area of the mine. The Roaster Complex was the group of buildings with associated infrastructure whose purpose was to separate the gold from the ore and treat the air emissions to reduce the release of arsenic trioxide into the atmosphere. The Roaster Complex expanded over time as more efficient technologies became available and were incorporated into the process train. The Roaster Complex footprint was approximately 7,800 m^2, and included the following primary structures:

- AC Roaster Building
- Calcine Plant
- Dorrco Roaster Building
- Cottrell Precipitator Building
- Baghouse Building
- Silo
- Weight Scale House
- Stack Fan Building
- 46 metre tall brick Exhaust Stack
- Exterior flues and other ancillary infrastructure

The Roaster Complex was known to contain free and poorly contained arsenic-containing dust, asbestos, cyanide and other hazardous substances. A waste audit of the Roaster Complex was completed in 2012 by AECOM (AECOM 2012). This audit identified the complex as containing large amounts of arsenic dust as described below:

- arsenic dust was contained in the kilns, tanks, reactors, exhaust stack and air handling infrastructure and present on building internal surfaces
- material with arsenic dust and asbestos was present within the complex and on internal building surfaces
- porous structural materials were impregnated with hazardous levels of arsenic
- cyanide compounds were present in some buildings mixed with arsenic in some process vessels, and asbestos in surface dust
- arsenic dust had accumulated inside the stack. The interior surface of the brick stack was also coated with arsenic trioxide dust or scale

In addition to the arsenic material in the Roaster Complex, arsenic waste was also identified in the Mill Building. Further discussion of these materials is provided in Chapter 4.0 and Section 5.1. The historical roasting operations not only created soluble arsenic dust that contaminated buildings and process equipment, the historical roasting operations also resulted in elevated levels of arsenic rich contaminants in the shallow soils adjacent to the Roaster Complex. Approximately 52,000 m^3 of heavily impacted granular fill materials are centered around the Roaster Complex. Forensic mineralogy studies suggest an oval shaped pattern of arsenic particle fallout from the roasting process surrounding the former roaster stack; this pattern defines a “near stack” zone approximately 1 km in radius, this is discussed further in Section 5.4.

3.3.5 Historical Impacts of Mining on Indigenous Peoples

This historical mining and the deposition of arsenic emissions from the Giant Mine have had significant impacts on the Indigenous people in the area through direct health impacts, impacts on the environment where they lived, and changes in the way of life. Fully dimensioning the extent of effects of the Giant Mine on Indigenous people in the area is outside the scope of this document; however, some key effects are highlighted below.

In their study of the historical impacts of the Giant Mine on public health and the environment, Sandlos and Keeling (2012) concluded that “Many Yellowknives Dene remember the advent of mining and arsenic pollution as central to their experience of colonialism and alienation from lands that had once supported them through subsistence hunting, trapping, and gathering activities.” As indicated in Section 3.3.4.1, roasting activities with the associated emission of arsenic started in 1949. Arsenic was emitted to the surrounding areas, resulting in the documented death of at least one Dene child from acute arsenic poisoning on Latham Island in 1951 (Sandlos and Keeling 2012). Oral histories suggest that there may have been other undocumented deaths, as well as local livestock deaths (YKDFN 1997). While notices were printed in the Yellowknife newspapers warning people not to use or drink meltwater, these warnings did not necessarily reach local First Nations groups.

Arsenic emission continued, at reduced rates, after the commissioning of the ESP in 1951. Arsenic has affected soils, surface water, sediments, and wildlife in the vicinity of the Site, with concentrations well above background levels (e.g., Hocking et al. 1978; Hutchinson et al. 1982; Houben et al. 2016; and Chapter 2 of this document). Several of the studies demonstrated effects that could be expected to have negative health impacts, especially for Indigenous peoples in the area who relied on the water, vegetation, and wildlife for sustenance. Moving

Yellowknife's water supply intake in 1969 to avoid impacted waters in Yellowknife/Back Bay did not necessarily benefit the Indigenous peoples living on Latham Island and in Dettah, some of who continued to rely on water collected from this area. While epidemiological information is limited, documentation of arsenic effects on the health of Indigenous peoples does exist (as summarized in Sandlos and Keeling 2012) and more localized studies in Yellowknife are forthcoming as required by Measure 9 (see Chapter 1 or MVEIRB 2013).

Traditional land use by the Tłı̨chǫ, Akaitcho, and Métis on lands currently within the project boundary have been restricted by mining and care and maintenance activities since development of the Giant Mine began. These uses included travelling, camping, and harvesting fish, berries, and wildlife. Significant restrictions on land use are likely to persist even with planned remediation activities.

Beyond the effects of arsenic, mining activities also resulted in other effects on the community. Mining activity and associated developments in the Yellowknife area (not exclusively attributable to the Giant Mine) resulted in changes in wildlife land use and migration patterns, affecting the livelihood of the Indigenous peoples in the area who relied on them. Mining also brought "outsiders" to the community and changed the social and economic conditions of the area. Some—but not all—transitioned to the new economy, finding work at the mines. In the EA process for the Site, local Indigenous people described fear and anxiety about arsenic from historical activities and from proposed clean-up activities (MVEIRB 2013). These concerns helped shape the approach to the CRP—to reduce contaminants to the environment in as safe a manner as possible with improved integration of the local Indigenous and Traditional Knowledge into closure planning and assessment.

3.4 Summary of the Closure and Reclamation Plan Activities

The previous sections discussed the existing conditions and history for the Giant Mine Site. This section provides an introduction into the project components, and subcomponents, which are to be addressed during the remediation of the Site. The planned closure and reclamation works have been grouped under 10 main project components as follows:

1) underground mine workings
2) freeze program
3) open pits
4) contaminated soils and sediments
5) Baker Creek and surface water drainage
6) Tailings Containment Areas
7) borrow material
8) water treatment plant and outfall systems
9) buildings and site infrastructure
10) landfill

The above elements are outlined in Table 3.4-1. including a description of the project components, current status of the component in the context of the ongoing care and maintenance phase, key closure issues associated with the component (or subcomponent), and a brief outline of the proposed closure and reclamation plan for the components. The final site conditions after remediation of these project components is shown in Figure 3.4-1.

Table 3.4-1 has been presented to match the content of Chapter 5, which contains detailed descriptions of each component such as the full details of the closure activities, uncertainties, monitoring/maintenance reporting needs, and plans for addressing contingencies. A brief summary of the overall waste management strategy is provided in Figure 3.4-2. Additionally, an outline of the project schedule is found in Chapter 6. Description of the post-closure site assessment is found in Chapter 7.

Table 3.4-1: Project Summary

Project Component	Overall Care and Maintenance Status Entering Remediation	Subcomponent	Key Closure Issues	Closure and Reclamation Plan
Underground mine workings (Section 5.1)	• A Site Stabilization Plan is in place to address stability concerns. • Arsenic stopes and chambers are monitored. • The mine dewatering system is in operation. • Backfilling of selected stopes has been completed to address most critical concerns (site stabilization program, four non-arsenic and two arsenic stopes). • A full-scale test of thermosyphons on Chamber 10 (Freeze Optimization Study) has been completed. • Regular maintenance of ground support systems in the access drifts and openings is performed. • Power systems, communications, support services (e.g., compressed air and water), ventilation, and mine safety infrastructure (e.g., refuge stations and general worker safety programs) are maintained.	Void stabilization	• Stability of some voids is marginal and poses risks to public and worker health and safety.	• Selected voids will be stabilized by backfilling in support of pit floor stabilization needs or protection of closure infrastructure. • Backfill drifts connected to arsenic stopes and chambers to protect bulkheads. • Openings to surface will be closed by filling, plugging, and capping.
			• A final disposal location is needed for arsenic-impacted material stored in containers (“sea-cans”).	• Containerized roaster and process waste will be disposed of underground and in B1 Pit, in future frozen zone. • Heavily contaminated soils from the roaster area will be disposed of underground in a future frozen zone or in B1 Pit.
		Minewater level management	• Groundwater inflow could result in the transport of arsenic dust into the minewater pool. • Control of minewater level will require pumping during the 20-year Water Licence period.	• Ongoing pumping and treatment of minewater will be carried out to maintain minewater below the 750L (-77 m amsl). • The new minewater supply well will be located near the C Shaft area by approximately 2026 (five years into the Water Licence period) which will replace the Akaitcho interim deep well pumping station. • Minewater will continue to be discharged to the Northwest Pond and treated using the existing ETP (summer only) until the new WTP is commissioned. The new WTP will release treated effluent year-round. • The Northwest Pond will be dewatered to the underground mine. • During this Water Licence period (2020 to 2040), the minewater level may be raised. The benefits and risks of a possible minewater raise to the underground are being studied through a Reclamation Research Plan. The Water Management and Monitoring Plan would be updated and sent for review to affected parties and for final MVLWB approval should a raise in the level of water in the mine be proposed. • Establish new long-term underground mine access location.
Freeze program (Section 5.2)	• Freeze optimization study performed on Chamber 10 to inform design for arsenic containment	Arsenic chambers and stopes (areas AR1, AR2, AR3 and AR4)	• Arsenic dust is present in underground chambers and has the potential to impact human health and the environment.	• Freeze the bedrock or fill around each arsenic containing chamber, stope, drift or pit fill using thermosyphons installed in boreholes to develop the frozen shell with ongoing monitoring of temperatures. • Chamber 10 (Freeze Optimization Study) requires additional work to convert to a fully passive system and achieve freeze containment. • Monitoring and modelling will further refine the estimated initial freeze completion dates.

Open pits (Section 5.3)	• Safe access is maintained to B2 and B3 pits (principal underground access portal).
	• Access control is in place for pits with no safe access.
	• Brock Pit is now a quarry.
			• Public health and safety is a concern (falls, unsafe access, subsidence of pit base).
			• There is a risk of flooding (sudden filling due to creek flooding, with impacts on minewater level, pit stability).
				• Pits will have a combination of clean rock and contaminated material placed in them:
				  • A2, C1, B2, and B3 pits will have quarried rock borrow material placed, some of which will come from recontouring the slopes above A1 and A2 pits.
				  • A1 Pit and the non-frozen portions of B1 Pit will have contaminated granular fill material placed.
				  • Contaminated granular fill will be placed in B2 Pit, if additional capacity is required.
				  • The frozen portions of B1 Pit will be filled with a combination of heavily contaminated granular fill, possibly some containerized roaster wastes, and contaminated granular fill required for grading.
				  • B4 Pit will be recontoured or partially backfilled with borrow material.
				• Some pits will require underground stabilization activities to permit safe material placement. These activities will be defined on a pit-specific basis and will depend partly on the backfill material(s) selected.
				• Openings to surface inside will be closed by filling with rock or plugging with cemented paste.
				• Pits will be fully or partially filled and may include berms to divert water. Scour protection will be provided for water courses, berms, diversions and vulnerable topography.
				• Drainage patterns will be designed through surface grading and possible use of a cover to shed water.

Table 3.4-1: Project Summary

Project Component	Overall Care and Maintenance Status Entering Remediation	Subcomponent	Key Closure Issues	Closure and Reclamation Plan
Contaminated soils and sediments (Section 5.4)	• Ongoing work in the care and maintenance (C&M) period has resulted in characterization of both the nature and extent of soil and sediment contamination. This information has been used to develop plans for management.	Soils	• Arsenic and PHC contamination of soils due to past mining operations has resulted in soil with concentrations in excess of applicable standards. Remediation is required to meet these standards.	• Heavily contaminated granular fill from the mill/roaster area will be disposed of in the frozen portion of B1 Pit or within another suitable frozen zone. • Contaminated granular fill will be placed within A1 and B1 pits and TCAs. • Contaminated fine-grained soil will be disposed of in TCAs. • PHC contaminated soil will be disposed of in TCAs. • Tailings-impacted fine-grained soil downgradient of Dam 3 will be placed within the TCAs. • Excavated areas will be backfilled with borrow material and graded. • Engineered soil covers will be constructed in areas where contaminated materials remain at a depth significantly greater than 2 m (e.g., Mill Pond, former Calcine Pond, and Area 4). • A fence will be built to surround the core area of site, surrounding area of primary roaster stack deposition.
		Sediments	• Sediments in surface waterbodies may impact water quality and aquatic life.	• Tailings located in historical Jo-Jo Lake will be removed and placed in the TCAs. • Contaminated sediment from Baker Creek Reaches 0 to 6 will be removed to the extent practicable and placed in the TCAs. • Contaminated sediment located along the shoreline of Yellowknife Bay, adjacent to the Townsite/Marina and Shoreline Lands, (i.e., nearshore sediment), will be partially excavated and placed in a TCA and/or capped with an engineered cover.
Baker Creek and surface water drainage (Section 5.5)	• Baker Creek is the principal surface water feature on the site. • Surface water on site is subject to ongoing monitoring of quality and levels. • Surface water from Baker Creek is prevented from entering B2 Pit via the B2 Pit dam. This dam was reconstructed in winter of 2008 and is regularly monitored and inspected. • On-site water contacts site features such as the TCAs and pits, and is currently pumped to the Northwest Pond and treated prior to release.	Baker Creek	• Adequate channel and flood plain dimensions need to be maintained to mitigate the risk of underground flooding. • There is a risk that contaminated sediments in Baker Creek could impact water quality.	• Baker Creek will remain on site. Channel and flood plain design of Baker Creek will accommodate the PMF. The plan includes realignments of several reaches to provide adequate channel and flood plain dimensions and to mitigate the risk of underground flooding. • To maintain long-term stability of the channel materials, a seepage barrier is planned between Baker Creek and the subgrade below. Floodplain fill material, if needed, would be composed of coarse rockfill, over which active channel fill material would be placed. • Fish habitat will be replaced in Baker Creek; pending consultation with affected parties and Fisheries and Oceans Canada. • Contaminated sediments will be removed and disposed of in the TCAs.
		Site-wide site surface drainage	• Site runoff (from areas such as covers) should be suitable for discharge to the environment. Site runoff will include both contact water and non-contact water.	• Runoff water from engineered structures will be collected and treated prior to discharge. Once runoff from engineered structures has been confirmed to meet runoff water quality criteria drainage patterns will be established to allow release directly to the environment. • Infiltration through reclaimed facilities will continue to flow to the underground. • Camp water and sewage will not be permanently stored on site. • Additional passive surface water treatment systems, such as wetlands may be installed on site in low flow areas but further research into this is required and is being considered through a Reclamation Research Plan.

Table 3.4-1: Project Summary

Project Component	Overall Care and Maintenance Status Entering Remediation	Subcomponent	Key Closure Issues	Closure and Reclamation Plan
Tailings Containment Areas (Section 5.6)	• There are over 20 dams on site, including dams that are used to retain tailings, as well as dams that have a role in water management. • All dams are inspected annually by a licensed geotechnical engineer, with regular inspection and monitoring of critical dams by the site C&M operator. • Dam 1 was raised by 1.5 m. • Dam 21D was raised by up to 0.6 m. • Reconstruction work on the B2 Dam was carried out. • The M&M dam was constructed. • The splitter dyke was rehabilitated. • The containment berm was constructed.	Northwest, North, Central, and South ponds	• Tailings generally contain elevated concentrations of arsenic and can impact human health and the environment, either through direct contact or through impact on water quality. • Tailings are fine grained and subject to erosion.	• South Pond tailings will be relocated into the remaining Original TCA, reducing the overall TCA footprint. • Dam 11 will be decommissioned as part of the relocation. Dam 7 will remain for surface water control until it can be demonstrated that surface water is suitable for direct discharge, at which time the dam will be decommissioned. • TCAs will be regraded and covered with a low-flux cover, consisting of a geosynthetic liner overlain by a protective bedding layer and rockfill, ensuring that surface runoff from the TCA area will be non-contact water, reducing infiltration to the tailings, and meeting expectations for the aesthetics of the closed facility. • Surface grading of the TCAs will allow discharge to spillway points. Re-grading will be undertaken as necessary to achieve this. • Contaminated soils and sediments will be placed in the tailings facilities, under the low-flux cover. This material will assist in establishing positive gradients over each TCA. • Tailings will be used for the generation of paste backfill for the underground remediation activities. Staging of cover placement will take into account this interaction.
		Tailings Foreshore Area	• Erosion and re-suspension of tailings in the Foreshore Area, human contact with tailings	• Tailings in the Foreshore Tailings Area will be capped.
		Dams	• Dams are subject to erosion and change over time. Dam instability can result in loss of dam function (water or tailings retention) with impacts beyond the current dam limits.	• Dam stability will be reviewed, and improvements or regrading will be undertaken as required. • An Engineer of Record will be responsible for inspection of dams, with annual dam safety inspections conducted. • Periodic dam safety reviews will be conducted in accordance with Canadian Dam Association recommendations.
		Settling and Polishing ponds	• Issues are similar to those for the TCAs.	• The Settling and Polishing ponds will be drained and covered with a low-flux cover, as per the TCAs. This will be done after the commissioning of the new WTP. Runoff from the Settling and Polishing ponds will be collected, tested and treated if necessary. Once runoff is confirmed to meet runoff quality criteria it will be routed directly to Baker Creek.

Borrow material (Section 5.7)	• Work during the C&M phase has included preliminary characterization and quantification of potential sources.	Rock quarry areas	• Final closure will require rock and fine-grained soils for the construction of covers and other closure activities (including pit filling). Fill will be required for:
			  • covers for TCAs and other areas
			  • pit fill
			  • freeze pad granular fill
			  • foundations for new structures
			  • landfill
			• Rockfill is required for pit backfilling and for construction of the covers on reclaimed areas.
				• Final rockfill volume requirements will be confirmed as part of detailed design. Preliminary calculations put requirements on the order of 3.6 million m^3.
				• Each borrow area will be designed in accordance with clearly defined project needs, factoring in material volumes generated by other site activities (e.g., recontouring slopes for safety reasons, spillway for the Northwest Pond).
				• The volume of rockfill to be developed from borrow sources will be minimized through use of rockfill generated by other site activities such as spillway construction.
				• Stockpiles of fine- and coarse-grained material will be used for site closure activities such that new borrow volumes are reduced.
				• Potential quarry locations were identified within the project boundary in areas that do not impact culturally sensitive areas. Surficial material may need to be handled as arsenic-impacted.
				• Quarry areas will be constructed with side slopes compatible with surrounding topography, with consideration of site-wide drainage.

		Borrow areas (fine-grained soil)	• Fine-grained soils are required as a component of cover designs (for protection of geosynthetic materials).	• Final fine-grained soil volume requirements will be confirmed as part of detailed design. • Potential borrow locations were identified within the project boundary. Surficial material may need to be handled as arsenic-impacted. • Following excavation of the borrow area, the surface will be graded.

Table 3.4-1: Project Summary

Project Component	Overall Care and Maintenance Status Entering Remediation	Subcomponent	Key Closure Issues	Closure and Reclamation Plan
Water treatment plant and outfall systems (Section 5.8)	• The existing ETP is operated seasonally during non-frozen months. • Minewater is accumulated in the Northwest Pond, treated at the ETP, and discharged to the Settling and Polishing ponds prior to final discharge to the environment.	Existing ETP	• Minewater is not suitable for direct discharge to the environment. Water treatment is needed for the full closure period to improve water quality.	• Interim operation of the ETP will continue to treat water from the Northwest pond. • The existing ETP will be decommissioned and removed after the new WTP is commissioned.
		New WTP		• A new WTP will be constructed and will be located in central core near the C Shaft. • Minewater will be pumped directly to the WTP from the underground near the C Shaft area. • The new WTP will be commissioned and operated to treat minewater to meet the effluent quality criteria • WTP process residuals will be collected and disposed as non-hazardous waste in the on-site landfill, or disposed of off site.
		Outfall	• Impacts from discharge of treated water need to be minimized.	• Treated water will be discharged year-round via a nearshore outfall in Yellowknife Bay, in the vicinity of Baker Creek. • Engineering controls will be in place at the outfall pipe location to prevent sediment scour and remobilization.

Buildings and site infrastructure (Section 5.9)	• Some buildings and site infrastructure are used in support of ongoing C&M activities. These are fully maintained.
	• The remaining buildings and site infrastructure have restricted access and are awaiting deconstruction.
	• Some structures have been demolished and removed from the site during the C&M period. Non-hazardous and arsenic wastes have been stockpiled on site awaiting final disposal.
		• Buildings and structures
		• Transport network
		• Utilities
		• Debris and waste storage areas
		• Existing waste disposal locations
			• Buildings, site infrastructure, and debris areas left on site pose a risk to humans and the environment due to physical and chemical hazards, e.g., health risks due to the presence of contaminants such as arsenic, asbestos, and lead paint or stability issues from building collapse.	• Buildings and site infrastructure with no future purpose will be decommissioned, demolished, and disposed of.
				• An abatement program will be undertaken to verify appropriate handling and disposal of hazardous wastes generated, including asbestos, arsenic-impacted materials, polychlorinated biphenyl (PCB), mercury-containing items, paint products, petroleum products, and process chemicals.
				• All hazardous wastes from building and infrastructure will be disposed off site in approved facilities. Non-hazardous waste will be disposed of on site in the landfill.
				• New site infrastructure present on site after implementation of closure works will include:
				  • New WTP and Freeze instrumentation building
				  • Fencing, signage, and security
				  • Transport network including bridge over Baker Creek
				  • Utilities to support ongoing operations, maintenance, and monitoring

Landfill (Section 5.10)	• Non-hazardous waste generated on site during C&M is stored within the Northwest Pond. Addressed in Section 5.9.
	• A hazardous waste storage facility is located in the Northwest Pond. Addressed in Section 5.9.
			• Non-hazardous demolition debris and site waste will be generated as part of closure activities. A safe, secure facility for the final disposal of this material is required.
			• Residuals generated from the new WTP will required disposal.
				• A landfill for non-hazardous material will be built within the fenced area. The selected location is in the developed area east of the existing C Shaft area, providing a location away from natural bodies of water, flood plains, and public roads.
				• The landfill will consist of two cells
				  • A non-hazardous waste cell, this cell has been designed with 100,500 m3 capacity, with a 25,500m2 area and a height of 8.5 m. This cell will be closed and covered at the end of active remediation phase.
				  • A WTP process residuals cell. This cell has been designed with 25,700 m3 capacity, with a 7,500 m2 area and a height of 8.5 m.
				• Surface water runoff will be captured and treated during active remediation. Once it is confirmed that runoff meets runoff quality criteria It will be routed directly to the environment.

ETP = effluent treatment plant; WTP = water treatment plant; L = level; MVLWB = Mackenzie Valley Land and Water Board; TBD = to be determined; TCA = Tailings Containment Area; C&M = care and maintenance

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Trapper Lake
Shot Lake
Yellowknife River
Gar Lake
Trapper Creek
4
Baker Creek
Pocket Lake
FORMER TAILINGS AREA (TYPICAL)
FORMER SOUTH POND
FREEZE PAD (TYPICAL)
NEW WATER TREATMENT PLANT
LANDFILL
FORMER PIT (TYPICAL)
Baker Creek
Handle Lake
Yellowknife Bay
OUTFALL

LEGEND

- GIANT MINE PROJECT BOUNDARY
- BREAKWATER
- FENCE
- HIGHWAY
- POST-CLOSURE ROAD
- POST REMEDIATION BAKER CREEK ALIGNMENT
- WATERCOURSE
- APPROXIMATE FORESHORE TAILINGS COVER
- APPROXIMATE LIMIT OF UNDERGROUND WORKINGS
- APPROXIMATE SHORELINE CAP
- CAPPED WITH ENGINEERED COVER
- CLOSED PIT
- CORE AREA
- EXCAVATED SPILLWAY
- FORMER TAILINGS AREA
- FREEZE PAD
- HERITAGE BUILDING
- NON-HAZARDOUS WASTE LANDFILL
- POSSIBLE BORROW SOURCE SITE
- RECLAIMED POND
- TOWNSITE AND SHORELINE
- TREATED EFFLUENT OUTFALL LOCATION
- WATER TREATMENT OUTFALL PIPE
- WATER TREATMENT PLANT

0 250 500
1:20,000 METRES

NOTES
SOUTH POND WILL BE REMOVED BY 2040.

REFERENCE(S)
HYDROGRAPHY AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROPONENT
Crown-Indigenous Relations and Northern Affairs Canada
Relations Couronne-Autochtones et Affaires du Nord Canada
Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-02-01
DESIGNED	SF
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

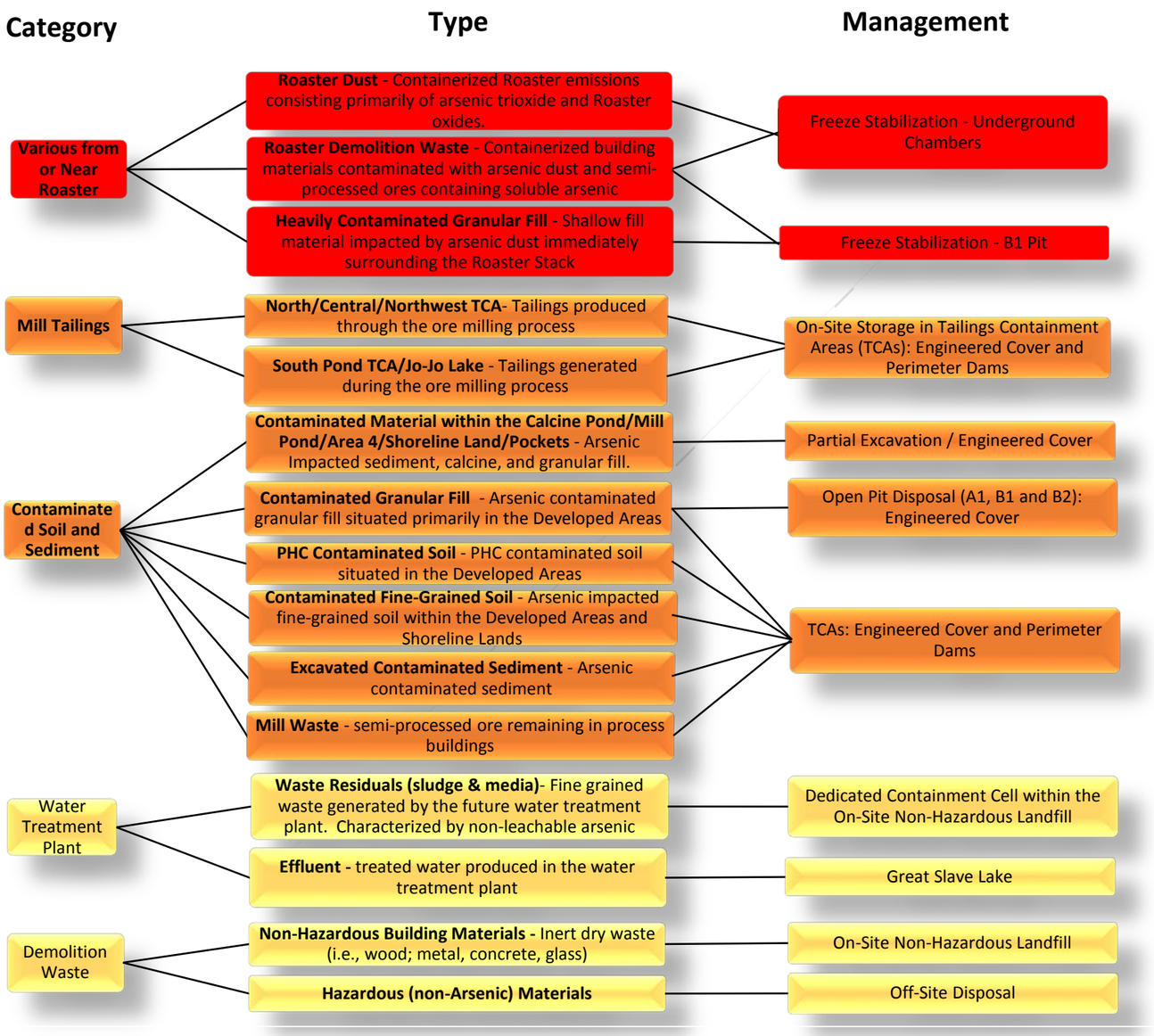
PROJECT
Giant Mine Remediation Project

TITLE
GIANT MINE POST-CLOSURE

REV. 0
FIGURE 3.4-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm
0

Figure 3.4-2: Giant Mine Remediation Project Summary of Waste Strategy



CHAPTER 4
Progressive Reclamation to 2018

4 PROGRESSIVE RECLAMATION TO 2018

As outlined in Chapters 2 and 3, the Giant Mine has been in care and maintenance since 2005. Since entering care and maintenance, activities have been carried out where practical, or where urgently needed to address specific site issues. This is collectively grouped in this section as 'progressive reclamation' for ease of reference.

As per the Closure Guidelines (MVLWB/AANDC 2013), the definition of progressive reclamation applied at the Site is as follows:

> *Progressive reclamation takes place prior to permanent closure to reclaim components and/or decommission facilities that no longer serve a purpose. These activities can be completed during operations with the available resources to reduce future reclamation costs, minimize the duration of environmental exposure, and enhance environmental protection. Progressive reclamation may shorten the time for achieving closure objectives and may provide valuable experience on the effectiveness of certain measures that might be implemented during permanent closure.*

Between 2005 and 2018, activities were carried out at the Site that meet the definition of progressive reclamation (INAC and GNWT 2010). The principal activities that occurred since 2006, when the EA for the closure was submitted, were as follows:

- Site Stabilization Program (SSP) including the Roaster Complex deconstruction (2013 to 2015) and underground stope stabilization (2013 to 2015, 2017, and 2018)
- C Shaft headframe deconstruction (2015)
- A Shaft headframe deconstruction (2016)
- Akaitcho interim deep well pumping station; pump upgrade and improved pump reliability (2018 to 2019)
- ETP upgrades (2015)
- C1 Pit buttress installation (2015) and other stabilization works
- Baker Creek Reach 4 relocation (2006) and other improvement to surface drainage (2002 and 2003, 2006)
- rehabilitation of the B2 Dam which separates Baker Creek from B2 Pit (2007)
- demolition of fuel storage tanks and small buildings (2006-2008)
- re-containerization of arsenic wastes stored in Northwest Pond hazardous waste storage location (2015)
- waste collection programs to disposal of lead-acid batteries, electrical capacitors, electrical transformers, polychlorinated biphenyl (PCB) dielectric fluids, waste oils and fuels, and remaining ore process chemicals (2015-2017).

These activities have helped to advance closure of the Giant Mine, as well as provide relevant experience to inform future closure and reclamation activities. Many of these activities have helped to maintain the integrity of the site, allowing ongoing care and maintenance activities, as well as allowing for the safe completion of remedial design assessments, underground stabilization works, and site monitoring activities. The progressive closure activities were carried out with appropriate approvals, such as the Water Licence for the SSP, Land Use Permits for the SSP, Development Permit, and *Fisheries Act* Authorizations. Details on regulatory considerations are provided in Section 1.5 and Section 3.

The principal programs and projects that were completed following the submission of the EA in 2010 are summarized in this chapter. Numerous engineering and scientific studies were carried out in support of developing the final closure and reclamation solutions. These studies are identified throughout this CRP, typically in Chapter 5 as part of the development of the selected closure options. In parallel with these studies, many activities were conducted as part of the ongoing care and maintenance of the Site. These activities are necessary for the safe operation of the site, but do not necessarily advance it toward closure.

4.1 Site Stabilization Program

In 2013, a Type B Water Licence was obtained for the SSP (MV2012L8-0010). This program included two major projects, which consisted of the Roaster Complex deconstruction program, and the underground stabilization of five arsenic-trioxide containing stopes and assessing general geotechnical stability at the Site. Two Land Use Permits (MV2016S0016 and MV2017X0030) were also obtained for this work. In 2017, the Water Licence and Land Use Permits were amended to allow installation of two deep well submersible pumps in the Akaitcho area (Akaitcho interim deep well pumping station project). The purpose of this work was to eliminate the need for workers to access the existing pumps underground and reduce health and safety risk.

4.1.1 Roaster Complex Deconstruction

Between 2013 and 2015, the decontamination and deconstruction of the roaster buildings were completed.

The Roaster Complex was known to contain free and poorly contained arsenic-containing dust, asbestos, cyanide, and other hazardous substances. The buildings had been locked up and not maintained since 1999. Structural assessments completed indicated that the likelihood of building and associated infrastructure failure was increasing with time, with increasing risks to neighbouring communities, on-site workers, and the environment due to releases of arsenic, asbestos, and cyanide in the event of failure. The demolition of the Roaster Complex was completed as emergency work under the SSP Water Licence.

During the deconstruction process all building components and contents were decontaminated to remove arsenic trioxide and other hazardous materials. Non-hazardous wastes were cleaned and stockpiled on site, while non-arsenic containing hazardous wastes (e.g., PCB, chemicals, petroleum products) were transported off site for disposal at a licensed facility in Alberta. Following the completion of the building decontamination phase, buildings were demolished down to their concrete floor slabs and a gravel cover was placed over the former roaster site. Non-hazardous demolition waste was left in stockpiles in an area adjacent to the former roaster site.

If the demolition materials could not be cleaned sufficiently, the items were removed and containerized for storage for eventual disposal as arsenic contaminated waste. The arsenic waste consisted of arsenic trioxide dust, building components and process equipment coated with arsenic trioxide dust and/or scale, porous materials (such as wood and brick) saturated with arsenic trioxide and disposable materials (personal protective equipment [PPE], filter media) contaminated with arsenic trioxide during the decontamination process. During decontamination, the containerized wastes were packaged in Transportation of Dangerous Goods approved containers. All containers of arsenic waste were placed in intermodal shipping containers and placed in the Material Storage Area (MSA) located in the Central Pond (Photo 4.1-1) for storage until final disposal. The typical contents of each bag/container are shown in Photos 4.1-2 to 4.1-5.

Photo 4.1-1: Containers of arsenic waste were placed in intermodal shipping containers and placed in the Material Storage Area located in the Central Pond



Photo 4.1-2: Shipping Containers for the Temporary Storage of Roaster Demolition Waste (arsenic-impacted waste stored in approved waste bags)



Photo 4.1-3: Typical contents of 1 m^3 bag



Photo 4.1-4: Typical contents of 2-3 m^3 bag



Photo 4.1-5: Interior view of marine shipping container with arsenic impacted process equipment



Table 4.1-1 presents a summary of the arsenic wastes which were containerized during the Roaster Deconstruction project, as well as additional arsenic wastes which are currently containerized or remain in-place in the Mill Building.

Table 4.1-1: Summary of Containerized Arsenic Waste

Container Size	Waste volume	Typical Contents
1 m^3 bag	6,553	Arsenic trioxide dust, contaminated building materials, contaminated PPE and filter media, coated porous materials (wood and brick)
2-3 m^3 bag	1,942	Building wall components containing encapsulated with layers of asbestos and arsenic trioxide, pipe and electrical conduit coated with arsenic trioxide scale
Large sized process equipment placed in lined 40' marine shipping containers	1,100 m^3 of waste in 31 shipping containers	Large steel process equipment coated with arsenic trioxide scale
Drums stored in Northwest Hazardous Waste Storage Compound	727 m^3	Arsenic trioxide dust, contaminated building materials, contaminated PPE and filter media, coated porous materials
In Place Ore Process Residuals Remaining in Mill	5,538 m^3	Semi processed ores and coasted porous materials containing arsenic trioxide

PPE = personal protective equipment; m^3 = cubic metres.

4.1.2 Underground Stabilization

The underground stabilization program has provided progressive stabilization works for previously mined stopes where unacceptable failure risks were identified for crown or rib pillars. The works carried out included stabilization of critical stopes with paste backfill. 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.

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 minewater pool

Several non-arsenic and arsenic storage stopes were identified as posing an unacceptable risk in these three categories, and a plan to stabilize them using paste backfill was included in the application for Water Licence MV2012L8-0010. Early work associated with the SSP included drilling 50 investigative surface and underground boreholes to plan and design the backfill work, as well as an additional 44 backfill delivery boreholes. Inaccessible arsenic bulkheads were also investigated during this drilling program to allow monitoring of their performance.

Between 2013 and 2015, approximately 72,000 m^3 of paste was placed into four non-arsenic stope complexes (B118, B306, B310, and A370) and the two arsenic stopes (B208 and B212/B213/B214) to stabilize the pillars by tight filling. Paste backfill was added to the voids in the stopes by way of boreholes drilled from surface. Fill fences and barricades underground were installed to keep the material in the targeted voids and reduce leakage during the curing process of the paste. The stopes and volume of paste backfilled are summarized in Table 4.1-2.

Backfill of the stopes has been completed with a paste material composed of Giant Mine tailings, binding agent, typically Type GU (General Use) cement and/or slag cement, and water. All backfill was mixed using mobile volumetric mixers, either truck or skid mounted. For Stope Complex B118, the paste was either mixed at the borehole and delivered via concrete pump truck or transported from the batching area at temporary tent by concrete truck and poured down the delivery borehole. For all other stopes, the paste was batched at the Norseman tent, transported to the stope by concrete truck, and poured down the delivery borehole until filled.

Table 4.1-2: Summary of Backfilling Completed

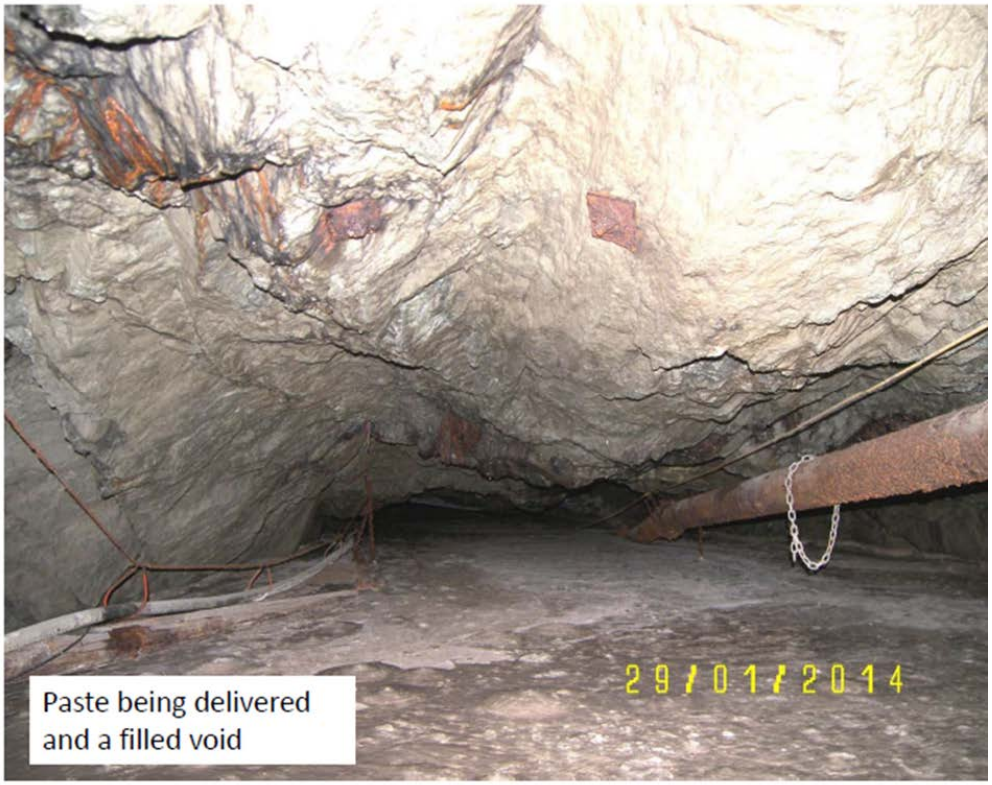
Stope	Volume Backfill Material (m^3)	Date Completed
A370 (non-arsenic stope complex)	22,380	18 September 2015
B310mid (non-arsenic stope complex)	24,912	16 September 2015
B306 (non-arsenic stope complex)	5,476	29 October 2015
B118 (non-arsenic stope complex)	12,915	6 September 2015
B208 (arsenic stope)	2,253	5 October 2015
B212/ B213/ B214 (arsenic stope)	4,084	6 October 2015

m^3 = cubic metre

Non-arsenic Stope Complex C509 is located adjacent to Stope C212 and Chamber 9; a potential risk of collapse over the medium to long term existed in this stope. This could have allowed arsenic solids to exit these voids. In 2015 to 2017, this stope complex was extensively investigated to stabilize the area with backfill material. The design included a 10 m thick concrete plug to be sandwiched between paste backfill in the stopes that could withstand the loss of material below it. Backfilling of Stope Complex C509 occurred in mid-2018 (see Photo 4.1-6 for example of backfill). The C509 complex was not filled in 2015 during the original work for the SSP. Further review of the physical stability of this area was required as part of a larger review of the potential impacts of a possible future minewater level raise, including possible mitigations to protect the overlying arsenic filled voids in the long term, should such a minewater level raise be appropriate in the future (see Section 5.1 for more information).

In addition to the drilling, backfilling, and planning work outlined above, 68 investigation boreholes were drilled between 2013 and 2016 to advance the overall remediation design for the underground and open pit. The boreholes targeted near surface non-arsenic stopes, non-arsenic drifts, arsenic stopes and chambers, and non-arsenic stopes adjacent to arsenic stopes and under open pits. The borehole casings have been secured with locking caps and labelled. Ongoing investigation programs to inspect the targeted voids with cavity monitoring system surveys and borehole cameras will provide information for the detailed backfill design of these stopes and drifts.

Photo 4.1-6: Partially Paste Backfilled Void at Giant Mine



4.2 C Shaft Headframe Deconstruction

Deconstruction of several structures in the C Shaft area of the Site was completed in 2015. The following structures were removed:

- screen house
- elevated ore conveyor galleries
- mill crusher house
- C Shaft headframe (Photo 4.2-1)
- wooden trestle (located between headframe and hoist building)

These installations were in poor structural condition and posed a safety risk to on-site workers. The deconstruction program consisted of a decontamination phase where all hazardous materials such as asbestos-containing materials, lead, mercury, PCB-containing materials, and potential ozone depleting chemicals and petroleum products were removed.

Hazardous wastes generated from this deconstruction and decontamination program were segregated, packaged, and shipped off site to a licensed hazardous waste disposal facility. Non-hazardous wastes generated from the deconstruction project included steel, wood, various metal containing items, electrical components, pipe, and small quantities of plastics and glass. Non-hazardous wastes were stockpiled adjacent to the former building site (referred to as the C Shaft area).

Following decontamination, the structures were demolished. The existing electrical and communication utility conduits and sewage utility that were routed underground through the C Shaft headframe building were protected. A temporary steel cover was installed over the C Shaft opening to the underground.

Photo 4.2-1: Removal of the Final Components of the C Shaft Headframe



4.3 Pumping Redundancy

In 2017, CIRNAC applied for amendments to Water Licence MV2010L8-0010 and Land Use Permit MV2016S0016 to change the type of pumps used for water management on site. This amendment request was approved, and in 2019 the Akaitcho interim deep well pumping station is expected to be commissioned.

The Akaitcho interim deep well pumping station consists of two deep wells, drilled to intercept the mine pool, with submersible pumps installed down the wells. The location of the pump station near Akaitcho was chosen to enable efficient transfer of minewater to the Northwest Pond and the existing ETP. The key benefits of the new system include:

- The selected pumps can be serviced from surface, eliminating the need for workers to access the underground to perform maintenance and repairs, reducing potential health and safety risk.
- The proposed 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.
- These submersible pumps are considered critical site infrastructure and will continue to support site water management during remediation activities until the new WTP is installed and online.

Following successful operational trials of the new pumping system in 2019, the existing underground fixed pumping system will be decommissioned and the high test line will be re-routed, via piping, to the mine pool near the new pumping system (for additional information see Section 5.8.2.2). Access to the Supercrest ramp system will no longer be required and the travel way will be barricaded. Additional details on the system can be found in the Water Management and Monitoring Plan (CIRNAC and GNWT 2019).

4.4 A Shaft Headframe Deconstruction

In 2016 an additional building deconstruction program was completed to remove a number of buildings that were in various states of disrepair and posed a potential risk to on-site workers and the public. The buildings that were deconstructed consisted of:

- A Shaft headframe (Photo 4.3-1)
- A Shaft hoist
- curling rink (located in Townsite)
- assay building

Following decontamination of the buildings, the structures were demolished, with timing of the work being advised by the YKDFN Elders Senate. A temporary steel cover was installed over the A Shaft opening to the underground. Hazardous wastes generated from this deconstruction and decontamination program were segregated, packaged, and shipped off site to a licensed hazardous waste disposal facility. Non-hazardous wastes generated from the deconstruction project included steel, wood, various metal-containing items, electrical components, pipe, and small quantities of plastics and glass. Non-hazardous wastes were stockpiled in laydown areas located south and east of the mill building (Building 106).

Photo 4.4-1: Removal of the A Shaft Headframe



4.5 Baker Creek Reach 4 Relocation

The alignment of Baker Creek was extensively modified during active operations of the Giant Mine (Chapter 2). Minor improvements to Baker Creek were done in 2002 and 2003 with removal of an old culvert and bridge foundations; this was done at the request of DFO under Water Licence MV2002L2-0020. During the care and maintenance period, Reach 4 of Baker Creek was relocated into a new channel. Reach 4 extends upstream to the weir next to B1 Pit and downstream to below the location of the old bridge north of C1 Pit. Prior to relocation, Reach 4 passed over the future freeze area for Stope C212. The relocated channel alignment is captured in Figure 2.5-1.

The primary objective of the Reach 4 realignment was to isolate the contaminated Mill Pond, which overlies Stope C212 from Baker Creek, thereby eliminating a source of ongoing contamination and preventing seepage loss from Baker Creek into areas of the mine itself (C1 Pit). Secondary objectives of the realignment were to provide a stable flood conveyance channel, maintain or improve fish passage, and provide spawning and rearing habitat for native

fish species. While the relocation was conducted as a flood prevention measure, the work completed also supported final closure, as this reach needed to be diverted around the future freeze area. This work was completed under *Fisheries Act* Authorization YK-06-0063.

To meet the requirements of the Authorization, the instream works in Reach 4 of Baker Creek had to provide unobstructed passage for fish from Yellowknife Bay to the spawning sites in Baker Creek, suitable spawning habitat, and allow egg viability and food availability. As such, in fall 2006, seven riffles were constructed in the new Baker Creek channel. Five riffles were constructed (50 m intervals) in the upstream portion of Reach 4, and two wider riffles were constructed 80 and 160 m downstream of the fifth riffle. The surface complexity (bed material) and slope of the downstream face of the riffles were designed to allow upstream fish passage over a wide range of flows (Golder 2008).

Studies following relocation showed that the restoration of aquatic habitat was successful, demonstrating major improvements over existing conditions and providing data and experience to support future work on the Baker Creek alignment. The relocation also demonstrated the hydrological effectiveness of the overall design, in particular the use of a wide flood plain and a channel that is free to move within the flood plain. Additional understanding was also gained on permafrost and ground ice conditions, and their impacts on earthworks through construction experience.

4.6 Other Projects

A summary of additional progressive closure and maintenance actions that were completed at the Site since 2010 is presented in Table 4.6-1.

Table 4.6-1: Summary of Closure Work Completed since 2010

Project Title	Description	Completion Date

Conveyor deconstruction	• The conveyor located between the screen house and mill was demolished to remove associated risks. These included:
	  • physical hazard and worker safety due to the poor condition of the structural supports
	  • the conveyor could have acted as a conduit for the movement of fire between the mill and the screen house
	  • asbestos hazard due to the weathered condition of the asbestos-containing exterior siding
		2011

Baker Creek improvements	• Due to icing conditions in Reach 7, flows from Upper Baker Creek were routed through a road near Baker Pond and through historical Jo-Jo Lake (located at the north end of Baker Pond). This flow caused scouring of historical tailings. A directive from an CIRNAC Inspector was given to cover the exposed tailings area. This was done in 2011 and 2012.
	• C1 Pit emergency channel
	• Additional instream works included:
	  • lining and installation of erosion protection and riprap in the A1 ditches
	  • construction of a dyke to prevent Baker Creek from flowing into a sinkhole near B2 Pit
	  • repairs along the shoreline of Baker Creek in Reach 4
		2011/2012

Arsenic interim underground stabilization activities	• Arsenic Stopes B208 and B212/B213/B214 were backfilled to within a minimum of 1 m of the stope back (top) with a cemented paste, minimum strength of 250 kPa, and backfill consisting of Mine tailings, binder and water.	2015
Effluent treatment plant evaluation and upgrades	• To identify the operating lifespan of the existing ETP, an assessment was completed. This assessment identified that to keep the facility operating for 10 years, mechanical and electrical upgrades were required. In 2015, the upgrades, including the installation of three new reactor tanks, were completed.	2015
Boiler evaluation and upgrades	• An assessment of the two boilers located in the boiler house identified that for on-site structures to continue to function over the period the remediation program is implemented, upgrades to the existing boiler system were required. The assessment identified that one boiler was vastly oversized (based on current loads) and a second boiler was non-operational. In 2015, upgrades to the boiler house were completed. These upgrades included the installation of two smaller more efficient boilers as well as new condensate tank and deaerator.	2015
Arsenic barrel re-containerization	• Due to the poor condition of barrels containing arsenic trioxide and to prevent the release of arsenic dusts, a program was completed to re-containerize 1,600 barrels of arsenic trioxide waste which are currently in storage in the compound in the Northwest Pond.	2015
C1 Pit wall risk reduction	• A rock buttress was constructed in the west wall of C1 Pit in 2015 to address the potential for a slope failure that risked release of Baker Creek into C1 Pit.	2015
Contaminated material removal	• A program was completed that removed and disposed of previously identified hazardous materials located in on-site debris piles, as well as on abandoned building exteriors. The hazardous materials included asbestos containing insulation and gaskets, potential PCB-containing electrical equipment (electrical capacitors and transformers), as well as asbestos containing exterior siding.	2015
ETP upgrades	• One treatment train of the ETP was replaced and new components installed included; new chemical metering pumps (for lime slurry, ferric sulphate and for polymer), three new batch tanks complete with new mixers, and new motor starters for the three reactor mixers. Miscellaneous structural and electrical modifications were also incorporated.	2015
Foreshore tailings cover	• Roughly 8 ha of cover was placed to control erosion of tailings deposited at the foreshore area of Yellowknife Bay. The cover profile included rockfill, gravel, and non-woven geotextile.	2001*
Removal of arsenic delivery pipes	• The abandoned arsenic distribution piping suspended from ceilings of underground drifts was removed and capped to reduce the risk of a future release of arsenic trioxide dust underground.	2016
Splitter dyke repair	• The dredging and splitter dyke repair project included the removal and disposal of 2,500 m^3 of sludge from the existing ETP Settling Pond, construction of a new containment berm in the Settling Pond and reconstruction of the splitter dyke between the ETP Settling and Polishing ponds.	2015
Electrical upgrades B3 Substation	• The B3 Substation was in service for approximately 50 years. Recently completed investigation work identified deficiencies and highlighted issues that would have had the ability to compromise its ability to safely operate over the next 10 years. The upgrade program included the modification and replacement of electrical infrastructure, including transformers, switch gear, wiring, and electrical panels.	2017
Underground communication system replacement	• The existing underground infrastructure and communication system was constructed approximately 50 years ago. Inspections of the underground communication system identified that it was in poor condition and required upgrades to provide reliable service. In 2017, the existing system was redesigned and replaced with a system that used fibre optic lines and VoiP technology. The new system is currently in operation.	2017
Underground electrical upgrades	• The underground electrical upgrade project included electrical improvements at 15 underground locations at the Giant Mine. The work activities involved disconnecting and removing the existing power distribution centres, supply and installation of new electrical equipment including switchgears, transformers, switches, circuit breakers, cables, ground mats, panel boards, etc., and commissioning of the new systems.	2017
UBC Bridge replacement	• During an inspection of the UBC Bridge, it was identified that movement of one of the bridge abutments and supporting piles had occurred, causing the bridge to be unusable. In 2017, a replacement bridge was designed; construction was completed in 2018.	2018
Fencing and signage	• A number of areas on the Site are identified as being a security risk. Temporary security fencing and signage was designed and constructed in 2018 to reduce the risk of inadvertent trespass at the site.	2018
Underground chutes and head cover repair	• Underground repairs to existing chutes and head covers to reduce hazards to workers carrying out care and maintenance work activities on the 750L were completed in 2018	2018
C Shaft power feed replacement	• The existing C Shaft power feed was replaced. The existing power feed for underground was provided through C Shaft. During an inspection of the power cable, it was determined that the containment system for the power feeder cables was not fit for service as there was risk of structural failure of the power cable hangers and C Shaft timbers, both of which would result in the failure of the electrical supply cable. The project was constructed in 2018.	2018

CIRNAC = Crown-Indigenous Relations and Northern Affairs Canada; kPa = kilopascal; ETP = effluent treatment plant; PCB = polychlorinated biphenyl.*Included because inspections in 2014 during low water levels relevant to lessons learned.

4.7 Lessons Learned

A list of lessons learned from past activities at the Giant Mine, as well as several other sites is provided in Appendix 4A. Some of the themes around the past work at the Site that will inform future closure and reclamation activities include:

Closure Activities/Engineering

- During the closure at Colomac Mine, a recommendation for improving engineering design at legacy mine sites was that old information provided for design needs to be confirmed ("ground-truthed") prior to including in design. Confirmatory drilling, survey work, and bathymetry has been incorporated into closure design planning at Giant.
- During the closure at Tundra Mine, a “depth-to-rock” geophysics survey should have been conducted during the design phase to mitigate the over-excavation of rock. These types of investigations are now being planned for various closure components at Giant, including the planning of the spillway channel alignments for the tailings containment areas.
- In rerouting Baker Creek in 2006, frozen material was encountered during excavation and proceeded to melt upon exposure, particularly to the sun, which caused thermal settlement in channel. Careful consideration of permafrost conditions and subsidence should be given to new design features. These will be built into designs and mitigations for specific activities and outlined in Design and Construction Plans, as applicable.
- Staff at Con Mine noted that closure takes more time than expected because of the northern, remote location. For example, sourcing sand or rock as fill and getting it shipped to the mine may take significantly more time than estimated. Accordingly, a proponent should communicate this with regulators and affected parties and have permits that allow for flexibility in schedules. Given this, the Site is applying for a 20-year licence term.
- Lessons learned during earlier backfilling work in 2013, 2015, and in 2018 will allow for more efficient and safe production of this stabilizing material. Key lessons learned during the underground stabilization completed to date include:
    - Multiple methods are required for dust control while disturbing tailings (water truck, backup, Soil-Sement on hand, black out period for when tailings work is suspended etc.).
    - Tailings should be left in place prior to processing. Stacking tailings up in the fall prior for use in the subsequent summer resulted in excessive freezing.
    - Central Pond tailings are the most straight-forward to make a pumpable paste with.
    - Binder type and quantity can be tailored to retard paste set time to aid in backfill placement (reduce set time against barricades, increase set time where need paste to flow longer distance).
    - Multiple paste matrix designs with many different slumps (viscosity) are required to deal with both expected and unexpected leakage out of complex voids.
    - Expanding foam can be a useful tool in stopping paste leakage.

- 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 little 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 one 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 (Photos 4.7-1 and 4.7-2), where sediments have been impacted by mine tailings during the early years of mining (SRK 2009). 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 (Spill#11-159). The Site was given a letter of direction from CIRNAC-Water Resources on May 30, 2011 to take permanent mitigative measures to remove the potential for release of tailings into the receiving environment. A tailings cover was placed on Jo-Jo Lake area in 2011 and completed in 2012. Key learnings from this were as follows:
  - Flows in Baker Creek can occasionally continue in winter and ice buildups may result.
  - Staff are needed to monitor key areas of 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. Attention given to risk areas where action may be urgent.

Photo 4.7-1: Aerial View of Reaches 6 and 7 of Baker Creek, May 13, 2011



Photo taken by Golder Associates Ltd., courtesy CIRNAC Cumulative Impact Monitoring Program

Photo 4.7-2: Baker Creek, May 13, 2011



Health and Safety of the Public and Workers

- **The importance of controlling access to and security around the site**—The Site is large, with many activities underway at any time. The MCM will provide clear responsibility and process for controlling access to the site. It is imperative that one agent have full knowledge of who enters and leaves the site. In the event of an emergency that requires directing first responders to an accident scene, the MCM will be able to provide that direction. If evacuation of the Site is required, the MCM must know who is on site and where and must be able to communicate with them and confirm their safe exit from the site. Underground access/construction is particularly unique. Systems of tagging in and out have proven effective in managing who is underground and it is expected that a similar system will be followed for future underground access/construction.
- **Health and safety protocols**—While many activities will have their own specific health and safety programs that address the nature of the work and specific hazards, all work on the Site will be under the overall control of the MCM, who will have prime responsibility for health and safety. The site-wide health and safety protocols will be honoured by all site workers, in addition to any protocols adopted for their specific work tasks.

- **Medical monitoring and personal hygiene**—The presence of arsenic as well as other chemicals requires education of the workforce about personal risks and diligence in monitoring and enforcing adherence to hygiene protocols to minimize the risk of exposure and maximize the effectiveness of any medical monitoring programs to avoid risk to workers or false positives. Lessons learned from previous contracts will be considered in the development of hygiene and monitoring programs that demonstrate the safety of the work force.
- **Dust control**—Dust will be generated by the construction activities. The prevalence of arsenic on the Site requires that dust be controlled to protect worker safety and the environment. Traditionally dust control is implemented through the use of water, but this method has challenges due to the requirement for surface water management and monitoring. Alternative dust control methods have been successfully implemented at the Site, including the application of calcium chloride on traffic routes and the application of polymer emulsions and acrylic copolymer products for dust control on the tailings containment areas. Experience with these effective alternatives to water-only dust control will be incorporated in construction planning
- **Air quality monitoring**—Past work at the Site has used a central agency for air quality monitoring and this approach will be continued. Environmental factors such as wind speed and relative humidity can influence the air monitoring results. Past experience will be utilized in the evaluation and reaction to future monitoring results.

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

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

GIANT MINE REMEDIATION PROJECT

Closure and Reclamation Plan

January 2019

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CHAPTER 5
Permanent Closure and Reclamation

SECTION 5.0
General Overview

5 PERMANENT CLOSURE AND RECLAMATION

5.0 General Overview

5.0.1 Introduction

Permanent closure and reclamation activities and long-term management solutions for arsenic storage have been developed for the Site. These are described in Chapter 5, organized by each of the major components as listed below.

- underground mine workings (Section 5.1)
- freeze program (Section 5.2)
- open pit mine workings (Section 5.3)
- contaminated soils and sediments (Section 5.4)
- Baker Creek and surface water drainage (Section 5.5)
- TCAs (Section 5.6)
- borrow material (Section 5.7)
- water treatment plant (WTP) and outfall systems (Section 5.8)
- buildings and site infrastructure (Section 5.9)
- landfill (Section 5.10)

Each major component's section includes:

- a summary of what is planned for each component
- a description of the component (including pre-disturbance and existing conditions)
- closure objectives and criteria, a summary of the key options that were considered and selection of the preferred closure option
- engineering works that are associated with implementation of the preferred activity
- final site conditions
- predicted residual effects that will be left after the closure works have been implemented
- key uncertainties

5.0.2 Closure Objectives and Criteria

As outlined in Chapter 1, closure goals and principles as well as objectives and criteria were developed for the CRP. Closure objectives and criteria were developed to meet the intent of the Closure Guidelines (MVLWB/AANDC 2013) directed by five sources of information:

- relevant acts and regulations and guidance
- EA Measures and Commitments

- affected party and regulatory input between 2010 and 2017
- engineering design and best practices
- risk assessment studies

Affected party and regulatory input included monthly Working Group and GMAC meetings and extensive 2015-2016 affected party/regulatory meetings hosted as part of the SDE process (see Chapter 1 for more details; Slater 2016) as well as a community workshop (technical session) in September 2018.

The approach to the objectives and criteria was as follows: avoid repetition, create a site-wide objective where numerous site activities influence one objective, allow criteria to be numeric or narrative but discrete and measurable, use lessons learned from any emergency works or closure actions taken at the Site (Chapter 4), and acknowledge the regulatory approval process for additional criteria under approved management and monitoring plans not yet fully known. It is acknowledged that socio-economic objectives are necessary; these will be presented under separate cover and not addressed in this CRP.

The site-wide objectives and criteria that apply to the entire Site are summarized in Table 5.0-1, along with a brief outline of the closure monitoring/maintenance/inspection that will be used to evaluate compliance with the criteria. As noted above, the objectives and criteria for individual components of the project are described within each component section of Chapter 5. The full list of objectives, closure actions, and criteria for the CRP is found in Appendix 5.0A.

Site-wide objectives and criteria are linked to numerous remediation activities and as such specific activities are not listed in Table 5.0-1. There are six site-wide objectives, whose focus is environment (air quality, loading of contaminants, erosion), long-term care, and communication of risk to local communities. Detailed monitoring plans and inspections will be required during and after remediation works (e.g., Ambient Air Quality Monitoring Plan, Water Management and Monitoring Plan) and that the specifics of each plan will include affected party input and regulatory approvals; as such, the specific details of those monitoring plans are not included in the closure objectives and criteria tables.

Table 5.0-1: Site-Wide Closure Objectives and Criteria

Closure Objectives	Closure Criteria	Monitoring/Maintenance and Inspection
SW1. Air quality is maintained at concentrations protective of human health and the environment	• **SW1-1** Air quality standards outlined in the Dust Management and Monitoring Plan and associated Air Quality Monitoring Program are met.	*Active Remediation Phase and Adaptive Management* • Dust Management and Monitoring Plan • Qualitative and quantitative monitoring per Air Quality Monitoring Program(s) *Post Closure Phase:* • Qualitative and quantitative monitoring per Air Quality Monitoring Program(s)
SW2. Site-wide loading of contaminants to the environment is reduced to the extent practicable	• **SW2-1** Approved effluent quality criteria are met • **SW2-2** Approved surface runoff quality criteria are met, as per the approved Water Management and Monitoring Plan • **SW2-3** Water quality objectives in the receiving environment are met (see Objective WTP 2) • **SW2-4** Concentrations of metals in tissue of small-bodied, resident fish and benthos tissue in Baker Creek decrease over time *Criteria in Development related to Passive and Semi-Passive Treatment Technology Reclamation Research Plan* • **SW2-5** Reclamation research plan to review if additional treatment methods such as wetlands can further reduce site-wide loading of contaminants	*Active Remediation Phase, Adaptive Management and Post Closure Phase:* • Surveillance Network Program: Water quality monitoring in surface water, runoff water, treated effluent • Water Management and Monitoring Plan: Operational Monitoring Plan: sump water quality • Aquatic Effects Monitoring Program: Water, toxicity, fish and benthos, sediment quality monitoring in Baker Creek

SW3. Remaining operational engineered structures/controls meet appropriate design levels required for long-term care	• **SW3 -1** Elements are designed to meet regulations as described in tables of Chapter 5 and below, and design specifications are met.
	• **SW3-2** Minimise perpetual care requirements including the following
	  • Lower in maintenance
	  • Lower long-term costs
	  • Remaining operational controls
	  • Low probability of failure of engineering controls
	  • Demonstrated design redundancy
		Active Remediation Phase:
		• As-built design report signed and sealed by Qualified Professional Engineer and submitted to MVLWB.
		Active Remediation, Adaptive Management and Post Closure Phases:
		• WSCC Mines Inspector and Qualified Professional Engineer inspection confirms Building Codes met.
		• Perpetual Care Plan

SW4. Residual risks are identified, and local residents have been, and continue to be, informed of residual hazards (post-remediation)	• **SW4-1** Public communication initiatives as outlined in the Perpetual Care Plan / Engagement Plan are undertaken • **SW4-2** A land map with residual risks identified and available at Land Titles and project websites • **SW4-3** Perimeter barriers are installed near risk areas to reduce inadvertent access and are visually displeasing to communicate that residual risk is present (e.g., large grey boulders, earth embankments) • **SW4-4** Landowners are provided with necessary information for Land title caveats, zoning (administrative controls)	*Active Remediation* * Perpetual Care Plan / Engagement Plan - Further engagement required on standard communication like newsletters, site visits, maps, websites, local radio and television alerts. Alternative forms of communication (e.g., mural, signs in various languages) will be discussed with affected parties *Active Remediation, Adaptive Management and Post Closure Phases:* • Engagement plan requirements met and reported to MVLWB • Perpetual Care Plan
SW5: Remediated areas are stabilized and protected from erosion in final configuration	• **SW5-1** Elements are designed to meet regulations as described in tables of Chapter 5 and below, and design specifications are met. • **SW5-2** Approved effluent quality criteria are met • **SW5-3** Approved surface runoff quality criteria are met, as per the approved Water Management and Monitoring Plan • **SW5-4** Water Quality Objectives in the receiving environment are met • **SW5-5** Remediated areas are designed to resist erosion including armouring and targeted revegetation with native species	*Active Remediation Phase, Adaptive Management and Post Closure Phase:* • *Fisheries Act* Authorization – vegetation requirements and monitoring (awaiting further consultation) • Water Management and Monitoring Plan/Surveillance Network Program - Water quality monitoring in surface water and runoff water. • Erosion and Sediment Control Plan(s) (Active Remediation Only) • Operational Monitoring Plan: structural erosion monitoring; visual inspection for slumping, mass wasting, cracking
SW6. Incorporate traditional and local knowledge and affected party input into closure design and implementation, where appropriate and available	• **SW6-1** Collect and utilize traditional and local knowledge for Site in environmental assessment process to inform remediation decisions where parties are interested, and information is available • **SW6-2** Collect updated traditional and local knowledge for Site with relevant affected parties, where parties are interested and available • **SW6-3** Document for relevant design elements and monitoring programs that traditional knowledge was reviewed and incorporated, to the extent practical	*Active Remediation Phase, Adaptive Management and Post Closure Phase:* • Engagement Plan- document plans to gather traditional knowledge • Quantitative Risk Assessment – document residual risk including local and traditional knowledge • *Fisheries Act* Authorization – use of traditional knowledge in design and monitoring of Baker Creek re-alignment and habitat replacement and monitoring • Input and involvement in Archaeological study and monitoring • Aquatic Effects Monitoring Program, Wildlife and Wildlife Habitat Management and Monitoring Plan – gathering and use of traditional knowledge to design monitoring and implement monitoring and interpret results

Note: Site-wide objectives and criteria are linked to numerous remediation activities and as such specific activities are not listed in this table. SW = site-wide; WTP = water treatment plant; GNWT = Government of the Northwest Territories; MVLWB = Mackenzie Valley Land and Water Board; * Number has been rounded to the nearest metre

As noted above, closure activities can have their success demonstrated by the achievement of criteria; this is explicitly acknowledged in MVLWB guidance: “Closure criteria can be…narrative statements or numerical values.” For various aspects of the closure plan, engineering designs have been developed or in the process of being developed to meet the closure objectives. Meeting the closure objective will require the implementation of these plans in accordance with their design intent. The following closure criterion is used to provide a narrative standard to measure that approved designs have been carried out in accordance with their intent: ‘Design engineering drawings are signed and sealed by a Qualified Professional and the specifications outlined therein are met, such that the design intent is met’.

The above criterion contains the following key elements:

- The design engineering drawings: These will document the details of the proposed design, and will form part of the Design and Construction Plan that will be submitted to the MVLWB for approval prior to construction.
- Signed and sealed by a Qualified Professional: A Qualified Professional is a term used that follows general legal definitions including the NWT *Mine Health and Safety Act*; the general definition is a person who is a registered professional and/or accredited practitioner and is qualified because of his or her knowledge, training and experience to design, organize, supervise and perform the appointed duties, and carries a burden of professional and ethical responsibility for work carried out under their supervision and signature. The explicit requirement for signing and sealing of drawings by a qualified professional is intended to demonstrate the accountability for the design drawings.
- Specifications outlined therein are met: The specifications of the design engineering drawings define the approved design. Meeting specifications demonstrates that the approved design has been completed.
- Such that the design intent is met: It is standard in engineering practice that minor deviations from design drawings occur during construction to adapt to unexpected field conditions. These adaptations must be approved by the engineer responsible for the design, who must evaluate if the design will still meet its intent if the adaptation is allowed, under his or her responsibility as a Qualified Professional.

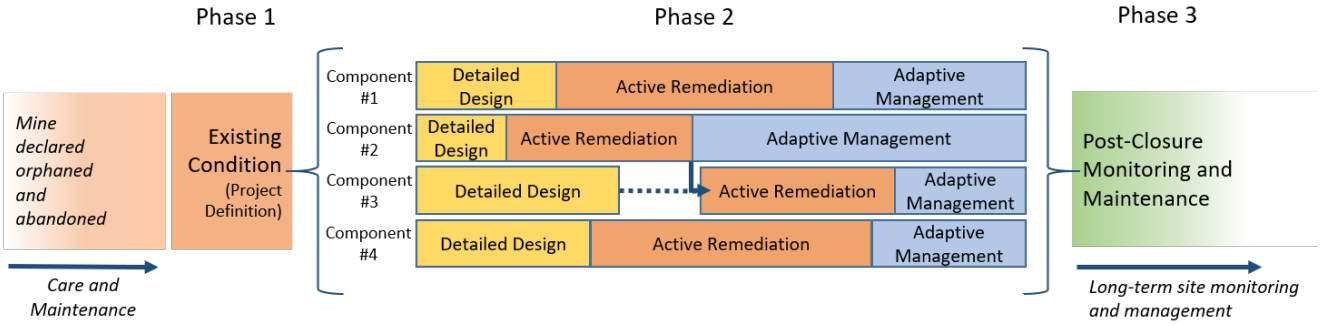
5.0.3 Phases of CRP Development, Implementation, and Monitoring

In contrast to the normal phases of a project, which often include project definition, construction, operation, closure, and post-closure, the GMRP is defined in three reclamation-focused stages (Figure 5.0-1):

- **Phase 1: Existing Condition** – Project Definition; from licence issuance until the first remediation activity commences
- **Phase 2: Active Remediation and Adaptive Management** – implementation of the approved closure activities, which has three corresponding sub-phases, applied on a component-by-component basis:
    - Detailed Design
    - Active Remediation/Construction (implementation of specific closure activity)
    - Adaptive Management (confirmation of component performance)

- **Phase 3: Post-closure Monitoring and Maintenance**[1] – long-term monitoring and maintenance after all site remediation is complete

Figure 5.0-1: Conceptual Diagram of the Three Project Phases



Phase 1 is defined as the period that commences when a Water Licence is issued for site remediation, prior to commencement of remediation activities; however, this period really extends back to 1999, when the mine's owner went into bankruptcy and CIRNAC assumed responsibility for the Site.

Phases 2 is the core phase of the GMRP and commences once the first remediation activity is implemented. This phase includes three sub-phases: detailed design, implementation, and performance assessment of the closure plan activities described in the CRP and approved by the MVLWB. Phase 2 applies to the GMRP as a whole, but its sub-phases are divided and applied to each component of the CRP individually (Sections 5.1 to 5.10). This approach enables one component to be undergoing detailed design, another active remediation, while a third has yet to commence, as it may require completion of another activity to be implemented. All closure activities enter a period of adaptive management once completed.

Phase 3 is the point at which the remediation of all components of the CRP are complete and adaptive management indicates they are performing as anticipated. At this point, the definition of the GMRP essentially changes from a remediation project to a post-closure monitoring and maintenance project. The purpose moving forward through Phase 3 will be to monitor the Site to ensure it meets closure criteria and continues to reflect the site objectives for the 100-year term of the project; this includes continued operation of the WTP to confirm discharged minewater meets EQC. It is anticipated a new Water Licence application will be submitted as the project enters post-closure, as has been done for other remediation projects in the Mackenzie Valley.

As the GMRP nears the end of Phase 2, a Post-closure Monitoring and Maintenance Plan will be developed for the Site. This plan will outline the updated post-closure long-term monitoring program and any foreseeable maintenance. Monitoring frequencies with anticipated changes over time will be detailed. A robust process for responding to contingencies post-closure will be defined at the commencement of this final phase.

Detailed site and activity-based management and monitoring will be tailored to ensure it accounts for and considers each activity being completed to ensure additional impacts from remediation activities is minimized. Anticipated monitoring details as the GMRP moves through Phases 1 to 3, as well as a process and potential responses for contingency scenarios, should the closure objective and criteria not be achieved, are provided in Section 5.12 and 5.13.

[1] Post-closure maintenance of this site includes ongoing operation of the Water Treatment Plant and the active cell in the non-hazardous landfill where treatment residuals will be disposed and managed.

A preliminary project schedule for Phase 2 is outlined in Chapter 6. It is anticipated the schedule will be adjusted as the project develops to reflect progress of interrelated tasks and with optimization of activities as work progresses. Updates will be reported in the Annual Water Licence Report and Design and Construction Plans for individual closure activities, as applicable.

5.0.4 Use of Regulatory Mechanisms to Advance Engineering Work and Monitoring Details

The GMRP has now developed a CRP that includes a complete set of the required final CRP components:

- Closure Goals and Principles
- Closure Objectives
- Closure Activities, resulting from closure options assessments
- Closure Criteria

Once the Water Licence process is complete, the GMRP anticipates updates to specific aspects of this CRP will be required, based on reviewer comments and MVLWB direction. In addition, detailed design/engineering work is still needed for several of the closure plan components prior to implementation of the selected closure activity, with corresponding monitoring and mitigation details needing to be developed.

The proposed MVLWB mechanisms for furthering implementation of remediation activities and communicating CRP updates, progress, and any changes are:

- **Design and Construction Plans –** These plans will be structured by closure component. They will include an implementation schedule, the final detailed design, final closure criteria, and activity-specific monitoring and mitigations to be followed during activity implementation (i.e., construction) and adaptive management (i.e., confirmation of performance). These plans will also propose a timeline for performance assessment of the implemented closure activity, once completed. The Design and Construction Plans will be submitted for review and MVLWB approval.
- **Construction Completion Reports –** These reports will be submitted after implementation of the Design and Construction Plan is complete. These reports include as-built designs including any deviations from design, and may provide updates to adaptive management and monitoring if necessary. Only changes to monitoring are for approval at this time, as per standard MVLWB conditions.
- **Management and Monitoring Plans –** These plans are living documents that include both site-wide and activity specific management and monitoring details. They will be updated to incorporate approved monitoring and mitigation plans as proposed through Design and Construction Plans and Construction Completion Reports (as necessary). Site-wide and ongoing aspects of the Plans will also be updated annually; changes are submitted to the MVLWB for review and approval.
- **Performance Assessment Reports** – These reports will be completed after enough time has passed for monitoring to identify that closure criteria have been met; each closure activity requires a performance assessment. Timing of assessments will vary by component and be approved through the Design and Construction Plans. These reports will include an assessment of environmental conditions surrounding the

implemented closure option against its performance and will identify any additional work or monitoring needed to achieve, or to confirm achievement, of closure criteria. This report is for MVLWB approval.

- **Annual Water Licence Report** – This report will provide a summary of closure progress for the previous calendar year and updated schedules for implementation of the closure plan for the coming year. It will also provide a summary of management and monitoring results. This report is not for MVLWB approval.

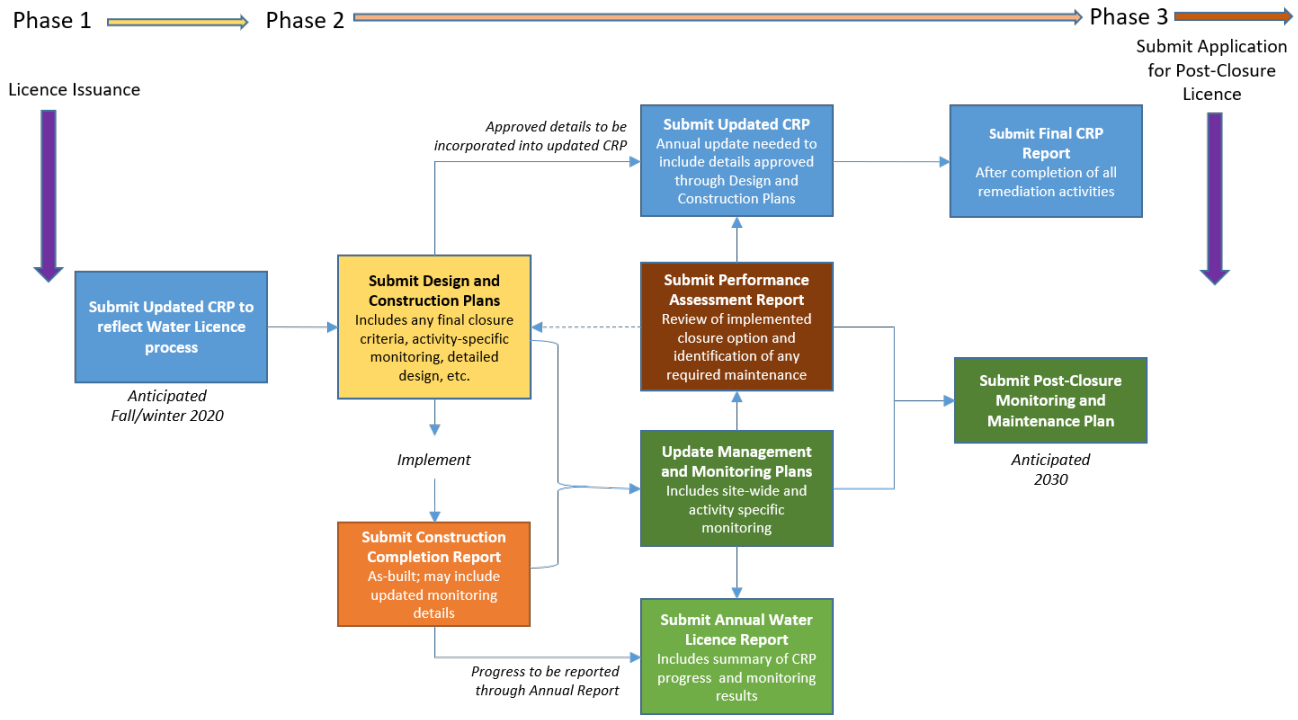
- **Closure and Reclamation Plan** – An updated CRP will be provided annually to incorporate any closure details approved through the Design and Construction Plans. Any new information presented in the CRP would be for approval.

Figure 5.0-2 outlines how these six key regulatory mechanisms move the GMRP from the end of the Water Licence process (commencement of Phase 1), through site remediation (Phase 2), to post-closure monitoring and maintenance (Phase 3). The diagram illustrates how each document is related to others and how reporting, evaluation, and document updates are linked. Timelines for submission of documents are included in the proposed Water Licence conditions.

The GMRP Team believes this approach will work to reduce reviewer overload and result in improved project implementation by allowing focused review, approval, and advancement of individual components over the life of remediation. It also provides an effective method for maintaining up-to-date documentation.

During Phase 3, monitoring will continue to assess and confirm the goals, objectives, and criteria outlined in the CRP continue to be met; maintenance may be implemented post-closure if needed. Operation of the new WTP will continue through this phase. Phase 3 details will be defined in more detail in the Post-Closure Monitoring and Maintenance Plan and the anticipated post-closure water licence application process, after remediation is complete.

Figure 5.0-2: Advancement of GMRP through Regulatory Processes



5.0.5 Climate Considerations

On a site-wide basis, the development of the CRP has been informed by a number of factors, including characterization of the project environment (Chapter 2). This characterization of the project environment is based on historical records documenting conditions to date. Changes to the climate in which the Site is situated may impact performance of some closure measures and have been accounted for through the design process. Assessment of potential climate change impacts is also incorporated into the Quantitative Risk Assessment (QRA) (see Chapter 1).

A necessary part of the design basis for the closure measures has been the development of projections of possible climate change during the project duration. Projections of climate change across time scales up to 100 years are available from approximately two dozen general circulation models, which model the global climate based on a range of scenarios, grid cells of varying sizes, and other assumptions. This results in a range of projections for any location on the earth's surface at any future time. Furthermore, the models generally project much lower changes in the early time period (e.g., 2040 to 2070) than in later periods (e.g., 2070 to 2100).

Freeze

As discussed in detail in Section 5.2, the freeze program to immobilize and contain arsenic trioxide in underground chambers at the Site will use a fully passive system using thermosyphon technology, and thereby depends on a cold climate. In the future, higher winter temperatures may lead to shorter winters and fewer thermosyphon operating days, and warmer summer temperatures will potentially cause greater seasonal ground thawing. The effects of climate warming have been accounted for in the freeze program design, by considering a 6.1°C increase to the mean annual air temperature over the next 100 years. This value was the upper-range

global average temperature as provided by multi-century stabilization scenarios published by the International Panel on Climate Change.

Baker Creek

Climate change is an important consideration in the Baker Creek closure design as well. An even greater uncertainty exists in factors that directly affect this design, as projections of future precipitation are less certain than future temperature predictions. Flood magnitudes depend on precipitation, evaporation, evapotranspiration, seasonal distributions of rain and snow, and other climate factors. This uncertainty was addressed by considering higher water levels than the design probable maximum flood (PMF) would indicate based on current climate data. The PMF represents the most extreme event that might occur in a given watershed. A recent climate-model based assessment of the potential effects of future climate change on PMFs in Canada (Clavet-Gaumont et al. 2017) was used to guide a sensitivity analysis of the Baker Creek hydraulic model, to mitigate the risk of underground mine flooding. Based on the high end of the range of potential change indicated by the climate change assessment, detailed designs will include provision of additional freeboard in critical areas near pits (nominally up to 1 m additional) to further decrease the risk of flooding pits.

Climate change was also factored into decisions around the final alignment for Baker Creek. The selected alignment involves bedrock cuts that will be resistant to climate change and will be less susceptible to changes in permafrost conditions.

Permafrost Considerations

Under a warming climate, permafrost in the North is at risk of degradation. This can affect the foundation for buildings or other civil structures. The risk permafrost degradation has been considered in the closure plan in several aspects. As a general principal, closure measures have been designed to be unaffected by changes in permafrost. New buildings, such as the new water treatment plant, will be sited to have bedrock foundations that will not be affected by changes in permafrost. The pipeline to the near shore outfall discharge will also be aligned to limit interaction with permafrost zones, and will be protected from forest fires (also potentially related to climate change) with burial or berm placement. The recently upgraded UBC bridge has been designed with large piles founded in bedrock, so that it will not be affected by changes in permafrost. New bridges will have similarly resistant designs.

Existing dams may also be affected by permafrost degradation. Settling that has been observed historically at Dam 1 is attributed to the thaw of ice within the dam. Dams will be upgraded if required to address changes in permafrost (see inspection and monitoring below).

Lake level changes

Measures for protection along the shoreline are discussed in contaminated soils (Section 5.4) and for the Foreshore Tailings area (Section 5.6). While these designs are still under development, historical and projected changes in lake levels will be considered.

Inspections and Monitoring

Ongoing inspection and monitoring will be integral to identifying and managing climate change impacts. Changes in ice accumulation patterns, drainage, or water quality due to climate change or other causes will be identified through the monitoring and maintenance program described in Section 5.12. For example, all dams have an annual program of inspections that is used to identify any changes in dams that could affect dam performance. This program of inspections will continue during the operating life of all dams. Similarly, buildings that remain on site are periodically inspected (see for example AECOM 2018), and changes in conditions, including foundation conditions noted.

SECTION 5.1
Underground Mine Workings

5.1 Underground Mine Workings

5.1.1 Description

The closure and reclamation of the underground mine workings includes work to stabilize near surface underground workings for safety, provide secure storage of underground arsenic trioxide waste, prevent mine flooding, and manage the minewater level. The various aspects of underground workings that are the subject of closure and reclamation activities described in this section are:

- arsenic stopes and chambers
- non-arsenic stopes including those near surface and those adjacent to arsenic stopes and chambers
- drifts connected to arsenic stopes
- openings to surface
- minewater level

Activities for closure and reclamation of the underground mine workings are:

- backfilling of potentially unstable arsenic stope and chamber voids
- backfilling of potentially unstable near surface non-arsenic stope voids
- filling and plugging of openings to surface within pits (as part of pit filling; Section 5.3)
- backfilling voids under pits to enable filling and creation of stable pit floor areas where possible
- plugging or filling of openings connected to arsenic stopes and chambers
- filling, plugging, and capping of openings to surface
- maintaining minewater elevation at approximately 750L.

Additional detail on closure and reclamation activities for underground components is provided in Section 5.12 and shown in Figures 5.1-1 and 5.1-2 in plan and vertical longitudinal projection respectively Additional detail on the freeze program for underground arsenic trioxide storage is presented in Section 5.2.

\\golder.gds\gal\burnaby\CAD-GIS\Client\PWGSC\Giant_Mine\99_PROJECTS\GIANT MINE CLOSURE AND RECLAMATION PLAN - EXTERNAL\02_PRODUCTION\DWG\FIG-5.1-1-Site Layout.dwg



GOLD LAKE MINE

LEGEND

- 1st LEVEL (100) UNDERGROUND SHALLOW DEVELOPMENT
- DEEP UNDERGROUND RAMPS, DECLINES AND INCLINES
- APPROXIMATE MAXIMUM STOPING EXTENT AT DEPTH
- PROJECT BOUNDARY
- DEEP UNDERGROUND WORKINGS (>~35 m DEPTH)
- OPENINGS TO SURFACE OUTSIDE OF PITS
- NEAR SURFACE NON-ARSENIC STOPES (<35m DEPTH)
- NON-ARSENIC STOPE BREAKTHROUGH TO OPEN-PIT, BACKFILLED WITH UNKNOWN FILL
- OPEN PIT BOUNDARY
- EMPTY CHAMBER
- NON-ARSENIC STOPES ADJACENT TO AN ARSENIC STOPE
- ARSENIC CHAMBERS AND STOPES MAXIMUM EXTENT
- BACKFILLED DURING SITE STABILIZATION WORK (2013-2018)

NOTES

1. NOT ALL WORKINGS AND STOPES SHOWN.
2. POSSIBLE RAISES TO DELIVER HEAVILY CONTAMINATED ARSENIC IMPACTED ROASTER WASTE TO CHAMBER 15 (TO BE FROZEN).

REFERENCES

1. MINE LAYOUT, LEASE BOUNDARY AND 2015 AERIAL PHOTO IMAGE PROVIDED BY PUBLIC SERVICES AND PROCUREMENT CANADA (PSPC).

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PROPONENT

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

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

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PREPARED	MICHAEL PAK / ALAN FARLOW
REVIEWED	DARREN KENNARD
APPROVED	BJÖRN WEEKS

PROJECT

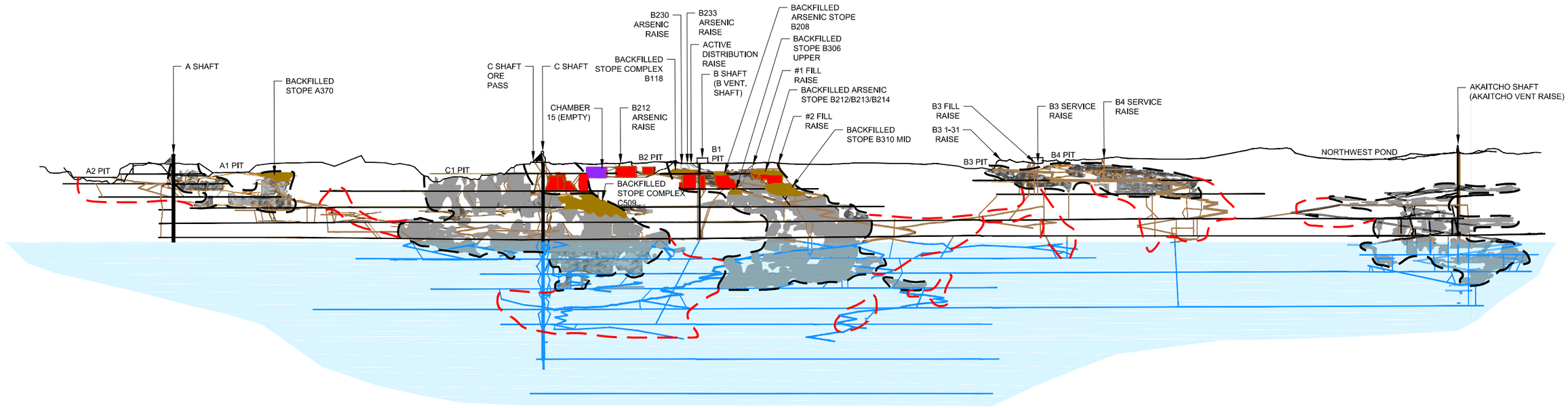
Giant Mine Remediation Project

TITLE

SITE LAYOUT SHOWING UNDERGROUND FEATURES INCLUDING SHALLOW STOPES AND DEVELOPMENT OPENINGS AND OPENINGS TO SURFACE

REV. 0

FIGURE 5.1-1



LEGEND

- FLOODED DEVELOPMENT (DRIFTS, RAISES, ORE-PASSES AND SHAFTS)
- DEVELOPMENT (RAMPS, DRIFTS, RAISES, ORE PASSES, AND SHAFTS)
- EXTENT OF MODELLED STOPES
- APPROXIMATE EXTENT OF STOPES (NOT MODELLED)
- NON-ARSENIC STOPES
- ARSENIC STOPES AND CHAMBERS
- EMPTY CHAMBER
- BACKFILLED DURING SITE STABILISATION WORK (2013-2018)

NOTES

1. C-TROUGH UNDERGROUND MODEL NOT SHOWN.
2. NOT ALL WORKINGS AND STOPES SHOWN.

REFERENCES

1. INDIAN AND NORTHERN AFFAIRS CANADA - GIANT MINE REMEDIATION PROJECT.
   DATE: OCTOBER 7, 2008.
   FILE: S:\5620-GMRP...\UNDERGR...\GIANTLONG2008MASTER.dwg
2. MIRAMAR GIANT MINE LTD. - VENTILATION PROJECT.
   FILE: VLONG2002.dwg

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

Government of Northwest Territories Gouvernement des Territoires du Nord-Ouest

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REVIEWED	DARREN KENNARD
APPROVED	BJÖRN WEEKS

PROJECT
Giant Mine Remediation Project

TITLE
VERTICAL PROJECTION SHOWING UNDERGROUND FEATURES

REV. 0
FIGURE 5.1-2

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5.1.2 Pre-disturbance and Existing Site Conditions

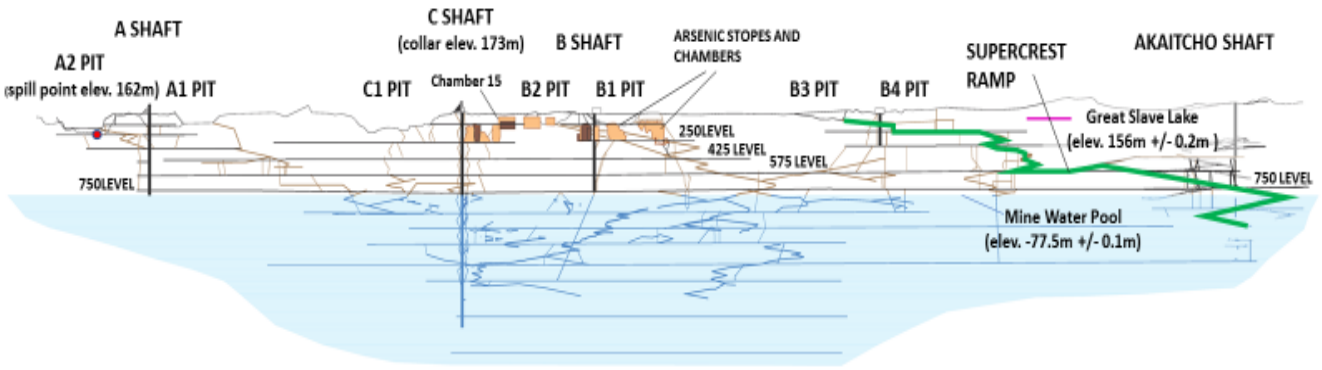
5.1.2.1 Pre-disturbance Conditions

Relevant information on subsurface conditions (geology) prior to mine development can be found in the description of the project environment in Chapter 2.

5.1.2.2 Existing Conditions

To understand the existing condition of the underground mine, a brief history of mining methods and terminology is required. Development of the historical underground mine was carried out by driving many kilometres of access shafts and tunnels, termed development openings, underground using drill and blast excavation methods. The locations of development openings below the shallow 100 Level openings are shown in Figure 5.1-1 (orange). Gold ore was recovered by excavating large underground voids, called stopes, which were mined using shrink stoping, cut-and-fill stoping, and longhole open stope mining methods. The A, B, C, and Akaitcho vertical shafts were sunk from surface to allow access to the gold ore to a maximum depth of 647 mbgs (Figure 5.1-3).

Figure 5.1-3: Schematic Longitudinal Section of Giant Mine (Looking West) Showing Current Location of Minewater Elevation and Flooded Workings Below



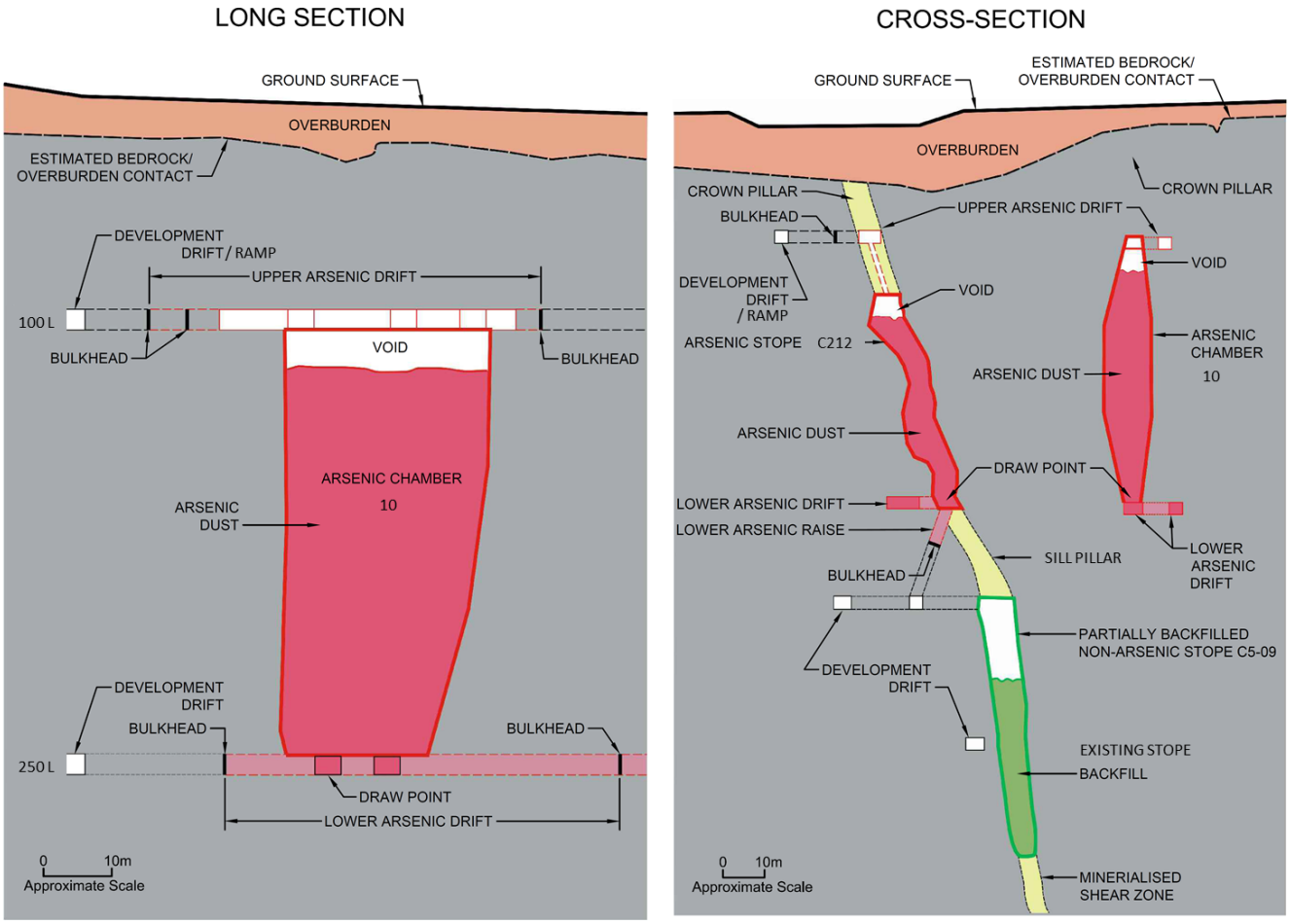
Early development openings were driven off the shafts for conventional track mining used in the 1940s and 1950s. Most stopes were steeply dipping, but some shallow stopes were developed where the structure of the folded gold-bearing shear zone flattened out.

After development, stopes were backfilled with a variety of materials including sand, made from cycloning tailings, and run-of-mine development waste rock. This backfilling was carried out to enable additional mining or for improving stability of the adjacent areas. When mining in one area was completed, backfill was often removed to enable mining elsewhere. As a result, large interconnected voids that are partially backfilled are present throughout the Mine.

Near surface crown pillars separate stope voids from the ground surface. These crown pillars were left behind over much of the underground. Some of these crown pillars are situated directly under Baker Creek. As part of

the SSP implemented in 2013, some of the stopes, including some which were used to store arsenic trioxide dust, were backfilled with a tailings paste to reduce the risk associated with a potential crown pillar failure. A summary of this is outlined in Section 4 and more detail is provided in Section 5.1.2.2 (Golder 2016b). Figure 5.1-4 shows schematic cross sections cut through the arsenic stope C2-12, Chamber 10, non-arsenic stope C509 area that describes key terminology used in this chapter.

Figure 5.1-4: Schematic Vertical Sections of Arsenic Stope C212 and Arsenic Chamber 10 Area to describe Common Underground Terminology (Existing Conditions)



In addition to the underground mining, open pits were excavated in the 1970s in some of the areas that had previously been mined using underground methods (Chapter 3, Figure 5.3-1, and Section 5.3). The open pits intersected underground stopes and development openings. To enable open pit mining, these stopes and openings were partially filled with a variety of materials. Thin crown pillars and backfilled stope voids are present under most of the open pits. Many openings to surface are present within the open pit limits (Section 5.3).

Starting in 1951, arsenic trioxide dust, which was a by-product of the gold extraction process, was pneumatically pumped into underground voids for storage. Many purpose-built chambers were excavated to store dust, while some dust was stored in previously mined-out stopes. Bulkheads of various types were constructed in the

access drifts connected to the stopes and chambers to contain the dust within the storage voids. Some non-arsenic stope voids are present adjacent to the stopes that have been filled with arsenic.

Arsenic Stopes and Chambers

There are a total of 15 arsenic stopes and purpose-built chambers that store arsenic trioxide dust and one chamber that was constructed for arsenic storage but never filled. They exist in four areas outlined in previous studies (AR1, AR2, AR3, and AR4) and are shown shaded in red in Figure 5.1-1 and again in Figure 5.1-5 where more details are shown. These four areas of arsenic stopes, chambers, and the peripheral drifts connected to them that likely contain arsenic dust are further outlined as follows:

- AR1: Arsenic Chambers 11, 12, 14, and 15[1]
- AR2: Arsenic Chambers 9, 10, and Arsenic Stope C212
- AR3: Arsenic Chambers B230, B233, B234, B235, B236, and Arsenic Stope B208
- AR4: Arsenic Stopes B212, B213, and B214[2]

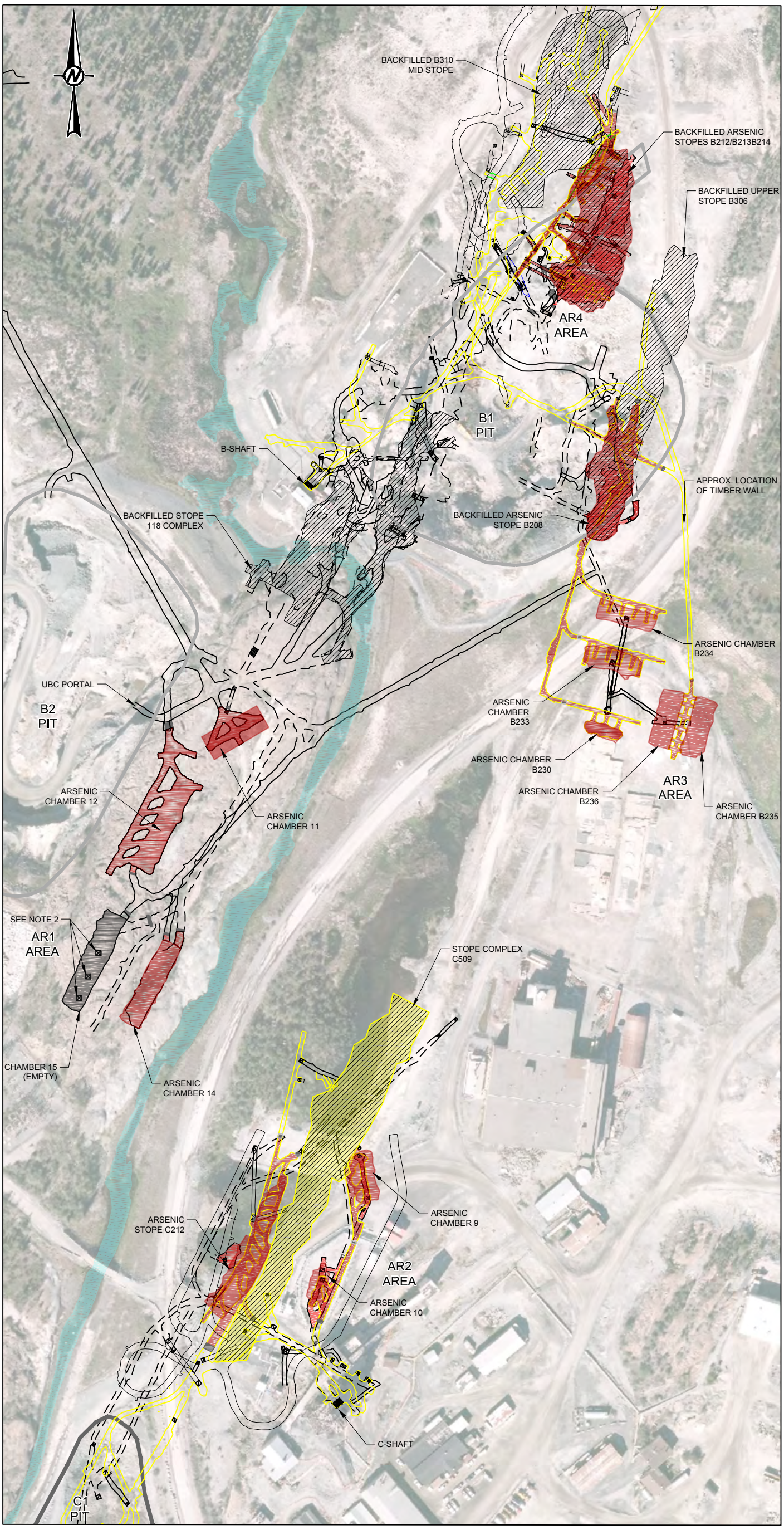
The geometry of the arsenic chambers is variable, but they are typically rectangular. The arsenic stopes have complex shapes due to the folded and complex nature of the orebody. The arsenic-containing underground workings are isolated from the other mine workings by bulkheads. Chamber 15 is currently empty and may be prepared to accept heavily contaminated material mainly from the roaster demolition or soil that needs to be frozen as part of the closure program. Many near surface non-arsenic and arsenic stopes and chambers were investigated during a drilling program in 2015, and no immediate crown pillar stability hazards were noted.

After the drill program, cameras were lowered in the boreholes to the top of the arsenic chambers and stopes to view the void space and condition of the arsenic dust. Some of the arsenic dust chambers and stopes contain spalled rock from the back and walls (i.e., rock that has broken off the walls), ice, lengths of pipe, steel and wood debris. Fractures in the dust were also observed suggesting that portions of the dust have been cemented in place over time. Photographs 5.1-1 and 5.1-2 show the condition of the dust in the top of chamber 14 and stope B208.

[1] Chamber 15 is empty and may be used to store frozen contaminated material or soil.

[2] Arsenic Stopes B212, B213, and B214 are connected.

N:\Client\PWGSC\Giant_Mine\99_PROJECTS\GIANT MINE CLOSURE AND RECLAMATION PLAN – EXTERNAL\02_PRODUCTION\DWG\FIG-5.1-5-Location of Arsenic Stopes.dwg



LEGEND

- 1st LEVEL (100) UNDERGROUND DEVELOPMENT
- 2nd LEVEL (250) UNDERGROUND DEVELOPMENT
- UNDERGROUND RAMPS, DECLINES AND INCLINES
- ARSENIC CHAMBERS AND STOPES MAXIMUM EXTENT
- NON-ARSENIC STOPES ADJACENT TO AN ARSENIC STOPE
- BAKER CREEK
- EMPTY CHAMBER
- BACKFILLED DURING SITE STABILISATION WORK (2013-2018)
- OPEN PIT BOUNDARY
- RAISE
- BULKHEAD

NOTES

1. NOT ALL WORKINGS AND STOPES SHOWN.
2. POSSIBLE RAISES TO DELIVER HEAVILY CONTAMINATED ARSENIC IMPACTED ROASTER WASTE TO CHAMBER 15 (TO BE FROZEN).

REFERENCES

1. MINE LAYOUT, LEASE BOUNDARY AND 2015 AERIAL PHOTO IMAGE PROVIDED BY PUBLIC SERVICES AND PROCUREMENT CANADA (PSPC).

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

Government of Northwest Territories Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-02-01
DESIGNED	MICHEAL PAK
PREPARED	ALAN FARLOW
REVIEWED	DARREN KENNARD
APPROVED	BJÖRN WEEKS

PROJECT
Giant Mine Remediation Project

TITLE
LOCATION OF ARSENIC STOPES AND CHAMBERS AND CONNECTED ARSENIC CONTAINING DRIFTS

REV. 0

FIGURE 5.1-5

Non-arsenic Stopes

A preliminary inventory of the number of non-arsenic stopes was developed in 2015 to support evaluations of stope stabilization requirements (Golder 2015b). Table 5.1-1 summarizes the non-arsenic stopes that will be addressed during closure, organized by the open pit that is nearest to the stope. This list does not include the non-arsenic stopes already stabilized during SSP (described in Section 4.1.2 and noted in Figures 5.1-1 and 5.1-5 [shaded]).

The non-arsenic stopes are sub-divided by the following categories, with "near surface" considered to be within 35 m of the ground surface (Table 5.1-1):

- near surface
- near surface under Baker Creek—noted because failure of those crown pillars would allow flooding of the Mine
- under open pits, either connected to the pit directly or where a thin crown pillar is present
- under or adjacent to an arsenic stope or chamber—noted because failure of the pillar between them would allow arsenic solids to be released into the underground (Figures 5.1-1 and 5.1-5)

Table 5.1-1: Number of Non-arsenic Stopes

Open Pit	Number of Near Surface Non-arsenic Stopes	Number of Near Surface Non-arsenic Stopes under Baker Creek	Number of Non-arsenic Stopes under Pits	Number of Non-arsenic Stopes Adjacent to or under an Arsenic Stope or Chamber
A1	-	1	5	-
A2	5	2	3	-
C1	1	-	7	1
B1	-	1	3	3
B2	-	-	-	-
B3	3	-	1	-
B4	11	-	-	-
Total	**20**	**4**	**19**	**4**

The GMRP maintains a stope inventory including associated stability issues and related risks evaluated based on standard industry practice. The geometry of the individual stopes is complex, and the volume of open voids contained within them is variable. Note that some individual stopes shown in mine plans are grouped together into a single stope complex if they are interconnected.

On the basis of visits to accessible mine areas, it was observed that most stopes were backfilled during the mining years to within about 6 m of the back on the last cut or zone mined. Stopes that dipped shallower than the typical angle of repose of waste rock (~35 to 40 degrees) were not filled tight to the roof of the stope. Often, backfill was removed from previously filled stopes to be used in other areas of the Mine, which in some cases has caused a potential instability in the emptied stope. Note that many near surface non-arsenic and arsenic stopes and chambers were investigated during a drilling program in 2015, and no immediate crown pillar stability hazards were noted under existing conditions.

Arsenic Chamber and Stope Access Drifts and Arsenic Bulkheads

During historical mine operations, development openings were required to excavate both the arsenic chambers and stopes. To excavate the arsenic chambers, both upper and lower drifts were required. To excavate the arsenic stopes, upper, lower, and intermediate drifts, and in some cases, sub-vertical raises were required. To isolate arsenic chambers and stopes from the "clean" mine workings where workers were present, bulkheads were added to connected development openings. The lower and intermediate arsenic bulkheads were fully sealed and designed to withstand hydrostatic pressure. Water is known to be present in the lowest elevations of some of the arsenic stopes and chambers. The upper bulkheads were designed with inspection hatches to allow dust viewing and ports for the pneumatic piping to transport dust into the chambers.

A total of 61 arsenic bulkheads were constructed using five different construction methods. The lower and intermediate arsenic drifts and raises are likely full to partially full of arsenic dust, and some water. The upper arsenic drifts likely contain limited arsenic dust.

The bulkheads were constructed with concrete or cemented tailings and remain in service currently:

- 26 lower/intermediate arsenic bulkheads (with 11 inaccessible for inspection by personnel due to safety considerations)
- 35 upper arsenic bulkheads (with 9 inaccessible for inspection by personnel)

Accessible arsenic bulkheads are inspected annually. Boreholes to allow remote camera inspection of some of the inaccessible lower bulkheads were drilled in 2015. Deterioration of the concrete and cemented tailings used to construct the bulkheads was first noted in 2017. Many arsenic bulkheads are observed to leak, with highly contaminated water exiting them. A system to collect and treat as much of this water as practical is in place; this is referred to as the high-test line. Water monitoring and control measures are in place for arsenic stopes that are known to contain water.

Openings to Surface

Underground excavations in the Mine that connect to surface are termed 'openings to surface'. These include 38 individual openings to surface which include vertical shaft openings, or vertical manways, portals to horizontal adits or underground ramps, inclined and vertical raises. A total of 25 of the openings to surface are outside the open pit limits and 13 are within the open pit limits. As noted above, many of the identified underground openings are located within an open pit perimeter.

Most horizontal openings (e.g. portals) to surface are secured with locked gates or similar temporary locked access controls (e.g., wooden covers or doors) or have been covered and/or partially plugged with course rock fill. Vertical openings to surface (e.g. shafts and raises) that are not in use are capped. Where safe to do so, these are inspected routinely to confirm that they are secure. Some openings to surface are required to be open for access by mine personnel (e.g., UBC portal, B3 portal) and others remain open but secured to allow mine ventilation (e.g. B-Shaft). The A Shaft and C Shaft headframes were recently demolished and temporary covers were placed on the openings (Sections 4.2 and 4.3).

Additionally, numerous boreholes connect the surface to the underground. Most were drilled during the exploration and operating phase of the mine. Some boreholes related to the operating mine were cased arsenic dust transport holes drilled to allow transport of arsenic dust from the roaster to the underground; Some are

open, uncased exploration holes. Between 4 and 6 cased arsenic dust delivery boreholes were drilled into the arsenic stopes and chambers of AR1 from the west bank of Baker Creek but these were filled with cement in 2007–2008 by Det'on Cho/Nuna Joint Venture during Baker Creek re-alignment work in the area (Chapter 4). Most of the boreholes drilled recently for SSP work have been decommissioned by filling with cementitious grout or paste backfill to prevent infiltration to the underground and those that are required for routine monitoring have been capped and locked. There are 1,337 historical surface boreholes in the current drillhole database that were collared outside a pit boundary and a subset of these intersect the underground.

Stability in the Underground

As noted in Chapter 3 and 4, conditions underground are changing and some stabilization of this area was required prior to the closure and reclamation activities described herein. A brief summary is outlined below and more information on site stabilization activities was outlined in Chapter 4.

The rock mass in which the underground openings at the Mine were excavated is typically massive and strong. Localized alteration adjacent to the shear zone orebody and fault and fracture zones has reduced the rock mass quality adjacent to the ore which was the target of mining. Ground relaxation around high-extraction mining areas creates local ground control issues. The underground excavations used as routine main travel ways by care and maintenance personnel are in reasonable condition, with either a systematic ground support system in place or management protocols applied to allow access where no ground support is present. Ground control is not maintained in the old stopes and rarely-used development openings. Access in these areas is only allowed by experienced personnel using specialized precautions. Note that the arsenic chambers were excavated in strong massive rock and have crown pillars that were previously assessed to be stable in the short to medium term which is broadly equivalent to a 10- to 50-year lifespan, though not specifically defined (Golder 2012a,b).

Underground backfilling work was initiated in 2013 as part of a site stabilization program (SSP) and is ongoing (approved Water Licence #MV2012L8-0010; Golder 2016a,b). The purpose of this program is to stabilize underground voids that pose an unacceptable risk to worker and public safety, and the future planned reclamation project. The stopes that were stabilized include:

- Arsenic Stopes B208 and B212/B213/B214 (Figure 5.1-1 and Figure 5.1-5)—assessed to have potentially unstable crown pillars and were backfilled in 2015. Investigations of selected arsenic stopes and chambers showed that they are not completely full, and some void space likely exists at the top of all of them.
- Non-arsenic stopes under Baker Creek (Stope B118 and Stope A370 complex; Figure 5.1-1)—hazard of potential crown pillar failure and subsequent mine flooding and were backfilled with cemented paste tailings in 2013 and in 2015.
- Non-arsenic stopes mid Stope B310 and upper Stope B306 (Figure 5.1-1 and Figure 5.1-5)—hazard of pillar failure with release of arsenic solids outside of the arsenic stopes. These were backfilled in 2015 using cemented paste tailings.
- Stope Complex C509 void which is under and adjacent to arsenic stope C212 and Chamber 9—represents an elevated risk of arsenic release into the underground. This was backfilled with a special backfill design in 2018 (Golder 2018c). See Section 4.1.2 for more detail.

No dust was placed in arsenic chamber 15 and it is currently empty. A fault zone was intersected during excavation of the chamber, which raised concerns that infiltration water could flow through the chamber during strong freshet seasons.

Underground Infrastructure

Mine infrastructure such as pumps, both large minewater pumps and small scale local sump pumps, ventilation fans, minewater and compressed air piping, mine rescue equipment, phones, electrical cable, etc. is present in the underground mine. The underground mine also contains hazardous waste and contaminants in areas such as maintenance shops, fuel and oil storage areas, and explosives storage areas but these have not been fully catalogued to date. Arsenic distribution pipes present in the underground have been dismantled and prepared for placement in a future frozen zone.

Minewater Pumping System

The minewater pumping system includes fixed underground pumps on the 750L near the Akaitcho Shaft that must be maintained using an underground travel way. Figure 5.1-3 shows a schematic long section of the mine with main shafts, pits, and the Supercrest ramp which is the current access pathway to the underground pumps which are on the 750L near the Akaitcho Shaft. The Akaitcho pumping system is used to maintain the minewater level approximately 12 m below the 750L (as measured at C Shaft) and the minewater elevation typically fluctuates around 0.75 m seasonally. Additional pump capacity is available at the Supercrest area if required during high inflow periods, for example, in 2012 when the minewater rose 3 m from the nominal operating level. Water is pumped to Northwest pond used a storage reservoir where water gets treated in summer and released to the settling pond, then the polishing pond, and ultimately Baker Creek.

This pumping system became increasingly costly to maintain due to deterioration of ground support; this support was installed in the access ramp that connect surface to the underground pumping station during production mining in the 1970s. In 2019, the underground pumps were replaced by two submersible pumps installed in boreholes drilled from surface to intersect the flooded underground mine workings in the Akaitcho area; the Akaitcho interim deep well pumping station is discussed further in Section 4. The combined pump capacity is similar to the combined capacity of the previous underground pumping system. The pumps are assumed to be operational for approximately 8 to 10 years (to 2026–2028) before pumping moves to the C Shaft area; additional detail on the underground pumping system and management of the water once it is pumped to surface is covered in Section 5.8.

5.1.3 Closure Objectives and Criteria

Based on the Goals and Principles for the GMRP, closure objectives were identified specifically for the closure and reclamation of the underground component. The objectives and criteria of the GMRP relating specifically to reclamation of the underground are presented in Table 5.1-2.

Table 5.1-2: Underground Mine Workings Closure Objectives, Activities and Criteria

Closure Objectives	Closure Activity	Closure Criteria	Monitoring/Maintenance and Inspection
UG1. Access to underground workings from surface openings is restricted for the safety of humans and wildlife	• Seal vertical openings to surface with either a cast-in-place engineered concrete cap, or a pre-cast cap placed over the opening. • Seal horizontal openings to surface using waste rock, concrete, polyurethane foam, or combinations thereof. • Close openings to surface present within the open pits in a manner that supports pit closure criteria (see Section 5.3).	• **UG1-1** All openings to underground are secured in a manner that meets the NWT *Mine Health and Safety Act*. • **UG1-2** Access to unsecured openings to underground areas is restricted. • **UG1-3** Design engineering drawings are signed and sealed by a Qualified Professional and the specifications outlined therein are met, such that access to the underground is restricted.	*Active Remediation, Adaptive Management and Post-Closure Phases:* • As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB. • Inspection by Mines Inspector as per the NWT *Mine Health and Safety Act*. • Operational Monitoring Plan: Physical inspection(s) of closed openings to surface.

UG2. Minewater elevation will be managed to maintain mine physical stability and chemical stability	• Construct the new deep well station in the C Shaft area to pump water from the mine pool to the new WTP (refer to Objective WTP2)
	• Maintain the minewater elevation such that it forms a groundwater sink (see Water Management and Monitoring Plan for details on pumping).
		Criterion in Development pending Planned Minewater Level Raise Reclamation and Research Plan
		• **UG2-1** Maintain minewater level at or below approximately the 750 L which is equivalent to -77 m * above mean sea level (amsl) ± seasonal fluctuation (refer Water Management and Monitoring Plan)
		
		Criterion in Development pending engineering works / Planned Minewater Level Raise Reclamation and Research Plan
		• **UG2-2** Minewater drawdown will not be faster than an amount that could destabilize the mine (estimated as 0.1 m/day, to be confirmed)
			Active Remediation Phase:
			• As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB.
			• Satisfactory final inspection by a Qualified Professional
			• Water Management and Monitoring Plan and Surveillance Network Program; monitoring of minewater pool chemistry and of minewater level at minewater intake.
			• Planned Minewater Level Raise Reclamation Research Plan
			Adaptive Management and Post-Closure Phase:
			• Water Management and Monitoring Plan and Surveillance Network Program;
			  • Monitoring of minewater pool chemistry and of minewater level at minewater intake.
			  • Monitoring of groundwater chemistry and levels to verify mine is a groundwater sink and confirm chemical stability
			• Operational Monitoring Plan: Monitoring to verify stabilizing backfill stays in place from surface via boreholes cameras.

UG3. Structures, controls, and adaptive management approaches used for the remediation of the arsenic trioxide meet appropriate design levels required for long-term care	• Plug underground openings connected to arsenic stopes and chambers and backfill all voids on top of arsenic stopes and chambers to provide thermal continuity to the frozen shell. • Backfill voids on top of arsenic stopes and chambers and near-surface non-arsenic stopes and boundary pillars as necessary • Establish new long-term underground mine access location within the Core Industrial Area.	• **UG3-1** Meets the NWT *Mine Health and Safety Act*. • **UG3-2** Satisfactory final inspection is performed by a Qualified Professional and the Mines Inspector. • **UG3-3** Stabilizing backfill stays in place. • **UG3-4** Potentially unstable crown pillar voids are backfilled such that subsidence does not cause damage to critical infrastructure. • **UG3-5** Design engineering drawings are signed and sealed by a Qualified Professional and the specifications outlined therein are met.	*Active Remediation, Adaptive Management and Post-Closure Phases:* • As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB. • Satisfactory final inspection by a Qualified Professional • Operational Monitoring Plan: Monitoring to verify stabilizing backfill stays in place and surface subsidence.
UG4. Underground is stabilized (geotechnically and physically) to reduce risks for public, workers, and wildlife safety	• Stabilize voids under surface crown pillars and under pits with paste tailings or other suitable materials as required based on stability assessments. • Backfill drifts connected to arsenic stopes and chambers to protect bulkheads in the event of unexpected mine flood or thawing of arsenic in chambers.	• **UG4-1** Drifts connected to arsenic stopes will be filled to the extent of the frozen shell • **UG4-2** Paste backfill meets minimum 100 kPa specification; to prevent liquefaction during seismic event • **UG4-3** Stabilizing backfill stays in place as documented by cameras/inspections • **UG4-4** Design engineering drawings for underground backfill are signed and sealed by a Qualified Professional and the specifications outlined therein are met *Criteria in Development pending engineering work* • **UG4-5** Voids under potentially unstable crown pillars will be filled to the extent practical (dependant on void geometry and access) such that no more than 1 m subsidence would occur at ground surface. • **UG4-6** Voids under pits will be filled to the extent practical (depending on void geometry and access) to prevent no more than 1 m subsidence of the fill in the pits, and damage to pit covers, where installed.	*Active Remediation, Adaptive Management and Post-Closure Phases:* • As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB. • Satisfactory final inspection by a Qualified Professional Operational Monitoring Plan: • Monitoring of position of stabilizing backfill in arsenic and non-arsenic stope voids from surface via boreholes cameras. • Monitoring of stope backfill settlement under pits. • Monitoring of settlement of fill in pits (see Objective P2)

NWT = Northwest Territories; MVLWB = Mackenzie Valley Land and Water Board; WTP = water treatment plant; L = level; * Number has been rounded to the nearest metre

5.1.4 Consideration of Closure Options and Selection of Closure Activities

Options for Stabilizing Pillars and Filling Voids

Early options for stabilization of underground voids to protect rock crown, rib, and sill pillars were outlined in the DAR (INAC and GNWT 2010) and during underground preliminary design work (Golder 2012d). These analyses included removal of crown pillars, stabilizing of pillars with ground support, or backfilling voids. The chosen option was backfilling voids with cemented tailings paste material made from primarily Giant Mine tailings. This was deemed the most efficient and effective over the long term as the material was present in large quantities on the Site and no new borrow or off-site materials would be required. Removing crown pillars would needlessly disturb the ground surface and the resulting void may need to be filled in with yet more borrow material and accordingly be costly. Ground support rarely has a lifespan of greater than 50 years and is therefore does not meet the principle of minimizing long-term care requirements. Key considerations driving the selection of closure activities for stabilizing pillars and filling voids are shown in Figure 5.1-6.

One key consideration in the selection of closure options and closure activities related to the underground includes keeping Baker Creek on site (Section 5.5), which impacts the open pit closure requirements as outlined in Section 5.3. The underground must be protected from a flood and some of the underground voids and partially backfilled stopes under and adjacent the open pits must be backfilled to meet the closure objectives and criteria.

Stabilizing most of the voids simply requires filling the stope with a relatively non-compressible material and keeping it in place to protect both worker and public safety as required for the chosen access profile. Backfill strength is only required for reasons of keeping any high liquid content backfill material, such as a cemented paste, from liquifying during a seismic event to protect underground workers, or if the backfill needs to form a structural support member which is minimal. As noted above, several rounds of stope filling using paste were executed between 2013 and 2015 as part of the SSP water licence work plan (INAC and GNWT 2014) and described in Golder 2016b. Additional backfilling of the C509 void to complete the SSP work was carried out in 2018. This work showed that the use of Giant Mine tailings to make paste can be successfully employed to stabilize voids by backfilling them.

Some non-arsenic stopes that are under Baker Creek and the Giant Mine Access Road were identified to be backfilled in the SSP program and were later determined to not be an immediate hazard and backfilling those stopes has been deferred to the Active Remediation and Adaptive Management Phase of the project (Golder 2015a). These include stopes adjacent to the north end of A2 pit and stopes and adjacent to the Northwest Pond near Highway 4.

Despite the success of the paste backfill, the wide variety of conditions observed underground will necessitate variations in backfill approach. This could include placement of concrete, cemented rockfill, classified tailings and/or pneumatically placed rockfill in addition to paste to stabilize voids. A detailed assessment of the most appropriate method to backfill each void that requires stabilization will be made including trade-offs that look at underground accessibility, surface delivery borehole location availability, number and nature of possible leakage points for high mobility semi-liquid backfill (e.g., paste), availability of material to make backfill, and cost, among others is currently underway.

Underground – Key Drivers for Closure Decisions

Higher ↑ Priority ↓ Lower

Drivers	Design Considerations	Selected Options
Safety/Physical stability for human, environment, infrastructure	➢ Stabilize underground mine to prevent damage to surface infrastructure ➢ Arsenic trioxide chambers are physically stable ➢ Stabilize underneath pits ➢ Water level in mine is maintained until further study confirms possibility of raising minewater elevation to reduce minewater pumping for water treatment ➢ Prevent injury to people and wildlife through surface expression of underground instability (sinkholes)	**Contaminated material and fill from roaster or roaster area put in a frozen shell** **Underground Stabilization with Paste Backfill** **Closure of Openings to Surface** **Construction of long-term access portal** **Minewater elevation maintained**
Technical Feasibility	➢ Minimize long-term care requirements ➢ Openings to surface are secured, but underground remains accessible for maintenance/inspection/reversibility ➢ Logistics of disposing of roaster area arsenic waste are reviewed	**Reclamation Research Plan on Minewater Elevation to inform minewater management and closure criteria**

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2018-12-19
DESIGNED	H. Machtans
PREPARED	D. Pahl
REVIEWED	J. Amphlett
APPROVED	J. Amphlett

PROJECT

Giant Mine Remediation Project

TITLE

KEY CONSIDERATIONS DRIVING THE SELECTION OF CLOSURE ACTIVITIES FOR THE UNDERGROUND MINE

REV.	FIGURE
0	5.1-6

Options for Closing Openings to Surface

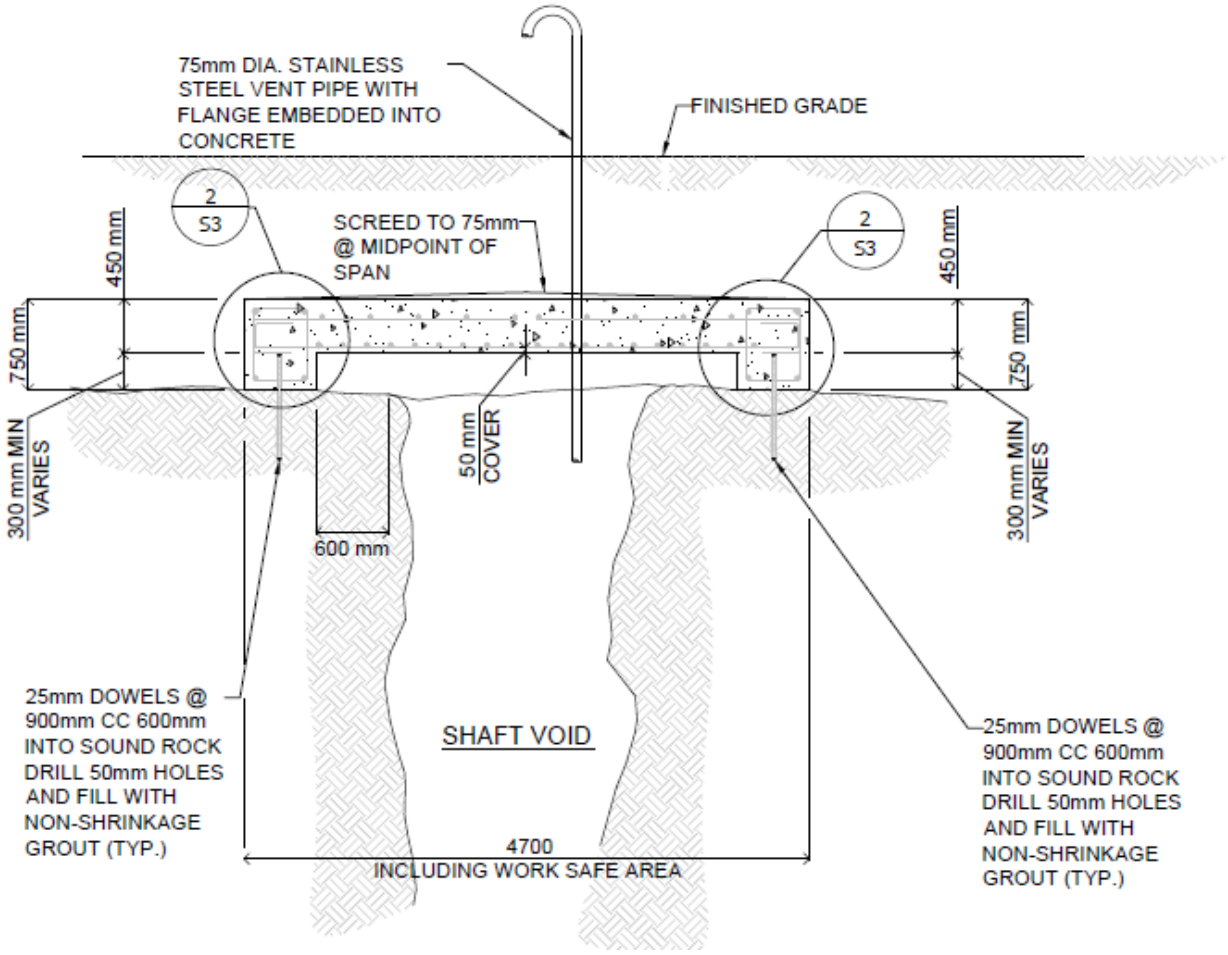
As noted above, numerous openings to surface are located within the open pits and will be closed as part of the pit closure work (Section 5.3). These openings include ventilation raises and underground portals, as well as mine workings (stopes and drifts) that were intersected during the mining of the pits. These openings will be closed by stabilizing the areas below the pit, adding clean borrow or contaminated granular fill to openings to surface, and in some cases filling the openings to surface with paste tailings, and backfilling the open pits (Section 5.3).

For openings to surface outside of the pits, other options were reviewed. The Closure Guidelines suggest constructing a cap over openings. The cap should be constructed on solid rock and secured to it, or supported with a concrete collar secured to solid bedrock (MVLWB/AANDC 2013). A typical example of a concrete cap placed on a vertical opening is shown in Figure 5.1-7. This example illustrates placing fill over the finished concrete cap, which may be appropriate in some case for final grading and terraforming purposes.

Alternatives could include filling sub-vertical shafts with backfill (soil, cemented rockfill, or paste), and blasting or destroying sub-horizontal adits. These options can also be combined with concrete caps. For the construction of concrete caps, alternatives were described in the preliminary design report (Golder 2012c) including the use of cast-in-place concrete, precast concrete segments (one-way or two-way slabs), and using different shoring/forming alternatives for the concrete.

The final approach to close the openings to surface outside of the pit boundaries has not been defined. Further investigations of the openings to surface will be completed to support selection of the preferred options.

Figure 5.1-7: Preliminary Design Report Typical Concrete Cap for Vertical Opening to Surface



Options for Disposing of Arsenic Wastes in a Frozen Zone

The DAR (INAC and GNWT 2010) indicated that process residuals from the Roaster and Mill complexes, as well as any other materials or machinery contaminated with soluble arsenic will be disposed within one of the planned freeze zones. The volume of this material was estimated at approximately 16,000 m^3 (Golder 2017b; Section 5.9).

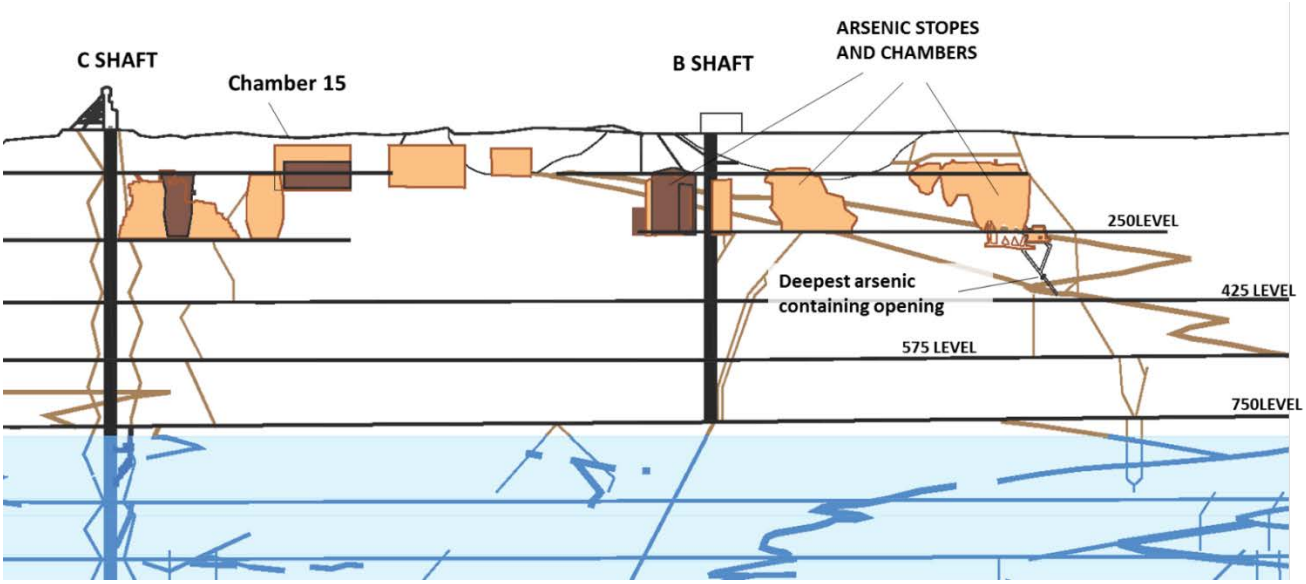
Chamber 15 of the underground mine is empty, and it lies within the planned freeze zone. An assessment was conducted to determine if the waste could fit into Chamber 15 and how best to place it there (Golder 2017b; Figures 5.1-3 and 5.1-8). This assessment identified that the two best options for placing contaminated material into Chamber 15 were (a) driving new drifts into Chamber 15 from B2 Pit or (b) excavating sub-vertical raises from surface directly into Chamber 15. Sub-vertical raises driven from the rock slope above Chamber 15 were chosen as the preferred approach (Golder 2018d) given that the full height of the chamber could be used, it provides a working platform that can be used for thermosyphon installation, and requires no lateral excavation or ground support.

In addition to the 16,000 m^3 of process residuals (and other materials and machinery contaminated with soluble arsenic), approximately 52,000 m^3 of heavily contaminated granular fill from around the perimeter of the Roaster Complex is planned to be managed in a freeze zone (Section 5.4). Storage in the frozen zone of B1 Pit may be possible for this material, and additional storage may also be available underground. The additional storage space underground includes in drifts adjacent to arsenic stopes and chambers, and in void spaces that are available in the arsenic stopes and chambers as a result of dust settlement or partial filling of the stopes and chambers in the past. The Roaster Complex wastes are currently stored in shipping containers on the Central Pond. There are also soluble arsenic wastes originating from other Care and Maintenance activities stored in the Northwest Pond hazardous waste storage area. The typical composition of recovered arsenic waste generated during remediation programs, is described in Section 4.1.1. Recovered arsenic wastes were segregated by size and placed in drums, 1 m^3 bags, and 2-3 m^3 bags. Larger waste items were not placed in bags or drums.

For the storage of arsenic waste in the frozen zones, it is preferred to dispose of the bagged wastes within Chamber 15 as this material is easier to handle and easier to recover in the future should alternative remediation approaches become available. Waste containing larger pieces of debris will be placed into B1 Pit for freezing. B1 Pit may be more suitable for this material as these pieces would be more difficult to handle and bring back to surface if placed in Chamber 15.

A similar approach is being reviewed for the disposal of the remaining contaminated on-site materials that are to be placed within a freeze zone (Chamber 15 and B1 Pit). The final configuration and placement of these materials in the freeze zone is under review, including the reduction of volume to be disposed of (Appendix 5.1A).

Figure 5.1-8: Schematic Long Section Showing Arsenic Stopes and Chambers and Mine Levels Above Current Water Level (Looking West)



Options for Minewater Level Raise

As outlined in the DAR and the Reasons for Decision (MVIERB 2013), the minewater level could be raised in the future, which would reduce long-term care and maintenance of this Site by reducing the need for water pumping

and treatment. It is common practice in mine closure projects to allow underground mine flooding so long as the receiving environment is protected. Note that full mine flooding or a partial minewater level raise are distinct from seasonal fluctuations around the current minewater level, which are expected (CIRNAC and GNWT 2019).

There are several advantages to including the option of raising the minewater above the 750L during the Active Remediation and Adaptive Management phase at the Site including:

- Flooded mine workings and stope backfill are typically more stable than dry ones and are much more stable than areas where minewater levels fluctuate between wet and dry, so flooding has an overall generally stabilising influence on the flooded portions.
- Reducing the potential for geotechnical instabilities by lowering the potential energy. It is noted that initial flooding may induce local instabilities that may or may not need to be managed, however it reduces the potential for future instabilities over time.
- Limiting oxidation of exposed wall rock and waste rock and tailings backfill in the underground is a benefit for chemical stability.
- Reducing the minewater pool interception with deep connate groundwater which will have higher total dissolved solids (salt).
- Reducing power consumption by lowering pumping rates to maintain the minewater level, as well as corresponding operating costs.
- Reductions in groundwater inflow from the subsurface surrounding the mine, reducing the total volume to be treated by the water treatment plant.
- Flooding may dilute zones of concentrated arsenic contamination and mixing in the mine pool, which could in turn create a more consistent water quality profile to make water treatment plan operation more efficient
- Flooding frozen zones will result in cracks being infilled with ice which will stop rapid movement of water and contaminated fluid through the rock mass.

Further, the DAR (Section 6.8.3 in INAC and GNWT 2010) suggested that prior to completion of the initial ground freezing the minewater level should not be raised above the 425L (Figure 5.1-3; Figure 5.1-8). This was identified as an interim measure to reduce the risk of arsenic seepage and to keep the arsenic trioxide dust in the chambers and stopes dry. The 425L is approximately 12 m below the deepest arsenic containing void and 50 m below the 250L (Figure 5.1-3; Figure 5.1-8). Once freezing was complete, the DAR also stated that the minewater could be raised to a proposed maximum level of just below the bottom of A2 Pit (Figure 5.1-8).

Despite the preliminary studies presented in the DAR to support a possible minewater level raise, it is anticipated that a raise cannot be done in the short term. The mine needs to remain open to complete stabilization of the underground and to allow removal of physical infrastructure and relevant hazardous wastes, to protect the arsenic chambers as they freeze, to keep the contaminated minewater in the mine pool and not allow later transfer of contaminants to nearby groundwater or lakes, and to remain as storage for minewater for water treatment. Additional studies are required to determine details on if, when, and how the overall minewater levels can be raised above the 750L during this Water Licence term. Details on how the mine will respond to a water level raise are required to fully understand implications of a raise above the 750L on freezing, water treatment plant operation, physical stability, void backfill designs, and where stabilising void fill position

monitoring is required. A minewater level Reclamation Research Plan (Appendix 5.1B) has been developed to determine when, and how, the overall minewater levels can be permanently raised above the 750L during the Water Licence period. As such, no final closure option for a planned minewater level raise is yet chosen.

Options for Mine Access

Long-term mine access is needed to allow for re-entry to the mine in case of unexpected conditions. This includes needing access for underground inspection to address occurrences such as deep underground instability or mine fill movement or access to the freeze areas. Options for the location of the new long-term portal and underground mine access were evaluated using the following factors:

- The portal elevation should be above possible minewater level increase elevations.
- Location must allow inspection of key underground areas such as the C509 backfill and backfilled drifts connected to the arsenic stopes and chambers
- Location should be near the main remediation construction office / shops areas in a secure area

Based on the above, the most appropriate location is thought to be near the current C-dry but final review is necessary. The location is also outlined in Section 5.9 on mine infrastructure that will remain once closure is complete.

Selected Closure Activities for Underground

To achieve the closure objectives outlined in Section 5.1.4 and Table 5.1-2 after review of various options, the CRP broadly proposes the following selected underground closure activities (Section 5.1.2.2):

- Selected arsenic and non-arsenic stopes and chambers will be backfilled, to the extent practicable. Selected near surface non-arsenic stopes that underlie Baker Creek will be backfilled to the extent required to reduce the risk of mine flooding via a failed or damaged crown pillar that would allow Baker Creek water into the mine. The type of backfill may vary depending on engineering factors and other factors such as access to the area for public safety (see Section 5.3.5.1 for more discussion).
- Underground openings, including drifts and raises that are connected to an arsenic stope or chamber, will be plugged or filled in a manner required to reduce the potential for damaging the arsenic bulkheads and allowing arsenic solids release should an unexpected mine flood occur before freezing is complete or should an unexpected chamber thaw occur. The backfill will provide a media for drilling thermosyphon holes through underground openings near arsenic stopes and chambers should it be required.
- Within pits, the openings to surface (see Section 5.3 on pit filling) will backfilled, to the extent practicable, where there is potential for crown pillar failure or void fill movement. Some openings may be plugged or capped in a manner required to enable safe filling of the pits and to allow drainage through the caps and plugs so that excess pore pressure cannot build up in the pit fills.
- Openings to surface outside the pits may be closed by installation of an engineered concrete cap or alternate design.
- Open boreholes that are known to exist, either cased arsenic dust transport holes or open uncased exploration holes, will be plugged with cementitious grout as they are encountered. Boreholes drilled for remediation purposes (e.g., adding backfill to subsurface stope voids) will be filled with cementitious grout.

Boreholes required for monitoring, such as groundwater monitoring and stope void fill position holes, will have a lockable cap placed on them and an inventory of borehole locations will be kept.

- Mine wastes that need to be frozen will be placed in Chamber 15 via new subvertical raises. The void space on top of the waste and the raises will be filled with paste and the new openings to surface capped. Additional contaminated soil waste may be placed in the frozen zone under or in B1 Pit.
- Minewater elevation will be maintained at approximately 750L and the feasibility of a future minewater level raise will be reviewed through a Reclamation Research Plan.
- A new long-term mine access portal will be established in a safe location to allow inspection of the underground in the long-term operation and maintenance phase should this be necessary.
- Hazardous material will be removed from the mine, particularly materials that could contaminate the minewater including material from maintenance shops, fuel and oil storage areas, and explosives storage areas. Note that no specific options analysis was conducted with regards to the removal of infrastructure underground, this will be included in the closure activities.
- Selected mine infrastructure such as the Supercrest and Akaitcho pumps, local sump pumps, selected ventilation fans, mine rescue equipment, etc., may be brought to surface and salvaged.

Note that the majority of underground development openings (tunnels, raises, ore passes, etc.) shown in Figure 5.1-1 (1st Level development openings in blue and deeper development openings in orange) are anticipated to be stable and will not be backfilled.

5.1.5 Engineering Work

A summary of engineering work associated with previous or ongoing site stabilization work and planned closure activities for the underground is included in Table 5.1-3. Most of this is design engineering. Previous studies are included as they represent case studies on which remediation activities will be based. Ongoing design studies to execute underground remediation activities and future investigations needed to support construction work are also listed.

Table 5.1-3: Engineering Design Work Required for Closure Activities for the Underground

Component	Engineering Work	Completed (Y/ N / In Progress) [Reference]
Openings to surface	Preliminary engineered design for closure options for each opening	Y [Golder 2012c]
	Design and construction of permanent engineered concrete cap on C Shaft	In progress 2018
	Design and construction of permanent engineered concrete cap on A Shaft	In progress 2018
	Geotechnical investigation and final designs for remaining openings to surface outside of pits	N, 2018–2020
Near surface non-arsenic crown pillars	Stope Complex C509 stability analysis and backfill design completed; void backfilled with a paste and concrete to stabilize opening in event the fill material moves during actively fluctuating the minewater level	Y [Golder 2016b, 2018c)
	Stope Complex B118 stability analysis and backfill design completed; stope complex backfilled in 2015	Y [Golder 2016b]
	Stope Complex B310-mid stability analysis and backfill design completed; stope complex backfilled in 2015	Y [Golder 2016b]
	Stope A370 stability analysis and backfill design completed; stope complex backfilled in 2015	Y [Golder 2016b]

Table 5.1-3: Engineering Design Work Required for Closure Activities for the Underground

Component	Engineering Work	Completed (Y/ N / In Progress) [Reference]
Near surface non-arsenic crown pillars (con't)	Stope B306 stability analysis and backfill design completed; stope complex backfilled in 2015	Y [Golder 2016b]
	Investigation of remaining near surface non-arsenic stopes	Y [Golder 2017a]
	Stope B212/B213/B214 stability analysis and backfill design completed; stope complex backfilled in 2015	Y [Golder 2016b]
	Stability assessments of near surface non-arsenic stopes and stopes under and adjacent to open pits to determine which need to be stabilized by backfilling	In progress 2018
	Assessment to determine requirements for backfilling near surface non-arsenic stopes under and adjacent to open pits	In progress 2018
Arsenic stope and chambers	Arsenic stope B212/B213/B214 and B208 stability analysis and backfill design completed; stope complex backfilled in 2015	Y [Golder 2016b]
	Stability assessment of un-filled arsenic stopes and chambers to determine which need to be stabilized using backfill.	In progress 2018
	Assessment to determine requirements for backfilling arsenic stopes and chambers.	In progress 2018
	Assessment to determine requirements for backfilling to support freeze activities	In progress 2018
	Designing plans for disposal of arsenic waste in Chamber 15	In progress 2018 (Updates in Appendix 5.1A, Golder 2018d)

Note: the Planned Minewater Level Raise Reclamation and Research Plan will support engineering works

The following sections provide additional details on the engineering work required for the underground components of the closure plan.

5.1.5.1 Underground Hazard and Risk Assessments

Detailed final stability and hazard assessments are required to determine which of the remaining underground voids need to be backfilled, the extent of the backfilling (e.g., void fullness), and the required performance (e.g., strength and durability) of the backfill material, to meet the objectives and criteria. They will not only determine which voids need to be stabilized by backfilling, but the priority sequence in which they should be filled to limit risks to the public and to workers when carrying out implementation such as pit filling or other closure activities. The determination of which voids need to be stabilized by backfilling will include the following steps:

1) Determine the stability condition of crown pillars of each stope or stope complex and whether the stope was backfilled during the mining cycle and with what material.

2) Assess the risk associated with failure based on: potential for injury or fatality using the probability of failure of the crown pillar coupled with a quantitative estimate of worker or public exposure, which will depend on the position of the void on the property (e.g., if any access restrictions). and risk tolerance thresholds. A QRA was undertaken in 2018 and underground stability assessments and public exposure estimates to determine risks to the public will be forthcoming. Risk tolerance thresholds will be determined through the QRA process and will be used to determine which underground voids need to be filled. The determination of backfilling requirements for voids under the pits will not only look at worker and public safety but also the requirement to limit settlement of the pit fills and possible pit covers. The results of the QRA may require changes to the underground design work to respond to concerns identified or for opportunities to reduce risk. It is assumed the fence around the Core Industrial Area (Figure 5.1-1) will limit public exposure and

will influence the QRA and underground risks including which near-surface stopes should be filled, the level/fullness of void backfill and type of backfill.

5.1.5.2 Void Backfilling

After updated stability assessments are completed, detailed designs will be developed and implemented to stabilize near surface non-arsenic stopes, arsenic stopes and chamber crown pillars, and non-arsenic stopes under and adjacent to arsenic containing voids and open pits. The primary void stabilization approach will be to add a suitable amount of backfill to the void to reduce void height and the potential for migration of any degradation of the rock in the top of the stope void. The requirements to determine how the backfilling work will be accomplished in the near surface non-arsenic stopes and in voids under the open pits includes:

- Determine the amount of underground ground support rehabilitation required to allow safe access for engineering assessment and design and for workers to implement underground void plugging.
- Use existing drilling and LiDAR based cavity monitoring system scan data in conjunction with underground inspection to determine the size and character of the voids to be filled, including connectivity to adjacent voids to the best extent practicable.
- Determine the potential for existing backfill in the stope voids to exit the stope via. connections, particularly during planned and potential changes to the minewater elevation through underground inspections and examination of historical mine plans.
- Based on stope void size, shape, connectivity to other openings, and proximity to accessible surface areas and safe underground access, determine an appropriate backfill method and material including volumes and the required level of backfill (e.g., allowable remnant void space after work is complete).

The requirements to determine how the backfilling work will be accomplished in arsenic containing openings include:

- For arsenic stopes and chambers, assess the potential for compaction of the arsenic dust to determine volume of backfill required:
- Develop a performance-based specification to fill the voids to the extent required to meet the criteria. Some voids will be filled to support other closure activities such as freezing. Lower, intermediate, and upper drifts connected to the arsenic stopes and chambers will be backfilled to support the arsenic bulkheads and enable drilling through voids where necessary. The amount of fill required, suitable fill material, and the best method of delivering it into the drifts connected to an arsenic stope or chamber will be determined using the following approach:
    - Assess the lower, intermediate, and upper arsenic drifts connected to arsenic stopes or chambers to assess the void size and shape and any connectivity of the drifts to adjacent stopes or mine workings.
    - Define the extent from the arsenic bulkheads outward into the drift that requires backfilling to meet freeze requirements as developed by the advanced freeze design (Section 5.2).
    - Based on drift void size, shape, connectivity to other openings, and proximity to accessible surface areas and safe underground access, determine an appropriate backfill method and material.

- Bulkheads with the potential for water pressure to build up behind them will be dealt with differently during stabilization programs than those in dry arsenic stopes and chambers.

Backfilling is anticipated to be carried out using a combination of existing tailings; aggregate from both on-site and off-site sources (primarily on-site); and water present in tailings ponds, the underground, or available treated water in the Polishing Pond; binder; and required additives. Anticipated backfill types may include paste backfill, cemented rockfill, concrete, self-consolidating concrete, lightweight/foamed concrete, and pneumatically placed rock fill. As noted in Section 5.1.3, the final stabilization assessment may determine that some voids that need to be backfilled are potentially subject to movement of the current fill in place in the void, and these may need special designs including plugging of exits and the addition of self-supporting structural members. At this time no stopes that require self-supporting members, such as have been implemented into the Stope Complex C509, have been identified. A detailed assessment of the most appropriate method to backfill each void that requires stabilization will be made prior to remediation construction work being initiated. Backfill option assessments will include trade-offs that look at underground accessibility, surface delivery borehole location availability.

Most voids will be filled by drilling a borehole and adding cemented paste to the void. Other backfill materials such as waste rock or concrete may be placed into the voids or into surface boreholes or directly from the underground if access is possible. Most boreholes used to fill voids will be filled with cemented paste or backfill upon the completion of the work except for those left open for monitoring the position of backfill. The type of fill will depend on whether the hole was cased or not and the character of the breakthrough into the underground void and will be designed on a case by case basis.

Preliminary backfill volume estimations have been calculated for the preliminary stability assessments completed for all non-arsenic stopes and arsenic stopes and chambers (Golder 2012a,b). Table 5.1-4 presents a summary of the volumes of backfill that are expected to be required to fill the remaining non-arsenic stopes and arsenic stopes and chambers.

Table 5.1-4: Summary of Backfill Volumes Required for Selected Closure Method

Backfill	Estimated Volume Requirement (m^3)
Non-arsenic stopes	~140,000
Non-arsenic stopes adjacent to arsenic stopes	~70,000
Arsenic stopes and chambers	~14,000
Backfill of voids under pits	~180,000
Backfill of arsenic freeze drifts	~25,000
Total	**~430,000**

Underground backfilling work is anticipated to be carried out in the following sequence:

1) Backfill any voids under and adjacent to arsenic stopes and chambers including drifts connected to them so freeze drilling can proceed.
2) Backfill voids under and adjacent to open pits so their filling can progress.
3) Backfill near surface stopes in a priority sequence based on risk ranking integrated with the overall site remediation construction schedule.

In some cases, incomplete backfilling may result due to factors such as:

- a lack of underground access to plug voids
- challenging access on surface to allow drilling and backfilling
- uncertainties related to the geometry of the underground and the connectivity of stopes between them

If underground backfill work cannot be done in a manner that satisfactorily reduces worker or public risks, fences or local berms will be used to control access to limited areas of elevated risk on the ground surface above these specific underground voids. Inside the core fenced area these may not be required depending on the level of expected uninvited access to the site as influenced by the QRA process.

5.1.5.3 Openings to Surface

Openings to surface will be closed once demolition of infrastructure on top of some of the openings to surface is completed, for example the B Shaft ventilation works, or the Akaitcho vent raise headframe, as outlined in Section 5.9. Preliminary designs for closure of openings to surface have been developed (Golder 2012c). The preliminary designs considered the construction details and plans needed for closing the vertical shafts and ramps. For the vertical openings, such as vent raises or mine shafts, the three concepts are a two-way cast-in-place concrete cap and either a two-way or a one-way pre-cast concrete beam panel. Closure caps will need to be designed to withstand a temporary impact from a Baker Creek flood and bear any soil fills required for final site grading.

Final designs will be determined by the following steps:

1) Complete a geotechnical inspection of the opening, which may include investigative drilling.

2) Based on geotechnical inspection, complete the design of closure structure.

Boreholes that connect surface and underground will be located and plugged, to the extent practicable. When undertaking surface construction, such as excavation of a new Baker Creek channel (Section 5.5), the borehole database will be used to check for boreholes that connect the surface to the underground and an attempt to locate and plug them will be made. Because the boreholes are small diameter (likely hole diameter of 60 mm) their collar locations are often difficult to locate, especially if drilled in overburden materials or even in rock where local surface weathering and sloughing into the holes makes them difficult to see.

5.1.5.4 Storing Contaminated Material in Frozen Zone

There are currently approximately 16,000 m^3 of combined process wastes and other materials and machinery contaminated with arsenic, along with approximately 52,000 m^3 of heavily contaminated granular fill from the roaster area that need to be placed in a frozen zone. Some mine wastes that need to be frozen will be placed in Chamber 15, which is currently empty and studies are currently under way to determine whether some of these materials can be placed in B1 Pit and frozen to the required criteria (Appendix 5.1A; Newman's 2018). Approaches to reducing the amount of material that needs to be frozen or finding additional areas in other pits or underground areas near areas planned to be frozen, including the open void portions of existing arsenic stopes and chambers (Appendix 5.1A) may be required for contingency planning. Investigations into these approaches are ongoing.

Placement of material that needs to be frozen into B1 Pit is described in Section 5.3. New sub-vertical raises that connect surface and Chamber 15 will be excavated to allow placement of the material in the chamber (Golder 2018d). The sub-vertical raises will be excavated using blasting techniques to connect surface to the chamber. Raise construction will take advantage of required road access and platform development needed to support freeze activities (Section 5.2). Waste material will be extracted from the temporary storage containers and inserted into Chamber 15 via the raises. Ventilation designs will be developed that include a negative air pressure from surface openings to keep dust from backfilling activities from escaping to the environment or posing an unacceptable risk to workers. Once the chamber has been filled as much as practically possible, the chamber will be topped with paste backfill to enhance stability and reduce permeability. Paste backfill will be delivered through either boreholes or drop raises from surface. The raise excavations will be backfilled with cementitious grout and/or paste to close them off. Where specified, monitoring holes or conduit installed within a drop raise will be left open for ongoing monitoring purposes. A concrete cap will be placed at the top of the raises. The filled Chamber will eventually be frozen as described in Section 5.2.

5.1.5.5 Incorporation of Minewater Level Changes in Underground Design Work

As outlined above in Section 5.1.4, a minewater level Reclamation Research Plan (Appendix 5.1B) has been developed as part of the CRP to determine if, when, and how the overall minewater levels can be permanently raised above the 750L during the Water Licence period. Ongoing groundwater modelling and underground water balance work will be used to evaluate the range of minewater fluctuations that could occur during after 2026 when the Northwest Pond is not available as a surface water storage pond and the water level could vary seasonally in higher water years (Section 5.5, 5.6 and 5.8; CIRNAC and GNWT 2019).

Potential effects of both expected seasonal minewater level fluctuations and possible minewater level raises that could impact the underground that need to be mitigated include:

- Flooding of critical mine infrastructure such as mine access for inspections and maintenance, and resulting damage to power systems, mine services, and communication systems.
- Destabilization of mine backfill located within the range of fluctuations. Minewater level rise may destabilize backfill, however, the biggest destabilizing effect of a fluctuation in minewater level is when the water level must subsequently be reduced by pumping, resulting in an unequal pore pressure distribution in both existing and new backfill due to variability in the permeability of the various materials. Sand backfill that was placed during past mining operations could be susceptible to liquefaction and movement out of the stopes to deeper areas of the mine. Where the possibility of such an event exists, the integrity of new stabilizing backfill located above impacted areas could be compromised.

To mitigate this, mine infrastructure on the 750L will be removed prior to the commissioning of the new WTP when seasonal minewater fluctuations are possible (Section 5.8; CIRNAC and GNWT 2019). In addition, some of the existing underground infrastructure, such as the maintenance shops, fuel and oil storage areas, and explosives storage areas, also contain materials that could contaminate the minewater with contaminants that the water treatment system is not designed to remove; these sources of contaminants will be removed from the underground infrastructure as part of planned reclamation activities (Section 5.10) prior to the commissioning of the new WTP when minewater fluctuations could impact these materials.

Ongoing groundwater modelling and underground water balance work will be used to also evaluate the range of minewater fluctuations that could occur under plausible future scenarios where minewater level raise could occur, and these studies are further described in Appendix 5.1B.

Any mine infrastructure that would impact minewater quality would need to be removed prior to any additional raises in minewater level above 750L should this occur in the future.

Void backfill design will consider the potential range of anticipated minewater level fluctuations during freshet and storm events and the subsequent required reduction in minewater level. This includes the period when the minewater level could fluctuate above the 750L, and under possible future scenarios where the minewater level is gradually raised in a step-wise manner above the 750L that will be developed during the minewater level Reclamation Research Plan work. Void backfill engineering will deal with the planned water level fluctuations and possible minewater level fluctuations and water level raises primarily through two broad methods:

1) Plugging off exits to stopes where potentially liquefiable or mobile existing stope and drift fills could move deeper into the mine, thus removing the stabilising effect on the crown pillars any new void filling backfill that was added for stabilizing purposes during the Active Remediation and Adaptive Management Phase.

2) Adding self-supporting backfill that could remain stable should the backfill below it move deeper into the mine. This would represent a similar approach to the backfilling carried out in 2018 to stabilize the Stope Complex C509 as described in Section 5.1.2.2 and in Golder 2018c.

These approaches are necessary because although placement of the mine backfill is reversible, re-entry into the mine in the adaptive management phase will be difficult and the correct backfill must be placed to deal with all plausible minewater level scenarios during the Active Remediation and Adaptive Management Phase.

5.1.5.6 Long-Term Access Portal

A new long-term mine access portal will be established in a safe location to allow inspection of the underground in the post-closure period should this be necessary. The portal will also serve as access to the underground frozen arsenic storage areas (arsenic stopes and chambers including Chamber 15) to support future reversibility efforts. The portal will be closed with a locking steel door to enable re-access when required. The portal location will be chosen based on criteria to allow underground inspection of key underground areas such as the C509 backfill and backfilled drifts connected to the arsenic stopes and chambers. The portal elevation will be chosen to be above predicted minewater raise elevations. It will be constructed in good quality rock mass for ease of construction and long-term stability.

5.1.6 Final Site Conditions

After completion of the underground mine closure activities, the final site condition will be as follows:

- selected underground voids near surface and under pits will have been backfilled. This backfilling will have been done with cemented tailings or concrete material
- underground drifts leading to arsenic stopes and chambers will have been backfilled with a material such as cemented paste tailings to form a local plug near the existing arsenic bulkheads
- caps will be constructed on top of vertical openings to surface that are not within the existing pit limits

- fill or concrete or paste plugs will be placed in horizontal openings to surface that are not within the existing pit limits
- selected backfill delivery boreholes that are cased with steel will remain present over critical backfill areas that are required for stability monitoring during the active remediation, adaptive management, and in some rare cases during the long-term operation and maintenance phase, some local fencing and signage may be present around areas of the underground that could not be reliably stabilized
- open boreholes that were previously connected to the underground that are encountered will have been filled with cementitious grout
- arsenic-impacted waste will be disposed of in the frozen zone of Chamber 15 or B1 Pit
- water management activities (Sections 5.5, 5.8, and the Water Management and Monitoring Plan) will occur, keeping the minewater level at 750L until the Reclamation Research Plan is complete
- a post-closure underground access portal will be maintained that can be re-activated if necessary, to allow personnel to check on stability or access the arsenic stopes and chambers (reversibility)

5.1.7 Uncertainties

Engineering designs for much of the closure plan related to underground are currently at a preliminary level. As such, the basis for estimates and analyses include engineering judgement. Additional design works are planned to address key assumptions and reduce relevant uncertainties. However, some underground entities associated with the SSP have been designed to a very high level and remediation work has been implemented adding confidence to the preliminary approach for the remainder of the closure plan. The key uncertainties that affect the underground mine workings are summarized below in Table 5.1-5, together with the engineering studies and other activities planned to address these uncertainties.

Table 5.1-5: Underground Mine Workings Uncertainties

Uncertainty	Potential Impact of Uncertainty	Plan to Address Uncertainty
The geometry of stopes and possible exit points for existing non-cemented fill to move deeper into the mine are uncertain.	Greater volumes of backfill may be required to stabilize stopes than estimated. There may be inadequate support to near surface non-arsenic stope crown pillars or pillars between non-arsenic stopes and arsenic stopes or chambers with resulting physical hazards and risk to the remediation plan. There may be inadequate support to stopes under pits, resulting in destabilization of fill in stopes below pit fills with resulting physical hazards and damage to pit covers, if present.	Detailed backfill design will consider securing existing fill. Cemented backfills will be used in locations where there is potential for openings below the backfilled stope. Monitoring plan will identify locations where fills have moved and a response plan to address changes to underground stability.
The volume of stopes and possible exit points for new void filling material being added to the stope are uncertain.	Greater volumes of backfill may be required to stabilize stopes than estimated.	The underground stopes will be backfilled prior to closure of the tailings ponds to verify adequate backfill materials is available to backfill stopes per the design criteria.

Table 5.1-5: Underground Mine Workings Uncertainties

Uncertainty	Potential Impact of Uncertainty	Plan to Address Uncertainty
The magnitude of minewater level fluctuations is uncertain.	Unexpectedly high minewater fluctuations could result in destabilization of fill and inadequate support to near surface non-arsenic stope crown pillars or pillars between non-arsenic stopes and arsenic stopes or chambers with resulting physical hazards and risk to the remediation plan. Unexpectedly high minewater fluctuations could result in destabilization of fill in stopes below pit fills with resulting physical hazards and damage to pit covers, if present.	Required stabilizing backfill will consider anticipated minewater level fluctuations and stabilization approaches will include the use of high cement paste and concrete in localized areas or to mitigate potential structural failures below the fill. Confidence in anticipated minewater level fluctuations and how a potential planned minewater level raise would be able to manage anticipated fluctuations will be gained during proposed tests outlined in the Minewater Level Reclamation Research Plan (Appendix 5.1B).
The integrity of existing mine infrastructure (sill pillars, wood bulkheads or doors etc.) is uncertain below the current water level or in areas that are otherwise inaccessible.	Failures could result in destabilization of fill and inadequate support to non-arsenic stope crown pillars or pillars between non-arsenic stopes and arsenic stopes or chambers, resulting in physical hazards and risk to the remediation plan.	Detailed design for mine backfilling will consider this uncertainty. Monitoring and response plans will be developed.
Areas that are stable after remediation could destabilize, particularly during future minewater level fluctuations.	There may be localized areas of subsidence with resulting physical hazards.	Information on residual hazards will be made available via as-built documentation, maps and signage.

SECTION 5.2
Freeze Program

5.2 Freeze Program

5.2.1 Description

From 1951 to 1999, approximately 237,000 t of arsenic trioxide dust was produced, and the dust was transferred to underground for storage in five mined-out stopes and 10 purpose-built arsenic chambers (Section 5.1.2.2). The arsenic trioxide dust is hazardous to human health and the environment and it can dissolve readily in water. Arsenic-contaminated groundwater could be released into the surrounding environment, so it is necessary to contain the dust. To accomplish this, a freeze program is proposed. 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 or fill and will freeze the arsenic dust in the storage chambers, stopes, and other mine workings to prevent the release of arsenic. The MVEIRB indicated in the Reasons for Decision that the frozen shell concept as an interim solution is acceptable for the 100-year lifespan of the project (MVEIRB 2013).

A monitoring program will be designed to measure ground temperatures at strategic locations. The temperature data will be hardwired to remote IO (Input/Output) cabinets at each chamber and stope, then will be transmitted to a central data storage location. The measured temperatures, in combination with a calibrated thermal model, will allow for monitoring of the status of the frozen shell into the future and any warming affects from climate change.

This section has been developed with information and conclusions from various reports completed over the course of the GMRP, especially the DAR (INAC and GNWT 2010), the *Giant Mine Remediation Plan* (SRK/Senes 2007), and the *Giant Mine Freeze Program – Design Basis Report* (DBR; SRK 2016). The Design Basis Report is attached in Appendix 5.2A.

5.2.2 Pre-disturbance and Existing Site Conditions

5.2.2.1 Pre-disturbance Conditions

Relevant information on subsurface conditions prior to mine development can be found in Chapter 2.

5.2.2.2 Existing Conditions

On-site mine processing and the production of arsenic trioxide by-products ended in 1999. In total, approximately 237,000 t of arsenic trioxide was stored in 15 of the 16 mined-out stopes and purpose-built chambers over the 50-year mine life. Purpose-built storage chambers were constructed for the storage of arsenic, but the mined-out stopes were also used for storage (Section 5.1) and were favoured as their development costs were lower.

These chambers and stopes are listed in Table 5.2-1 with their respective quantities of stored arsenic trioxide dust. A full history of the management of arsenic trioxide at the Site is described in the *Giant Mine Remediation Plan* (SRK/SENES 2007).

Table 5.2-1 Arsenic Trioxide Dust Storage Chambers and Stopes

Chamber/Stope	Mass of Arsenic Trioxide Dust (dry tonnes)
B230	2,835
B233	11,426
B234	12,048
B235/236	32,945
B208	29,364
B212/213/214[(a)]	59,289
C212	16,946
9	18,394
10	9,569
11	5,860
12	26,243
14	12,257
15	0

a) Arsenic Stopes B212, B213, and B214 are connected.

Prior to the mid-1980s, it was anticipated that at closure the permafrost would naturally re-establish around the underground stopes and chambers and immobilize the arsenic trioxide dust. Over time, investigations indicated that the natural permafrost no longer existed around the chambers or stopes due to proximity with adjacent mine workings and the impacts from warm air in the mine as a result of the mine ventilation system. The DAR (INAC and GNWT 2010) also notes that there was strong observational evidence that groundwater flow in these areas was increasing.

In the mid-1980s, the criteria for selecting suitable storage chambers changed and no longer relied on the presence of natural permafrost. Instead, a site was considered suitable if the rock was competent, the area could be sealed off from the other mine workings, and the excavation was generally dry. Chambers 11, 12, 14, and 15 were built to satisfy these criteria and exist, at least partially, above the permafrost zone elevation. Chamber 14 was commissioned in 1995 and was the last chamber to be used for arsenic trioxide dust storage. Chamber 15 was also built at the time but was never filled and remains empty.

Temperature sensors installed in and around the stored dust in Stopes B208, B214, and C212 and Chamber B233 in 2004 indicate the temperature range was -4°C to 5°C at that time. It was identified that without a permanently frozen barrier, arsenic trioxide has the potential to contaminate the surrounding groundwater and environment. To prevent this from happening, the Site's water level is currently maintained below the arsenic dust storage areas.

In 2010, Chamber 10 was outfitted with ground freezing equipment as part of a pilot project. The bedrock and fill surrounding Chamber 10 was frozen to less than -5°C. In 2015, the active ground freezing equipment was shut off, and the bedrock remains partially frozen. This is further described in Section 5.2.4.1.

5.2.3 Closure Objectives and Criteria

Based on the goals and principles for the GMRP, closure objectives were identified specifically for the freeze program. The objectives and criteria of the GMRP relating specifically to reclamation of the TCAs are presented in Table 5.2-2.

Table 5.2-2: Freeze Program Closure Objectives and Criteria

Closure Objectives	Closure Activity	Closure Criteria	Monitoring/Maintenance and Inspection

F1. Arsenic trioxide dust and arsenic-impacted waste disposal areas are not, and will not become, a source of contamination to the environment	• Prepare and install supporting site infrastructure for the freeze program:
	  • Civil works including access roads, backfilling, and pads.
	  • Underground mine works (refer to Objectives UG3 and UG4).
	  • Electrical works, instrumentation, and monitoring equipment.
	• Freeze the bedrock or fill around each arsenic containing chamber, stope, drift or pit fill using thermosyphons to develop the frozen shell.
		• **F1-1** The dust will be considered contained when a 5 m wide frozen shell at -5°C or colder exists in the bedrock or fill around each arsenic containing chamber, stope, drift or fill in pit.
		• **F1-2** Design engineering drawings are signed and sealed by a Qualified Professional and the specifications outlined therein are met, to contain the arsenic trioxide dust.
			Active Remediation Phase:
			• As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB.
			• Satisfactory final inspection by a Qualified Professional
			Active Remediation Phase, Adaptive Management and Post-Closure Phase:
			Arsenic Trioxide Frozen Shell Management and Monitoring Plan
			• Monitoring of frozen shell temperatures to show evidence that they remain at, or colder than -5°C within 5 m of an arsenic containing chamber, stope, drift or fill in pits. Any warming trends will be evaluated and if necessary, mitigation efforts to protect the frozen shell will be undertaken.
			• Post-closure monitoring will be used to evaluate climate change impacts on the frozen shell with action being taken to satisfy the containment criteria
			• Results of thermal modelling will predict performance, and instrumentation monitoring demonstrates the performance of the system; the alignment between modelling and monitoring shows the system will remain effective under a wide range of climate change and operational scenarios.
			• Review and regular calibration of thermal models to confirm frozen shell performance.
			• Inspection of thermosyphons, electrical, instrumentation, and monitoring equipment.

F2. Reversibility for future technology developments in remediation has been maintained	• Freeze the bedrock or fill around each arsenic containing chamber, stope, drift or pit fill using thermosyphons to develop the frozen shell. • Plug drifts connected to arsenic stopes and chambers with a fine-grained cemented material that can be excavated later if access through the long-term portal to the arsenic dust is required in the future (refer to Objective UG3).	• **F2-1** Reversibility is maintained as each arsenic containing chamber, stope, drift or pit fill with arsenic trioxide dust and arsenic-impacted waste are contained within the frozen shell. • **F2-2** Backfill at minimum 100 kPa strength can be excavated to access chambers. Refer to UG4-2. • **F2-3** Design engineering drawings are signed and sealed by a Qualified Professional and the specifications outlined therein are met, such that reversibility for future access is maintained.	*Active Remediation Phase:* • As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB. • Satisfactory final inspection by a Qualified Professional *Active Remediation Phase, Adaptive Management and Post-Closure Phase* Arsenic Trioxide Frozen Shell Management and Monitoring Plan • Monitoring of frozen shell temperatures to show evidence they remain at, or colder than -5°C within 5 m of an arsenic containing chamber, stope, drift or fill in pits. Any warming trends will be evaluated and if necessary, mitigation efforts to protect the frozen shell will be undertaken. • Review and regularly calibrate thermal models to confirm freeze performance to confirm frozen shell performance. • Inspection of thermosyphons, electrical, instrumentation, and monitoring equipment. • Independent review conducted every 20 years to evaluate effectiveness, and consider research results

MVLWB = Mackenzie Valley Land and Water Board

The key to achieving the closure objective of preventing arsenic release to the environment is the containment of the arsenic trioxide dust. By creating a frozen shell, the arsenic dust will be isolated from the surrounding environment preventing the movement of dust or water across the frozen barrier. The dust will be considered contained once the surrounding rock at each chamber or stope is frozen. To achieve the active remediation and post closure objectives for containment, a single freeze criterion has been adopted as stated below. This criterion simplifies and maintains or increases the conservatism of the freeze criteria suggested in the design basis report (DBR). Meeting this criterion indicates that the dust is always inherently contained. Integrity of the frozen shell can be confirmed through a post closure monitoring program that includes temperature monitoring outside of the dust.

As noted in Table 5.2-2, the freeze containment criterion is:

- A minimum 5 m wide zone of bedrock or fill at -5°C or colder around each arsenic containing chamber, stope, drift or pit fill.

While the frozen shell will isolate the dust below a temperature of -2°C, a -5°C target provides a margin of safety against local variability in freezing rates, rock properties, and porosity. The requirement for -5°C at a distance of 5 m from the dust provides additional security. This security is particularly relevant during re-saturation of the surrounding rock, as would occur if the minewater level was allowed to rise.

If a warming trend occurred with the potential to exceed the containment criterion, this would be indicated by post-closure monitoring of temperature. Warming trends will require investigation and could require mitigation. This will be included as part of Arsenic Trioxide Frozen Shell Management and Monitoring Plan.

Extensive thermal modelling has been completed to indicate that the ground freezing criteria can be achieved at each arsenic-containing chamber or stope. In addition, a full-scale trial was implemented on Chamber 10 as part of a freeze optimization study to demonstrate, amongst other objectives, that large scale ground freezing has the ability to achieve the ground freezing criterion. This is further described in Chapter 4 and in Section 5.2.4.1.

5.2.4 Consideration of Closure Options and Selection of Closure Activities

In 1999, a technical advisory team was formed to develop a long-term management plan for the arsenic trioxide dust. Between 2000 and 2002, the technical advisory team assessed over 56 options. Twelve remedial alternatives were considered: seven in situ alternatives that would store the dust underground and five ex situ alternatives that would have the dust brought to the surface for disposal or further processing:

- A1: water treatment with minimum control
- A2: water treatment with drawdown
- A3: water treatment with seepage control
- B2: frozen shell
- B3: frozen block
- C: deep disposal
- D: removal and surface disposal
- F: removal, gold recovery and arsenic stabilization

- G1: removal and cement encapsulation

The nine alternatives listed were further assessed on the basis of arsenic release and health and safety risks, implementation costs, and long-term monitoring/maintenance costs. Following evaluation by the technical advisory team and the Independent Peer Review Panel, it was recommended to narrow the options down to the best in situ alternative and best ex situ alternative. Of the in situ alternatives (A1 to C), it was concluded B3 was the best due to its combination of arsenic release risks both during remediation and post-closure. The water treatment alternatives (A1 to A3) would require long-term operation of pumping and treatment equipment and was therefore considered to have higher post-closure arsenic release risks. Alternative C, which involved mining the dust and disposing at the base of the mine, was considered to have worker health and safety risks that were too high. Of the ex situ alternatives, alternative D, which involved trucking the dust to hazardous waste disposal sites in Alberta had unacceptable risks of arsenic release. Alternatives F and G1 had similar and more acceptable arsenic release risks, but alternative G1 was less costly and was therefore considered the preferred ex situ alternative.

These two remaining alternatives (B3 and G1) were brought forward for presentation to the final round of public discussion. During these discussions, from January to May 2003, concerns were expressed on the ex situ alternative with certain participants from the Yellowknife Members of the Legislative Assembly and from GNWT outright rejecting the ex situ alternative. Direct opposition to the in situ alternative was limited. From these discussions, the recommendation was then made to proceed with the in situ frozen block alternative (B3). Details of the recommendation are described in the *Giant Mine Remediation Plan* (SRK/SENES 2007) and the *Giant Mine Arsenic Trioxide Management Alternatives – Final Report* (SRK 2002).

During the EA process, suggestions were received for refining the frozen block alternative. These suggestions, combined with findings from the Freeze Optimization Study (FOS, described below), were used to further modify the frozen block alternative by removing the need for freeze pipes underneath the chambers and stopes and eliminating the need to wet the dust within them. In support of the reversibility closure objective, keeping the dust dry facilitates potential future extraction if alternative ex situ remediation technologies evolve to better manage the arsenic trioxide dust. The recommended design thereafter became known as the dry frozen shell method. The alterations are presented in the *Freeze Optimization Study Update for MVEIRB and Parties* (SRK 2012). Key considerations driving the selection of closure activities for the containment of arsenic trioxide dust is shown in Figure 5.2-1.

Freeze – Key Drivers for Closure Decisions

Higher ↑ Priority ↓ Lower

Drivers	Design Considerations	Selected Options
Meet regulatory requirements: **- Measure 18, 19**	➢ **Adoption of dry method after further assessment** ➢ **Reversibility: do not adopt any method of freezing that significantly reduces opportunities for future arsenic removal or other remediation by future technologies**	**Freeze existing arsenic chambers in place** • **Use thermosyphons to create frozen shell** • **Seal chambers with material that can be excavated in future**
Technical Feasibility	➢ **Freeze Optimization Study demonstrates technical feasibility** ➢ **Modelling shows that freeze can meet design needs even with climate change** ➢ **Passive freeze can be upgraded to active if needed**	
Input from affected parties and technical experts	➢ **Independent expert evaluation of options to address arsenic trioxide dust** ➢ **Input from affected parties on freeze alternatives**	

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2018-12-19
DESIGNED	H. Machtans
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APPROVED	J. Amphlett

PROJECT

Giant Mine Remediation Project

TITLE

KEY CONSIDERATIONS DRIVING THE SELECTION OF CLOSURE ACTIVITIES FOR THE CONTAINMENT OF ARSENIC TRIOXIDE DUST

REV. 0

FIGURE 5.2-1

5.2.4.1 Freeze Optimization Study and Selection of Ground Freezing Technology

The FOS was a full-scale physical trial that evaluated active, passive, and hybrid (both active and passive) freeze systems. It also considered different pipe spacing, installation techniques, and construction materials. Prior to the FOS, thermal models had been developed using literature estimates of thermal properties. The FOS was instrumental in collecting data to quantify thermal properties of the bedrock at the Site. The specific objectives of the FOS, which are also summarized in the DBR (SRK 2016), are as follows:

- demonstrate the effectiveness of large-scale ground freezing
- estimate parameters needed for engineering design
- test implementation methods
- develop monitoring and data handling methods
- identify constraints and opportunities related to procurement and project delivery
- examine “unknown unknowns” (i.e., acknowledging project uncertainty and unexpected design issues)

The full-scale trial included 38 drill holes outfitted with associated freeze pipes, 31 instrumented drill holes to collect performance data, a mechanical plant for the active freeze system, a mechanical plant for the hybrid freeze system, and all associated auxiliary piping, electrical, monitoring, and control equipment. The system is fully described in the *Giant Mine Freeze Optimization Study Freeze Pipe Installation As-Built Report* (SRK 2010). A photograph showing the above-ground components of the FOS, taken in 2014, is provided in Photo 5.2-1.

Photo 5.2-1: Components of Freeze Optimization Study



Construction of the FOS was completed in late 2010 and freezing started in March 2011. The FOS was designed with different configurations of pipes/thermosyphons. Throughout the life of the FOS, different groupings of freeze pipes were activated and deactivated or converted from hybrid to passive operation as part of the overall testing program. The results of the FOS were compiled into the *Giant Mine Freeze Optimization Study Findings Report* (SRK 2015). These findings fed into the recommendations for the design of the site-wide freeze program as summarized in the DBR (SRK 2016).

As of April 2015, the active freeze systems have been shut down but thermosyphons, where installed, continue to passively freeze the ground. The monitoring to date suggests that where thermosyphons exist the frozen conditions are being maintained, and the ground is warming where active freeze pipes have been deactivated. This means the FOS is now providing data regarding warming of the system as it trends to a new equilibrium while responding to climate and geothermal drivers. As part of final design, the FOS freeze infrastructure already installed at Chamber 10 will be modified to match final design requirements.

Information requests during the EA process, together with results obtained during the FOS, led to the identification of 12 design variants of the dry frozen shell method. Each variant considered passive-only systems, active-only systems and a hybrid system and resulted in different thermosyphon layouts, freeze time frames, and associated costs. These optimization studies are summarized in the DBR (SRK 2016). It was concluded that the preferred closure option (Variant 9) would be a fully passive solution.

Variant 9 was configured to passively freeze all chambers and stopes as quickly as possible. The time to achieve freeze-containment criterion was estimated and then later refined using 3D thermal modelling. The freeze objectives are met when the freeze criterion is reached, but the risk will start decreasing earlier as the ground falls below 0°C. The times for each chamber / stope to freeze differ and will be refined during detailed design based on final design layouts and calibrated inputs.

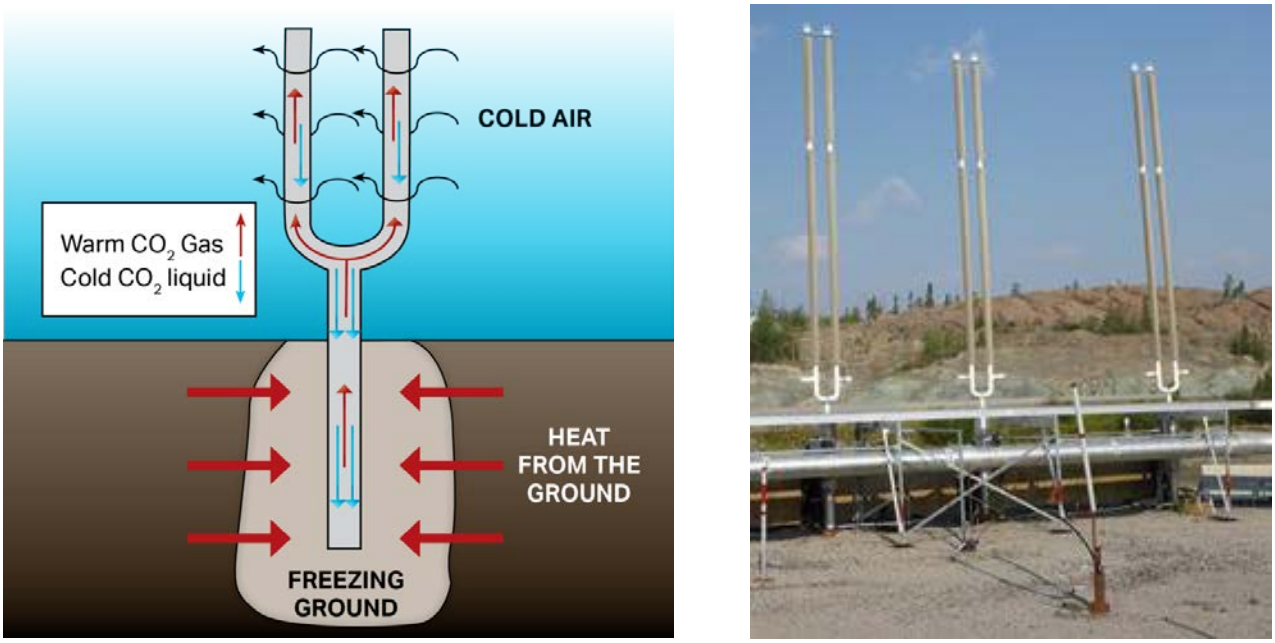
5.2.4.2 Description of Passive Freeze System

A passive freeze system can only be used with northern climates where the effects of winter cooling are not completely offset through summer warming. The passive system uses specially designed pipes called thermosyphons to freeze the ground without the need for additional electricity or a freeze plant. Thermosyphons are installed as deep into the ground as freezing is required. The pipes then protrude above the ground a relatively short distance. The portion of pipe that extends above the ground is fitted with radiator fins.

The thermosyphon pipe is filled with carbon dioxide (CO_2), which acts as the heat transfer medium. Thermosyphons are inactive when the air temperature is warmer than the ground temperature. When the air temperature cools, the warmer ground heat evaporates the CO_2 in the pipe. As the CO_2 gas warms, it rises until it reaches the above radiator fins that are exposed to the colder air. The air cools the gas which then condenses to a liquid and flows back down the inner wall of the pipe. It is reheated by the ground, evaporates, and rises to the top of the pipe. This process continues as long as the air is cold enough to condense the CO_2 and the ground is warm enough to evaporate the CO_2. When the air temperature becomes warmer than the ground, the process temporarily stops.

A photograph of a thermosyphon installed for the FOS and a diagram showing the heat transfer process is provided in Figure 5.2-2.

Figure 5.2-2: Process Diagram and Thermosyphon



Thermosyphons have advantages over active freeze pipes. They are less complex in design and also less expensive. An active freeze system requires an energy source and a mechanical system to cool and distribute the heat transfer medium to each freeze pipe. It also requires full time operation and maintenance personnel. The disadvantage to thermosyphons is that the rate of freezing is slower as it can only function in cold weather. The fully passive solution was preferred since it had the best balance of cost, complexity, and the time to meet the freeze criteria.

The DBR includes preliminary thermosyphon layout patterns for each dust-filled chamber or stope. Thermal models of these layout patterns indicate that ground freezing will be adequate to meet the overall remediation objectives. Optimization of these layouts will be completed during detailed design to fine tune system performance, constructability, schedule, and cost.

At the time of preliminary design, Chamber 15 and B1 Pit were not included in the initial freeze program. Contaminated materials from the roaster demolition, as well as the heavily contaminated granular fill excavated from the area surrounding the former Roaster Complex, will be disposed in a freeze zone such as Chamber 15, B1 Pit, or in other arsenic-containing mine workings. Options for the disposal of this arsenic contaminated waste are summarized in Appendix 5.1A (refer to Section 5.1).

5.2.5 Engineering Work

The DBR (SRK 2016) provides a comprehensive summary of the engineering work completed to date. The engineering work presented in the following sections provides a summary of the current design of the passive freeze system for the long-term management of the arsenic trioxide dust at the Site, the engineering works to support the freeze system, and key issues to be addressed in detailed design.

5.2.5.1 Passive System Design

The selected design (SRK 2016) has the thermosyphon perimeter pipes extend 20 to 30 m below the base of the arsenic dust to create the frozen shell zone below the chamber/stope bottom. The typical surface pipe layout has a 5 m offset distance from the chamber/stope walls to the freeze pipes. Each chamber/stope has a slightly different pipe spacing but generally ranges from 3 to 5 m. A site layout for the design is shown in Figure 5.2-3.

In total, there are 688 proposed thermosyphons consisting of 605 thermosyphons installed around the perimeter of the chambers/stopes, 48 shallow thermosyphons installed above the chambers/stopes, and 35 thermosyphons installed into the chambers/stopes. This translates to an estimated cumulative pipe length of 64,456 m.

Pipe spacing and thermosyphon locations will be refined during detailed design to account for underground geometries, surface topology, and constructability issues. Modifications to layouts will also be refined to account for the disposal option for the contaminated materials from the roaster demolition, as well as the heavily contaminated granular fill excavated from the area surrounding the former Roaster Complex.

Spacing of the thermosyphons has been based on the maximum feasible spacing to maintain the containment criterion under a future global warming scenario. The freeze design also provides for future flexibility in design modifications if needed to maintain the freeze criterion. For example, localized freezing can be supplemented by converting a thermosyphon into a hybrid freeze pipe.

The ground temperatures will be monitored with temperature sensors at strategic locations and a regularly calibrated thermal model will be used to identify any areas that may require additional localized freezing to meet and maintain containment criterion. Decisions on implementation of these contingency measures can be made well in advance. Corresponding action trigger levels will be established as part of the monitoring plan.

Figure 5.2-4 shows an example of a graph that could be generated using a calibrated thermal model. The image presents the warmest temperature within a 5 m thick shell around a chamber over the design life of 100 years of freezing and subjected to climate warming. Once all the ground within the frozen shell is at, or colder than -5°C, the chamber is considered contained. The thermosyphons will continue to cool the ground with each winter season following containment, initially over cooling the ground as reflected by the hatched area between the -5°C dashed line and the warmest temperature line. This additional cooling provides a buffer against possible climate warming. Data collection and modelling as part of the monitoring plan will indicate when a warming trend develops and will help identify action trigger temperatures or conditions, so containment of the arsenic dust will be maintained.

Thermosyphons will be constructed using welded high pressure steel pipe connected to a radiator. Above- and near-ground portions of the pipe and radiators will be painted white to maximize heat losses and mitigate against corrosion. The thermosyphon design includes the ability to maintain, fix or replace individual thermosyphons including the installation of a hybrid thermosiphon should it be required during the life of the project.

P:\60540587\900-CAD_GIS\910-CAD\30-FIGURES\G\00\60540587-FIG-00-0000-G-0523.dwg

ANGLED AT 13°
FROM VERTICAL

ANGLED AT 13°
FROM VERTICAL

AREA 4 (B212-B213-B214)
3m SPACING ON SIDES
4m SPACING ON ENDS
5m SHALLOW THERMOSYPHON SPACING

ANGLED AT 16.7°
FROM VERTICAL

B1 PIT

STOPE B208
3m SPACING ON SIDES
4m SPACING ON ENDS
3m INTERNAL THERMOSYPHON SPACING

CHAMBER B234
4m SPACING ON NORTH SIDE
5m SPACING ON ENDS

CHAMBER B233
3m SPACING ON SIDES
4m SPACING ON ENDS

CHAMBERS B235 AND B236
3m SPACING ON SIDES
4m SPACING ON ENDS
3m INTERNAL THERMOSYPHON SPACING

TWO ANGLED THERMOSYPHONS TARGETING THE SIDES OF BULKHEAD 66 TO MOVE THE COLLAR LOCATIONS AWAY FROM THE B2 PIT SLOPE

B2 PIT

CHAMBER B230
3m SPACING ON SIDES
4m SPACING ON ENDS

CHAMBER 11
4m SPACING ON SIDES
5m SPACING ON ENDS
6m SHALLOW THERMOSYPHON SPACING

CHAMBER 12
4m SPACING ON SIDES
5m SPACING ON ENDS
6m SHALLOW THERMOSYPHON SPACING

CHAMBER 14
5m SPACING ON SIDES
6m SPACING ON ENDS
8m SHALLOW THERMOSYPHON SPACING

SEE NOTE 6

CHAMBER 15
(EMPTY)

C2-12
3m SPACING ON SIDES
4m SPACING ON ENDS

CHAMBER 9
4m SPACING ON SIDES
5m SPACING ON ENDS
6m SHALLOW THERMOSYPHON SPACING

CHAMBER 10 (FOS LAYOUT)
4m SPACING AROUND PERIMETER
8m SHALLOW THERMOSYPHON SPACING

C1 PIT

LEGEND

- 1st LEVEL (100) UNDERGROUND DEVEOPMENT
- 2nd LEVEL (250) UNDERGROUND DEVELOPMENT
- UNDERGROUND RAMPS, DECLINES AND INCLINES
- INTERMEDIATE DEVELOPMENT BETWEEN LEVELS
- ARSENIC CHAMBERS AND STOPES MAXIMUM EXTENT
- NON-ARSENIC STOPES ADJACENT TO AND ARSENIC STOPE
- BAKER CREEK
- EMPTY CHAMBER
- BACKFILLED DURING SITE STABILIZATION WORK (2013-2018)
- RAISE
- BULKHEAD
- LONG SIDE THERMOSYPHONS
- END THERMOSYPHONS
- SHALLOW THERMOSYPHONS
- INTERNAL THERMOSYPHONS

0 62.5 125 m

1:2500

NOTES

1. COORDINATE SYSTEM IS THE GMRP COORDINATE SYSTEM.
2. COMPOSITE LEVEL PLANS, EXISTING GROUND TOPOGRAPHY, AERIAL PHOTO AND MINE LAYOUT PROVIDED BY PWGSC.
3. CHAMBER LAYOUTS OPTIMIZED FOR CONTAINMENT AS PER PRELIMINARY DESIGN PROGRESS IN THE 2016 DESIGN BASIS REPORT.
4. THE UNDERGROUND MINE GEOMETRY INFORMATION IS APPROXIMATE AND NOT SUITABLE FOR DESIGN PURPOSES.
5. NOT ALL WORKINGS AND STOPES SHOWN.
6. POSSIBLE RAISES TO DELIVER HEAVILY CONTAMINATED ARSENIC IMPACTED ROASTER WASTE TO CHAMBER 15 (TO BE FROZEN).

SOURCE

PORTIONS OF THIS FIGURE ARE EXTRACTED FROM THE SRK DRAWING "Variant9Layout.dwg" FROM THE 2016 FREEZE PROGRAM DESIGN BASIS REPORT. OTHER PORTIONS ARE TAKEN FROM GOLDER FIGURE 5.1-5 WITHIN THIS REPORT.

PROPONENT

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

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

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PREPARED	C. Eros
REVIEWED	M. Gregg
APPROVED	R. Schmidtke

PROJECT

Giant Mine Remediation Project

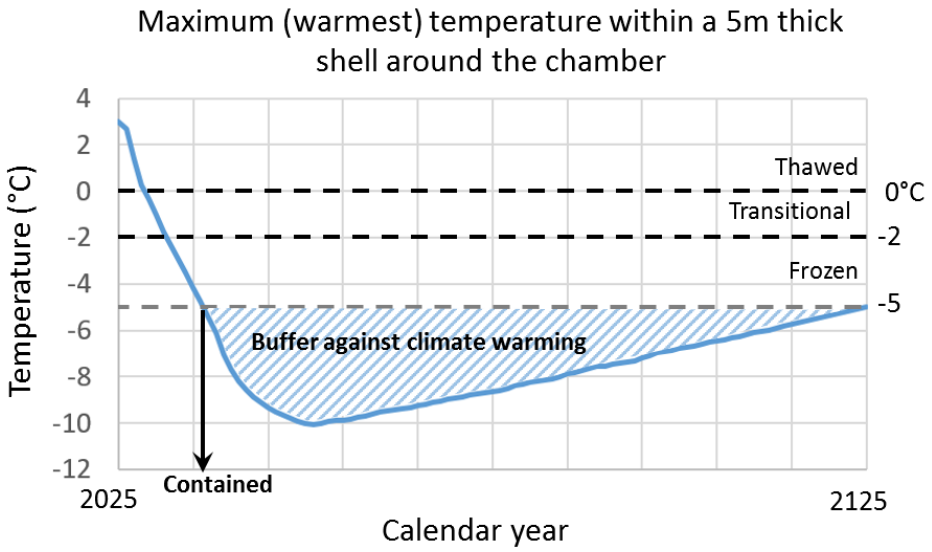
TITLE

THERMOSYPHON CONCEPT LAYOUT

REV. 0

FIGURE 5.2-3

Figure 5.2-4: Modelling predictions of the warmest temperatures within a 5 m thick shell around a chamber



During detailed design, aspects of the design for each chamber/stope will be finalized, including:

- refining thermosyphon pipe layouts, orientations, and depths to account for any underground interferences and surface constructability issues
- co-ordinating the need for, and the design of, drift plugs where thermosyphons might pass through existing drifts
- confirming where internal thermosyphons are required that will be drilled directly into the arsenic trioxide dust
- confirming where shallow thermosyphons are required; these will be located above, but not into, the chambers or stopes
- co-ordinating and accounting for backfilling required within the planned freeze zones
- planning and designing drilling access for each thermosyphon
- specifying and characterizing surface treatments above each chamber/stope

Detailed design for each chamber and stope will be completed in co-ordination with 3D thermal modelling to refine freeze time predictions to achieve the freeze criterion. In some cases, the modelling will be completed by only analyzing the worst-case section (i.e., vertical slice) of the chamber or stope. Where more complex issues exist (e.g., varying ground or fill types as a result of B1 Pit backfilling), a full 3D geometry of the chamber or stope may be modelled.

The key steps involved with refining thermal models during detailed design include:

- updating underground model geometries and geology in the area of the arsenic chambers and stopes
- accounting for proposed surface treatments and impacts of snow cover
- refining moisture contents of existing chamber or stope dust and saturation depths
- updating finite element mesh sizes and boundary conditions

Thermal modelling provides better predictive accuracy compared to other geotechnical modelling efforts such as groundwater flow rates or ground deformations. Thermal predictive accuracy is achievable because the required model inputs have a narrow range of potential values. For comparison, when predicting groundwater flow rates, the governing material property is the hydraulic conductivity of the ground, which is known to vary up to 10 orders of magnitude (10 to the power of 10) for different ground types. This means that the predicted rates can also vary by a wide range. In contrast, thermal inputs and therefore predictions only vary by a factor of 3 to 4 across all ground types. The rock at the Giant Mine is very competent and homogeneous from a thermal perspective, which narrows the likely range of model inputs even further. Data obtained from the FOS also adds to the accuracy of the models. For this reason, it is expected that the freezing duration predictions are reasonably accurate.

Thermal models will be used not only to predict freeze times but also to plan the construction schedule for the Site (Chapter 6). Since thermosyphons become active the first cold season following installation, staging of thermosyphon construction will govern when freezing is initiated across the site.

5.2.5.2 Civil, Electrical and Instrumentation Design

A program of civil works is required prior to the thermosyphon drilling and installation program. Surface preparations are required for both safe drilling and installation of the thermosyphons and will also provide access to the thermosyphons in the long term for follow up maintenance and contingency work, if required. In general, the surface preparations entail constructing a granular freeze pad above each chamber/stope that consists of a base layer of 100 to 150 mm crushed rock, a layer of 75 mm minus granular material, and topped with a layer of 20 mm minus granular material to provide a serviceable running surface for equipment. The thickness of each layer will vary by specific requirements in each freeze area, but the total fill depth will typically range from 1,600 to 3,000 mm.

Access roads to each freeze pad will be constructed to allow access for drill-rigs, excavators, and other construction vehicles. Roads will range between 6 to 10 m in width with a maximum road grade of 11%. The typical road structure will be 300 mm thick consisting of similar materials to the freeze pads (i.e., base layer of 75 mm minus granular material and driving surface of 20 mm minus granular material).

Each freeze area has specific demolition and construction requirements for surface preparation. Area 1 is located below a large bedrock outcrop with B2 Pit on its west side and Baker Creek on its east side. Part of the bedrock must first be blasted and/or filled to provide a flat surface for the freeze pads. The civil design will be done with a goal to minimize both the cut and fill volumes, as well as minimize changes to the appearance of the bedrock outcrop. The optimization of cut and fill volumes along with crown pillar stability assessment will be completed in detailed design.

Area 2 is located between the former Highway 4 and C Shaft, with part of Stope C212 beneath the Mill Pond. The Mill Pond will be backfilled to allow construction of the C212 freeze pad. Areas 3 and 4 are located to the north of the former roaster buildings and extend adjacent to B1 Pit. The former Highway 4 crosses above Chambers B233 and B234 and the thermosyphons will lead to its closure. General levelling and backfilling will be required in the areas either side of Highway 4.

Stopes B208 and B212/213/214 are partially located below B1 Pit. The drilling and installation of thermosyphons for these stopes require at least partial backfilling of B1 Pit. The pit will be backfilled with well-graded and compacted material to mitigate excessive settlement to prevent damage to thermosyphons. The majority of this backfill will be within the freeze zones; therefore, arsenic impacted materials from the roaster demolition, as well as the heavily contaminated granular fill excavated from the area surrounding the former Roaster Complex could be used as fill. Refer to Section 5.10 for descriptions and estimated quantities of the arsenic impacted materials and its proposed disposal strategy. Refer to Section 5.4 for descriptions and estimated quantities of contaminated granular fill and its proposed disposal strategy.

The freeze design also requires an electrical and instrumentation program. In some areas, demolition or relocation of existing power poles and overhead lines is required. For example, in Area 1 there are two power poles located in the proposed construction zone. These will be demolished and the power lines will be relocated as part of the site wide electrical distribution redesign.

A series of instrumentation drill holes will be constructed at each chamber/stope to allow for monitoring of bedrock and fill temperatures. These drill holes should be a minimum of 76 mm (3-inch) diameter to allow installation of threaded 38 mm (1.5-inch) ID SCH80 PVC pipes that house the instrumentation strings. The DBR recommended a total of 126 instrumentation holes plus an additional 42 thermosyphon pipes to be instrumented. This requires an estimated total of 12,990 m of cable length for these holes. Final numbers, locations, and sensor technologies will be selected during detailed design.

Instrumentation will be hardwired to a local heated control cabinet in each freeze area. Data will be wirelessly transmitted to a central data server, located in the proposed water treatment plant. The only electrical requirements will be for the local control cabinets and security lighting.

5.2.6 Final Site Conditions

After completion of the freeze program mine closure activities, the final site conditions will be as follows:

- The ground surrounding the mine workings containing the arsenic trioxide dust will be frozen to contain and isolate the dust. The dust will be permanently contained within the established frozen shell and the thermosyphons will remain in place to maintain the frozen shell.
- A series of thermosyphons will be spaced around the perimeter of each chamber and stope. In some cases, thermosyphons will also be installed above or inside the chamber or stope to help reduce the time it takes to create a satisfactory frozen zone, as well as mitigate effects from potential climate change. Preliminary numbers, depths, and locations of the thermosyphons have been proposed in the DBR (SRK 2016). Further optimization of the design will occur during detailed design through assessment of underground geometries, constructability issues, and thermal modelling to refine predictions of ground freezing extents and durations.

- The top of each thermosyphon will be visible on the ground surface as thermosyphons need to extend several metres into the air to function. Thermosyphons will require monitoring and maintenance so that they continue to function properly over time.
- A temperature monitoring program will be installed to provide feedback on the integrity of the frozen shell over time with various contingency measures available to augment freezing if required at specific locations.
- Areas being frozen will remain within the Core Industrial Area that is fenced.

5.2.7 Uncertainties

Engineering designs for the closure plan are currently at a preliminary level. As such, the basis for estimates and analyses include engineering judgement. Additional design works are planned to address key assumptions and reduce relevant uncertainties. The important uncertainty that affects the freeze program is summarized below in Table 5.2-3, together with the potential impacts and the engineering studies and other activities planned to address the uncertainty.

Table 5.2-3: Freeze Program Uncertainties

Uncertainty	Potential Impact of Uncertainty	Plan to Address Uncertainty
The degree to which climate change may impact the freeze process due to increases in ambient air temperatures, higher winter temperatures, and warmer summer temperatures is uncertain.	Increased ambient temperatures as a result of climate change may decrease the temperature gradient that drives the thermosyphon process, thus slowing the rate of heat extraction from the ground. Higher winter temperatures may lead to shorter winters and fewer thermosyphon operating days. Warmer summer temperatures will work to potentially thaw the ground faster.	The effects of climate warming have been accounted for in the design. Thermal modelling predictions included a 6.1°C increase to the mean annual temperatures over the next 100 years, with +8.4°C applied in winter and +3.9°C applied in summer. These values were obtained by the University of Alaska Fairbanks Scenarios Network for Alaska and Arctic Planning and are in line with the upper-range global average temperature as provided by multi-century stabilization scenarios published by the International Panel on Climate Change.

SECTION 5.3
Open Pits

5.3 Open Pits

5.3.1 Description

The closure and reclamation of the Site includes closure of the open pits by stabilizing the underground beneath and adjacent to the pits and filling or partially filling the pit excavations to mitigate physical hazards to workers, the public, and wildlife and to protect the underground from flooding. Flooding to the underground prior to freezing of the chambers (Section 5.2) could allow escape of arsenic trioxide presently being stored in the arsenic stopes and chambers into the mine pool and potentially to the environment. Re-alignment of Baker Creek and accommodation of the PMF in the new channel (Section 5.5), and partially filling/filling the pit excavations is proposed to mitigate these risks.

This section describes the proposed closure and reclamation activities for the open pits, which include the following components:

- open pits with slopes of exposed bedrock, waste rockfill, or overburden materials, and various forms of fill material in the pit bottoms
- connections to underground mine workings, including partially backfilled underground stopes and openings to surface, and thin crown pillars above open voids under and adjacent to pits
- dams and berms separating the open pits from Baker Creek and surface water management areas

5.3.2 Pre-disturbance and Existing Site Conditions

5.3.2.1 Pre-disturbance Conditions

The pre-disturbance pit areas consisted of undulating topography with areas of exposed bedrock on the higher ground and minor surficial deposits characteristic of glacial activity in low-lying areas. Most of the surface mining occurred within or immediately adjacent to Baker Creek, which is straddled by natural rock ridges between 10 and 20 m high, controlled by bedrock outcrops. Vegetation was taiga with low scrub brush and wetlands in areas near Baker Creek. The pre-disturbance pit areas were all within the Baker Creek drainage basin (see Section 5.5, Figure 5.5-1 for view of the pre-disturbance landscape, Baker Creek, and the location of the pits).

5.3.2.2 Existing Conditions

The open pits are currently open excavations with exposed slopes of bedrock, waste rock, or overburden materials, and various open or backfilled connections to underground workings. Where pit floors intersect underground openings, some open portals remain, with the rest either fully or partially backfilled with run of mine waste rock or tailings. Some thin crown pillars with open voids below them also exist and are discussed below. Access to A1, A2, and B1 pits is restricted with fencing, signage, and berms. Most surface water that makes its way into the pits simply drains to the underground through stope backfill. In pits where water collects at the bottom, such as B1 and C1, the excess water is collected and pumped to the TCAs for management.

Open Pits

In total, eight separate open pits were mined (Figure 5.3-1), and one of these, Brock Pit, has since been developed as a quarry. Brock Pit has been, and will continue to be, used as a borrow source (quarry), which will be reclaimed after extraction is completed (Section 5.7) and is not included in this discussion on open pit closure. The volumes of the individual pits range from approximately 10,000 to 770,000 m^3. Table 5.3-1 shows the as-mined geometry of the open pits based on historical geology sections and the existing geometry based on a 2015 LiDAR survey (Golder 2018a). Dimensions are commonly estimated from the spill point elevations (i.e., the lowest elevation of the lip of the open pit). The difference between as-mined and current (2015) volumes is largely due to materials being dumped in the pits after their excavation. These materials consist mostly of waste rock, overburden, tailings, and debris such as used equipment, timber, etc. In the case of C1 Pit, a rock buttress of approximately 50,000 m^3 was constructed in 2014 to stabilize the west wall of the pit.

Detailed descriptions of each individual open pit relevant to the closure plan are provided in Appendix 5.3-A.

Table 5.3-1: Open Pit Dimensions and Quantities

Item	A1	A2	B1	B2	B3	B4	C1	Total
Description/specifics	Largest volume Deepest pit	Lowest elevation pit Minewater spill point[a] exists at this pit Large stopes underneath only partially backfilled	Site stabilization in 2013–2015 needed for pit wall and three stopes underneath	Not undercut by any mine workings Main access route to B and C shafts via UBC portal is located at the base pit	Has two portals one partially backfilled with waste rock and one in use Some rock overhangs the pit walls	Partially undercut by a small stope and a partially backfilled adit	Undermined across most of the strike Partially filled stopes and thin crown pillars making up the pit floor Stopes below the pit are narrow but connected to deep workings Subsidence of the pit floor observed	n/a
Length (m) / Width (m)	350 × 125	290 × 120	175 × 145	190 × 95	160 × 75	105 × 60	285 × 120	n/a
Spill point elevation[b] (m)	162.0	161.0	165.0	166.0	166.0	171.0	165.0	n/a
Max. depth below spill point elevation (m)	50	38	35	26	11	7	28	n/a
As-mined pit volume to spill point (m^3)	876,000	549,000	415,000	239,000	77,000	15,000	502,000	2,672,000
Current pit volume to spill point (m^3) (estimated maximum volume available at spill point elevation)	774,000	493,000	341,000	208,000	57,000	10,000	328,000	2,210,000
Current volume of existing fill material in pit (m^3) below spill point	102,000	56,000	74,000	31,000	20,000	5,000	174,000	462,000
Pit plan surface area (m^2) at spill point	47,000	32,000	22,000	20,000	10,000	7,000	32,000	170,000
Pit rim perimeter (m) at spill point	975	1,020	660	635	500	290	1,035	5,115

(a) Minewater spill point in this context means: the location where if the mine were to flood from minewater coming up from underground, water would exit the pit
(b) In general, the spill point is defined as the lowest point on the pit rim, where water would overflow if the pit was flooded from surface or underground.
n/a = not applicable



LEGEND

- 1st LEVEL (100) SHALLOW UG. DEVELOPMENT
- DEEP UG. RAMPS, DECLINES AND INCLINES
- APPROXIMATE MAXIMUM STOPING EXTENT AT DEPTH
- PROJECT BOUNDARY
- OPENINGS TO SURFACE OUTSIDE OF PITS
- NEAR SURFACE NON-ARSENIC STOPES (<35m DEPTH)
- NON-ARSENIC STOPE BREAKTHROUGH TO OPEN-PIT, BACKFILLED WITH UNKNOWN FILL
- OPEN PIT BOUNDARY
- EMPTY CHAMBER
- NON-ARSENIC STOPES ADJACENT TO AN ARSENIC STOPE
- ARSENIC CHAMBERS AND STOPES MAXIMUM EXTENT
- BACKFILLED DURING SITE STABILIZATION WORK (2013-2018)

NOTES

1. NOT ALL WORKINGS AND STOPES SHOWN
2. UG = UNDERGROUND

REFERENCES

1. MINE LAYOUT, LEASE BOUNDARY AND 2015 AERIAL PHOTO IMAGE PROVIDED BY PUBLIC SERVICES AND PROCUREMENT CANADA (PSPC).

0 250 500
1:15,000 METRES

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

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REVIEWED	DARREN KENNARD
APPROVED	BJÖRN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

SITE LAYOUT SHOWING OPEN PITS AND ASSOCIATED UNDERGROUND FEATURES INCLUDING OPENINGS TO SURFACE INSIDE PITS

REV. 0

FIGURE 5.3-1

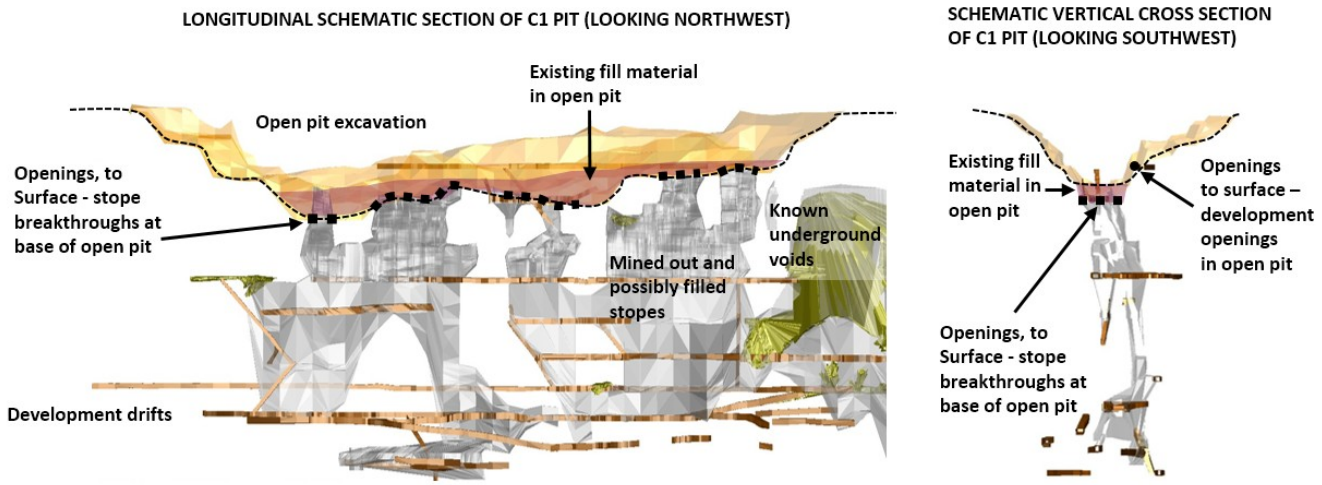
Openings to Surface inside Open Pits

Openings to surface that connect with the underground are present within the open pit boundaries and include underground development openings (e.g., drifts, raises, manways, ore and waste passes) and mined-out stopes that were intersected during pit mining. In most cases, the development openings located within the open pits were closed off by partially backfilling the intersection of the opening and the open pit with waste rock, or by constructing timber barricades from underground to keep out cold winter air. Some new openings to surface were constructed within the pits to allow access for rubber-tired equipment when the mine was mechanized in the mid to late 1970s. Two of these openings to surface (UBC portal in B2 Pit and the 1-38 / B3 portal in B3 Pit) are currently in use by the care and maintenance contractor to access the underground.

Many of the stope breakthroughs intersected during open pit mining are fully or partially backfilled; exact geometry of the original breakthrough is unknown. The intersected voids were backfilled with tailings or undifferentiated fills including run-of-mine waste rock and overburden materials such as glaciofluvial silts, sands, and organics. The stopes may or may not have been filled, and remnant voids under and adjacent to the open pit to which they are connected may exist. Some thin crown pillars with open voids below them also exist in the pit floors and the lower pit walls. Some of these partially filled voids are connected to deeper underground workings, and others are isolated and limited in extent.

A schematic of the nature of these openings to surface within the open pit limits is shown in Figure 5.3-2.

Figure 5.3-2: Schematic Description of Openings to Surface within Open Pit Limits



The locations of these openings to surface are shown in Figure 5.3-1, and Table 5.3-2 outlines the following preliminary quantities related to openings to surface inside the open pit limits:

- the number of openings to surface within the pit limits that need to be plugged (Golder 2018a)
- the estimated number of non-arsenic stope complexes presently connected to the open pit excavation or separated from the pit by a crown pillar
- the estimated volume of empty space present in voids connected to or close to the pit bottoms that likely need to be backfilled to stabilize the pit floors

Table 5.3-2: Information on Stopes and Openings to Surface Associated with Each Pit

Quantity	A1	A2	B1	B2	B3	B4	C1	Brock	Total
Number of closure of openings to surface required	3	1	3	1	2	1	1	1	**13**
Number of non-arsenic stope complexes under or adjacent to pits	5	3	3	None	1	1	7	None	**20**
Estimated stope void volume below pit (m^3)	35,000	41,000	8,200	0	5,000	3,000	86,000	0	**178,200**

Note that this list of openings to surface does not include historical exploration boreholes and boreholes drilled as part of ongoing site stabilization.

The estimated volume of the underground voids, both under and adjacent to the pits, to support pit floor stabilization prior to filling is outlined in Table 5.3-2.

Existing Flood Risk via Pits

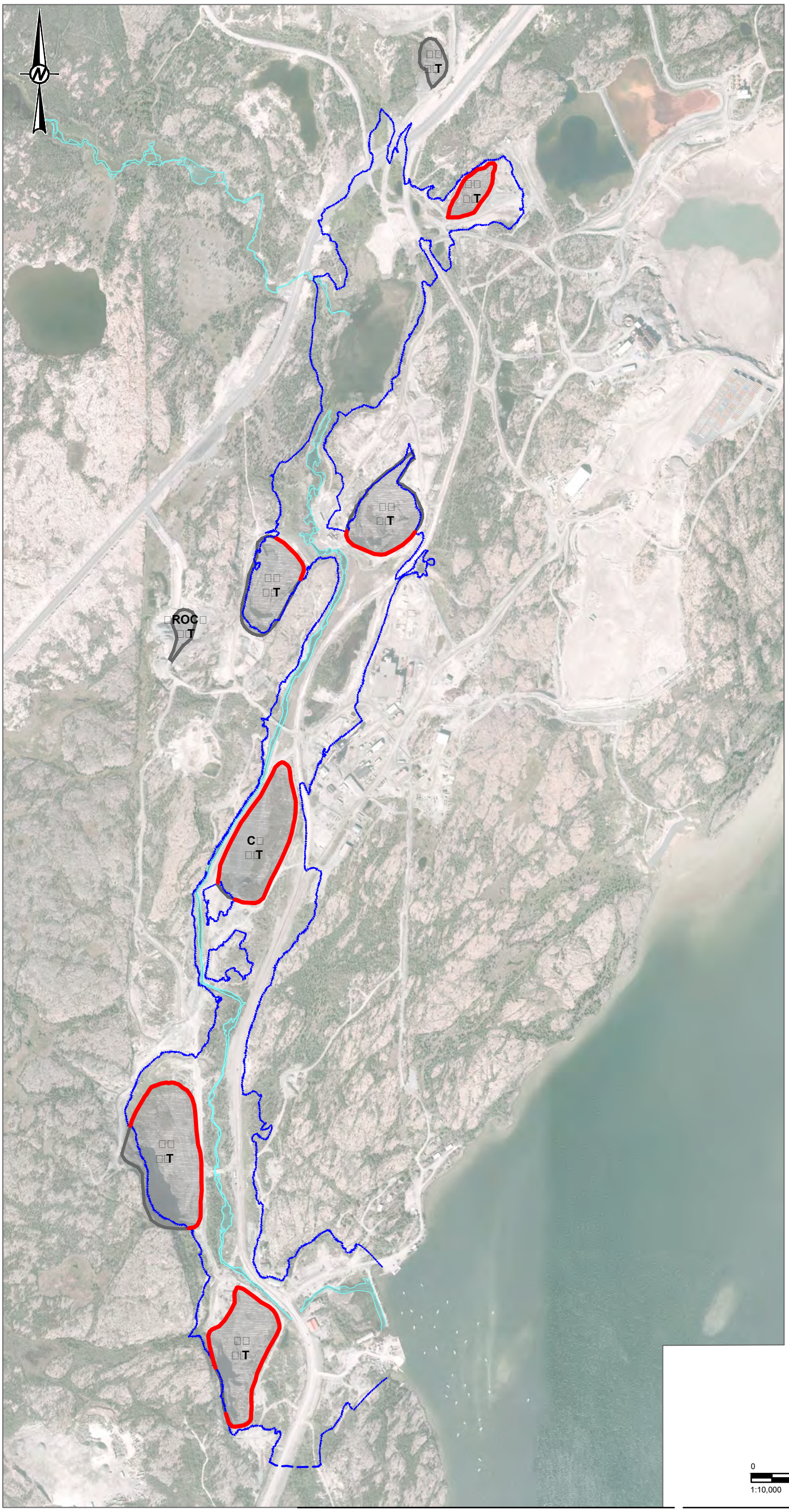
The risk of flooding the open pits, and subsequently the underground, with Baker Creek in its current channel is shown in Figure 5.3-3. This was the flood risk predicted by Northwest Hydraulics Consultants Inc. (NHC) in 2007. These were based on the elevation of the centreline of the current Baker Creek alignment projected to the adjacent creek banks and is therefore not a model of the actual extent of the flood plain. The diagram is for illustrative purposes only. This was the model used in the DAR.

Under existing site conditions, a PMF event with the current alignment of Baker Creek would inundate the pits, except for B4 Pit. Such a flood would lead to flooding of the underground if it occurred prior to the implementation of site remediation. Updates to the flood model were completed in 2017; this is discussed in full in Section 5.5 in relation to Baker Creek.

5.3.3 Closure Objectives and Criteria

Based on the goals and principles for the GMRP, closure objectives were identified specifically for the closure and reclamation of the open pits. The objectives and criteria of the GMRP relating specifically to reclamation of the open pits are presented in Table 5.3-3.

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LEGEND

- BAKER CREEK
- OPEN PIT BOUNDARY
- PORTION OF OPEN PIT BOUNDARY BELOW PMF OF EXISTING BAKER CREEK ALIGNMENT
- PROBABLE MAXIMUM FLOOD (NHC 2007)

NOTES

1. PROBABLE MAXIMUM FLOOD BASED ON NORTHWEST HYDRAULICS CONSULTING INC. (NHC), *BAKER CREEK CHANNEL SURVEY AND NUMERICAL HYDRAULIC MODELLING*, PREPARED FOR SRK, MARCH 2007.

REFERENCES

1. 2015 AERIAL PHOTO IMAGE PROVIDED BY PUBLIC SERVICES AND PROCUREMENT CANADA (PSPC).

0 250 500

1:10,000 METRES

PROPONENT

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

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

PROJECT

Giant Mine Remediation Project

YYYY-MM-DD	2019-01-24
DESIGNED	MICHAEL PAK
PREPARED	MICHAEL PAK / JACOB HOPSON
REVIEWED	DARREN KENNARD
APPROVED	BJÖRN WEEKS

TITLE

FLOOD EXTENT FOR THE EXISTING ALIGNMENT, PROBABLE MAXIMUM FLOOD AND REQUIREMENT FOR FLOOD PROTECTION

REV. 0

FIGURE 5.3-3

Table 5.3-3: Open Pits Mine Workings Closure Objectives and Criteria

Closure Objectives	Closure Activity	Closure Criteria	Monitoring/Maintenance and Inspection
P1. Potential for flooding the underground by way of the pits is reduced	• Re-align Baker Creek such that potential for pit flooding is reduced (refer to Objective BC1). • Install water diversions/berms, when needed to protect underground water quantity (refer to Objective UG1) • Install scour protection between water courses and the pits that protect berms, diversions and vulnerable topography* • Install engineered cover over pit when needed to protect underground water quantity or quality (refer to Objective UG1)	• **P1-1** Berms/Diversions are built to an elevation of Baker Creek PMF. • **P1-2** Diversions/berms include low flux features to limit water entering the underground to achieve UG1 criteria of maintaining the minewater level. • *Refer to Objective BC1* for criteria related to the re-alignment of Baker Creek • **P1-3** Design engineering drawings are signed and sealed by a Qualified Professional and the specifications outlined therein are met, such that potential flooding for the underground through the pits is reduced. *Criteria in Development through engineering works* • **P1-4** Fill in pits or pit cover settlement is confirmed not to exceed damage criteria (to be developed); refer to Objective UG4 for voids under pits • **P1-5** Where berms or diversions are predicted to be in contact with the PMF, the minimum size of scour protection will be calculated based on water flow velocity and depth during PMF.	*Active Remediation, Adaptive Management and Post-Closure* • As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB. • Satisfactory final inspection by a Qualified Professional • Operational Monitoring Plan: Scour-resistant water diversions/berms monitored for erosion annually and after each major flood event and inspections of pit fill and pit cover, where installed. • Water Management and Monitoring Plan: Minewater monitoring for elevation changes (refer to Objective UG2).

P2. Public, worker, and wildlife safety risks associated with pits are reduced	• Backfill underground voids connected to pits as required (refer to Objective UG4)
	• Fully or partially fill pits and re-contour the smaller B4 Pit.
	• Recontour remnant high walls above A1 and A2 pits.
	• Cap each pit with clean, coarse material of large size to discourage public and animal use
		• **P2-1** Pits will not permanently retain ponded water
		• **P2-2** Design engineering drawings for fill placement into pits are signed and sealed by a Qualified Professional and the specifications outlined therein are met
		
		Criteria in Development related to further engineering works:
		• **P2-3** Recontour high walls to appropriate slope (pending further engineering work)
		• **P2-4** Settlement and erosion of fill in pit/cap occurs within standard parameters (appropriate numbers to be determined differential settlement of 1% of fill height pending further engineering work)
		• **P2-5** Pit cover criterion (to be determined pending further engineering work)
			Active Remediation, Adaptive Management and Post-Closure
			• As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB.
			• Satisfactory final inspection of grade and shape of fill in pits.
			• Operational Monitoring Plan: Monitoring of fill in pits
			  • Monitor for settlement and erosion annually and after each major flood event.
			  • Monitor for wildlife presence in pit area.
			  • Survey of fill of pits as required.
			• Water Management and Monitoring Plan, Operational Monitoring Plan
			  • Inspections for ponded water in pits
			• Waste Management and Monitoring Plan – volumes of waste
			• Surveillance Network Program - water inflow through pit covers does not exceed expected values required to support minewater elevation management requirements
			• Wildlife and Wildlife Habitat Management and Monitoring Plan – monitoring of wildlife presence near pits

P3. Pit fill material will not become a source of contamination to the environment	• Fill pits with a combination of borrow and contaminated granular fill from the Site. • Cap each pit with clean, coarse material of large size to reduce potential for dust. • Install engineered cover over pit when needed to protect underground water quality (refer to Objective WTP2)	• **P3-1** Design engineering drawings are signed and sealed by a Qualified Professional and the specifications outlined therein are met, such that fill in the pits will not become a source of contamination. • **P3-2** Runoff off pits (caps or covers) meets surface runoff quality criteria, as per the approved Water Management and Monitoring Plan • *Refer to Objective SW1 for Air Quality standards are met* • *Refer to Objective UG2 and WTP2, EQC are achieved*	*Active Remediation, Adaptive Management and Post-Closure* • As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB. • Satisfactory final inspection by a Qualified Professional • Surveillance Network Program, - Water quality monitoring of minewater quality, treated effluent quality • Air Quality Monitoring Plan

MVLWB = Mackenzie Valley Land and Water Board; * Vulnerable topography = landforms or infrastructure that are susceptible to flooding either because they are in a flow path, are easily erodible or have high value aesthetically or for the community and require protection from flooding.

5.3.4 Consideration of Closure Options and Selection of Closure Activities

5.3.4.1 Review of Pit Filling

Previously, fencing and berms were chosen as the pit closure activity (SRK/Senes 2007; INAC and GNWT 2010; Golder 2012). Two significant factors changed the closure activity for pits:

1) **Affected Party Preference and Suggestion 13**
   During the EA process, some affected parties expressed a preference to fill the pits. The MVEIRB commented that it agreed with some affected parties that "filling the pits may be the preferred alternative… other options besides leaving the pits open may be available" (MVIERB 2013). There was recognition that sourcing material to fill the pits would be a challenge. As such, the MVEIRB (2013) made Suggestion 13: "The Developer should investigate options for filling in the pits, in consultation with the City of Yellowknife and YKDFN." During SDE, affected parties preferred options that included filling the pits Considerations included reducing health and safety risks, to store contaminated material from site, and to protect the underground from flooding by Baker Creek. Protecting the underground from flooding would allow Baker Creek to stay on the Site and not have contamination from upstream of the site be routed to new watersheds (SRK 2016).

2) **Baker Creek Probable Maximum Flood Analysis and Measure 11**
   At the end of the EA process, the MVEIRB ruled that the risk of flooding the underground in the case of an extreme flood event in Baker Creek could possibly result in a significant adverse effect and required additional mitigation. More specifically, the MVEIRB commented that "The Board is not convinced that the Project's engineering design is adequate to justify the risks presented by flooding from Baker Creek" (MVERIB 2013). The MVEIRB therefore required that the GMRP Team review options to divert Baker Creek off-site (Measure 11; MVEIRB 2013; INAC 2014). A review of possible alignments was conducted, as well as an updated flood hazard assessment (see Section 5.5 for more information). This work determined an on-site alignment with flood-plain improvements and some re-alignment could accommodate a PMF (Golder 2018c; Section 5.5). It is noted this revised design is an improved mitigation from the DAR which would accommodate a 1:500 flood. In this revised design, the risk of Baker Creek overtopping and entering the pits and flooding the underground is reduced. However, some residual risk of pit flooding may remain after the improvements. This would include at the B1 pit, which has the lowest pit rim elevation (see further discussion on low pit elevation below, related to Figure 5.3-7). Erosion of the material dividing pits from the creek could also potentially generate a risk. As a result, pit fill will incorporate additional barrier elements in selected areas where required to further protect the underground from a Baker Creek flood to meet the intent of Measure 11(a) (Sections 5.4, 5.5, and 5.6 complement this discussion and address Measure 11[b]).

Depending on the final configuration of pit fills selected, the potential volume of material needed is substantial. Work is advancing to refine on-site borrow quantities and availabilities (Section 5.7).

In summary, full or partial filling of pits has the following benefits:

- Appropriate placement of fill in pits eliminates or significantly reduces the physical hazards associated with steep pit slopes, unstable pit slopes, most openings to surface in and around pits, partially backfilled stope breakthroughs, and crown pillars.

- Pits provide a potential disposal location for some contaminated material.
- Pit fills can be placed in such a manner as to create additional controls to prevent a Baker Creek flood from entering the pits or the underground, even under extreme flooding conditions (addressing Measure 11). This may include placing fill to backfill pits, construct berms, or both.
- Some affected parties preferred filling pits, as opposed to leaving them unfilled, to reduce risk. This input was documented in the Report of EA (Suggestion 13) and during SDE.

For these key reasons it was determined that fill would be selectively placed in the open pits, as described in the following section. Collectively these factors drove the decision to fill pits. These key drivers are illustrated in Figure 5.3-4.

Pits– Key Drivers for Closure Decisions

Higher ↑ Priority ↓ Lower

Drivers

- **Safety/Physical Stability for human, environment, infrastructure**
- **Meet regulatory requirements:**
  - **Measure 11**
  - **Suggestion 13**
- **Input from Surface Design Engagement process & affected parties**
- **Align with other remediation activities**

Design Considerations

- Prevent injury to people and wildlife, and damage to surface infrastructure due to pit wall instability or falling.
- Reduce risk of flooding underground once Baker Creek is re-aligned
- Evaluate filling pits with contaminated material from site to address risks associated with open pits
- Preference during SDE for options with pits backfilled
- Preference to consolidate contamination (e.g., tailings, soil) in previously impacted areas
- Pit flood risk to be mitigated for PMF after re-alignment of Baker Creek
- Manage surface water flow in areas of pits
- B1 Pit includes freeze area to provide additional isolation of contaminated material
- Provide contaminated soils disposal capacity
- Limit borrow requirement for pit filling

Selected Options

- **Partially or fully backfill pits**
- **Where flood risk is present at PMF, protect pits with backfill, berms or both**

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

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REVIEWED	J. Amphlett
APPROVED	J. Amphlett

PROJECT

Giant Mine Remediation Project

TITLE

Key Considerations Driving the Selection of Closure Activities for Open Pits

REV. 0

FIGURE 5.3-4

5.3.4.2 Open Pit Options Assessment

Once the decision to place fill in the pits was made, options for pit fill material for each of the open pits were assessed (Appendix 5.3B). An options assessment approach was used to determine options for filling the open pits. This multi-disciplinary approach allows evaluators to select advantageous alternatives, from a list of alternatives, by weighing benefits and costs of each. These analyses incorporated the results of qualitative and general quantitative risk assessments, carried out with a failure-modes-effects analysis approach.

Risk Factors Informing the Pit Fill Options Assessment

The selection of preferred options was informed by an evaluation of risks related to the open pits—human health risk and flood risk—assuming there could be worker access and occasional and uninvited public access to each pit, which is conservative since many pits will not be accessible to the public. The specific fatal risks posed by the pits to worker or public safety are the following:

- falling off steep bench faces (cliffs) or steep pit covers
- being struck by a rock fall
- being caught in a slope failure
- falling into open connections to the underground
- falling into or being engulfed in a rapid subsidence (crown pillar failure or fill displacement)

The potential risk of the pits to the environment is if Baker Creek floods its banks and discharges to the pit(s), resulting in uncontrolled flooding of the underground. This could happen via open or erodible connections in the pits to the underground, resulting in:

- damage to the arsenic bulkheads and further contamination of the mine pool, with potential impacts on the water treatment system and eventual discharges to the environment
- damage to critical underground infrastructure during a flood; this could include impacts on the infrastructure for pumping minewater to the surface

The risk assessments influenced the open pit options selection with the following broad conclusions:

- Fill should be placed in the pits in a manner that protects the underground from a Baker Creek flood, although this risk is reduced with the re-aligned creek.
- Remnant pit rock slopes and pit fill slopes need to be shallow enough that workers and the public will be safe. The pit slope design will be different inside and outside the fenced, Core Industrial Area (Figure 5.1-1).
- Underground stabilization is required in specific areas under some pits prior to pit fill placement to reduce the potential for sinkholes to harm workers, the public, and wildlife and to minimize damage to any pit covers.

Engineering Consideration Informing the Pit Fill Options Assessment

Engineering considerations that informed the pit fill options assessment are listed in Table 5.3-4 and included:

- underground stabilization of pit floors (Section 5.1.6)
- type of majority pit fill
- potential cover types where they might be required
- other factors such as pit high wall recontouring

Table 5.3-4: Open Pit Closure Option Components

Component	Options	Description
Pit floor stabilization	Underground stabilization	Constraining stope areas below the pit with underground plugs and backfilling voids with cemented paste tailings
	Engineered spans	Excavating existing pit fills and near surface stope backfill to expose rock walls, and construct engineered spans
Majority pit fill material	Borrow	Quarried construction material (Section 5.7)
	Tailings	Small diameter waste material left over after the ore milling process (Section 5.6)
	Contaminated granular fill	Contaminated fill obtained from site remediation activity (Section 5.4) with geotechnical characteristics that make it suitable for use as pit fill. Gradations of this material will range from sand and gravel, with limited silt and clay, up to cobble and boulder sized material.
Cover (if needed)	Low permeability and barrier to isolate contaminated material	Rockfill cover with geosynthetic barrier layer as chosen for tailings (Section 5.6)
	Low permeability	Rockfill cover underlain by compacted fine-grained soil (no geosynthetic)
Other	High wall recontouring (A1 and A2)	Recontouring of remaining high walls above the spill point elevation of the pit to eliminate slope stability hazards

After screening, 68 options were evaluated (Appendix 5.3B). Criteria to score the various options relative to each other included:

- closure objectives (Table 5.3-3)
- constructability and complexity based on engineering judgement
- social considerations (primarily per SDE outcomes as outlined in SRK 2016; Chapter 1)
- cost and value, based on order-of-magnitude costing

Full results of the options analysis are reported in Appendix 5.3B. In general, the options assessment concluded that using contaminated granular fill or tailings as majority or partial pit fills scored almost as high as coarse mine rock borrow for some pits, particularly A1 and B1, and did not introduce any obvious environmental risks.

Once the pit fill analysis was complete, an internal materials balance workshop with technical experts was held to examine where and how different material types from the Site could most efficiently and effectively be obtained. Availability and accessibility of material influenced the final choice of fill for each pit (Golder 2017d).

Use of contaminated granular fill material at selected locations can reduce the amount of clean fill that needs to be generated through quarries elsewhere at the Site; contaminated fill material will be used to fill A1 and B1 pits, to the extent practicable. Based on the current understanding of the material balance for the site (Golder 2017d), which summarizes both the site needs for fill, and the various potential sources of fill, these pits were selected in an internal project workshop as being the most practical options for anticipated volumes. During this internal workshop, the use of tailings as pit fill was also ruled out due to the geotechnical difficulties presented by tailings as pit fill material, and the existence of adequate storage capacity in the TCAs, which are by design better suited to the accommodation of tailings.

Contaminated fill

A1 Pit is a good candidate for the placement of contaminated material for the following reasons:

- The risk of overtopping of A1 Pit during a Baker Creek flood is lower than other pits (Section 5.5).
- A1 Pit is further from Baker Creek than A2 Pit. As a result, placement of contaminated fill in A1 poses a marginally lower risk of potential impacts on Baker Creek from localized movements of shallow (perched) groundwater flow through the pit and towards the creek. Note that in both cases, the predominant groundwater flow is expected to be downwards (towards the minewater pool).
- A1 Pit is farther from Great Slave Lake than A2 Pit and therefore represents a lower risk of potential impacts on the lake.
- A1 Pit is large and can hold a significant volume of material in one consolidated area.

B1 Pit is also a good candidate for heavily contaminated fill as heavily impacted soils can be disposed of in the portion of the pit that will be frozen. Frozen conditions will provide effective isolation and containment of materials placed in the freeze zone.

B2 Pit is also a good candidate to store contaminated granular fill if additional storage beyond what is available in A1 Pit and the non-frozen portions of B1 Pit becomes a requirement. Final checks on the potential for this contaminated granular fill material that may be placed in A1 and B1 pits to negatively impact the minewater quality will be carried out as part of final design. Any remaining pit requirements will be addressed with new quarried rock.

5.3.4.3 Selected Closure Activity for Pits

Based on the above information, the selected closure option is to place a combination of newly quarried rock and contaminated granular fill in open pits. The openings to surface present in the pits will be plugged with rock borrow in a manner that does not allow movement of pit fill material into the underground, enhances drainage, and does not allow excess pore pressure to build up in the pit fills. The underground voids under and adjacent to pits will be stabilized to reduce unacceptable hazards due to sinkholes forming in the pit fill material (Section 5.1.). In selected areas, pits may have a cover incorporated into the fill design if required, to prevent contact with contaminated fill material.

As determined based on project-wide materials balance (Golder 2017d) and in the open pit options assessment (Appendix 5.3B), specific materials planned to be used in pit filling are as follows:

- Fill placed in A2, C1, B2, and B3 pits will be quarried rock borrow material some of which will come from recontouring the slopes above A1 and A2 pits (Photos 5.3-1 and 5.3-2).
- A1 Pit, the non-frozen portions of B1 Pit, and possibly B2 Pit will be filled or partially filled with contaminated granular fill material that does not need to be frozen.
- The frozen portions of B1 Pit will be filled with a combination of highly contaminated granular fill, possibly containerized roaster wastes (as discussed in Newman's 2018 and in Appendix 5.1A), other containerized arsenic waste and contaminated granular fill required for grading.
- B2 Pit could be used for contaminated fill if necessary.
- B4 Pit will be recontoured or partially filled with coarse quarried rock borrow material.

Photo 5.3-1: A1 Pit high wall, looking north.



Photo 5.3-2: A2 Pit high wall looking south.



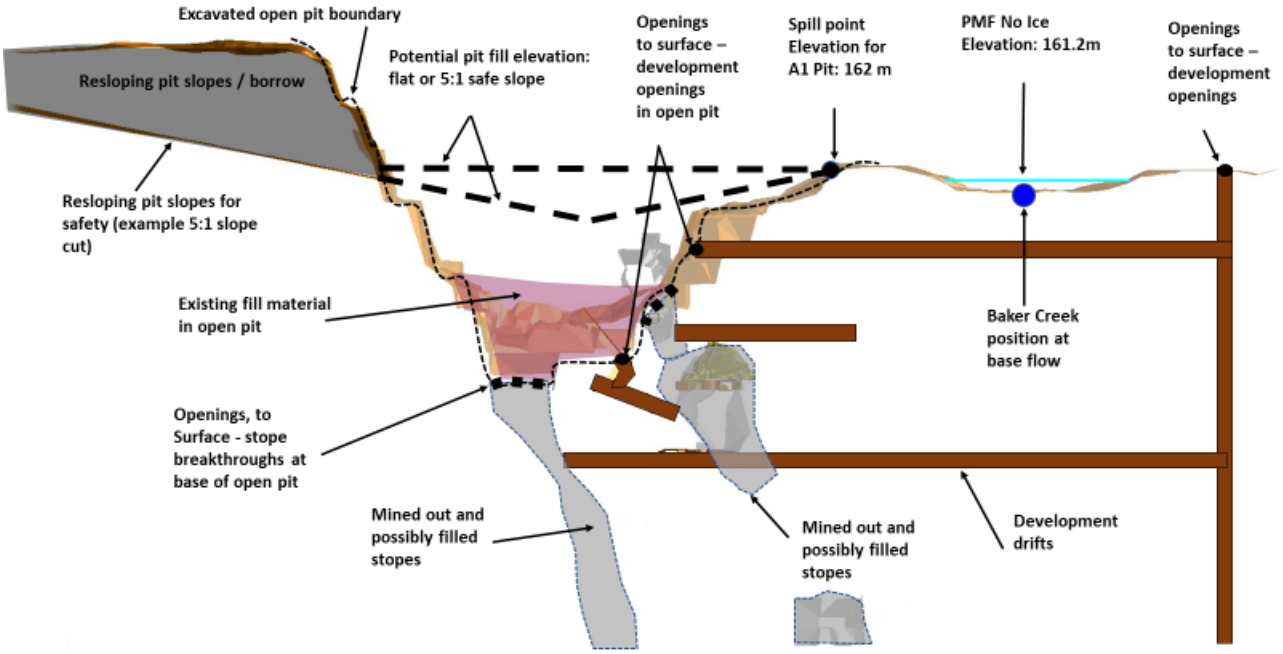
5.3.5 Engineering Work

Details on the design work carried out to date and the future work required to close the open pits are presented below in the following categories:

- underground stabilization under and adjacent to open pits
- closure of openings to surface in pits
- remnant pit high wall recontouring
- partial or full pit filling
- pit covering, if required

These broad categories of pit closure work are shown schematically in Figure 5.3-5.

Figure 5.3-5: Schematic Vertical Cross-Section of Open Pit Closure Activity Elements and Baker Creek PMF Elevation



5.3.5.1 Underground Stabilization Under and Adjacent to Pits

Underground stabilization work will be carried out under and adjacent to open pits on an as-needed basis to permit safe placement of pit fill by workers, achieve risk thresholds given worker and public access to each pit, and minimize the potential for damage to the pit covers due to underground backfill movement as detailed in Section 5.1. Schematic stopes that intersect the base of an open pit and may require filling to stabilize are shown in grey in Figure 5.3-5. The underground stabilization work needs to be able to withstand a range of possible stability issues (Section 5.1), including the sudden exit of existing stope backfill that is connected to deeper underground workings, which will most likely could occur when water levels in the mine fluctuate in the future.

A drilling program was carried out in 2016 to characterize the underground voids, both under and adjacent to the pits (Golder 2017a). This program was developed planning for pit floor stabilization prior to pit filling. Based on the results of this program, void volumes were estimated, as summarized in Table 5.3-2.

Additional work is planned for 2018-2019 to improve these estimates, and support future design studies to better understand the feasibility and associated costs of stabilizing the voids under and adjacent to the open pits where required.

Final stabilization assessments of the crown pillars, pit fills, and pit slopes have yet to be completed.

Approximately 19 individual stope complexes that are present under and adjacent to the pits need to be assessed and possibly filled with a maximum of approximately 180,000 m^3 of material.

Stabilization of these underground voids under and adjacent to the pits, where required, is planned to be primarily accomplished by backfilling with various types of materials including but not limited to:

- cemented paste tailings sourced from the South Pond
- tailings sourced from the South Pond
- dry rockfill sourced from on-site borrow areas

As outlined in Section 5.6, the South Pond is to be relocated and any tailings used for paste backfill will be preferentially sourced from there.

The geometry of underground workings under and adjacent to the open pits that may need to be filled is complex, and to limit the volume of pit fill required, some underground plugs may need to be put in place to control the mobility of pit fill materials such as paste tailings. Where underground access is not practical or safe, filling of underground openings under and adjacent to open pits can still be accomplished via remote surface borehole based plugging techniques. These approaches have been proven at the Site (Golder 2014, 2016) but require additional effort (Appendix 5.3B).

The first step in the assessment of underground stabilization requirements is to understand what does and does not require underground backfilling. For example, B1 and B2 pits require little, if any, underground stabilization work if access to the ground surface in the area is limited to occasional uninvited access by the public. For other pits, risk-based trade-offs are needed to determine whether underground stabilization efforts are needed to reduce the potential for sinkhole development and achieve public/worker safety. The QRA will provide guidance on the exposure assumptions of the various planned filled pit areas to public access in both the fenced Core Industrial Area and unfenced areas (Figure 5.1-1) to support detailed design of underground stabilization.

Detailed backfilling plans including the type of backfill to be used, the required level of void fullness, and the backfill delivery methods employed will be carried out. The majority of required void backfilling is expected to be accomplished by delivery of cemented paste tailings via boreholes to the targeted voids. The paste will be contained within the targeted voids by plugs placed in mine development openings such as drifts where the paste could otherwise exit.

If underground backfilling cannot be accomplished to suitably reduce stability risks (Section 5.1), delineation will be carried out for pit areas that may require access limitations. These limitations may take the form of fencing or other types of access control that will require longer term maintenance.

5.3.5.2 Closure of Openings to Surface in Pits

The openings to surface (Table 5.3-2) present in the pits (see examples in Figure 5.3-5) will be primarily plugged with borrow in a manner that enhances drainage and does not allow excess pore water pressure to build up in the pit fills or migration of pit fill material into the underground. Detailed designs for the closure of each opening to surface will be developed.

Openings to surface that are partly filled will be excavated, and any non-hazardous wood debris removed to the landfill (Section 5.10). Engineering designs for placement of borrow will be designed so that pit fills do not enter the underground.

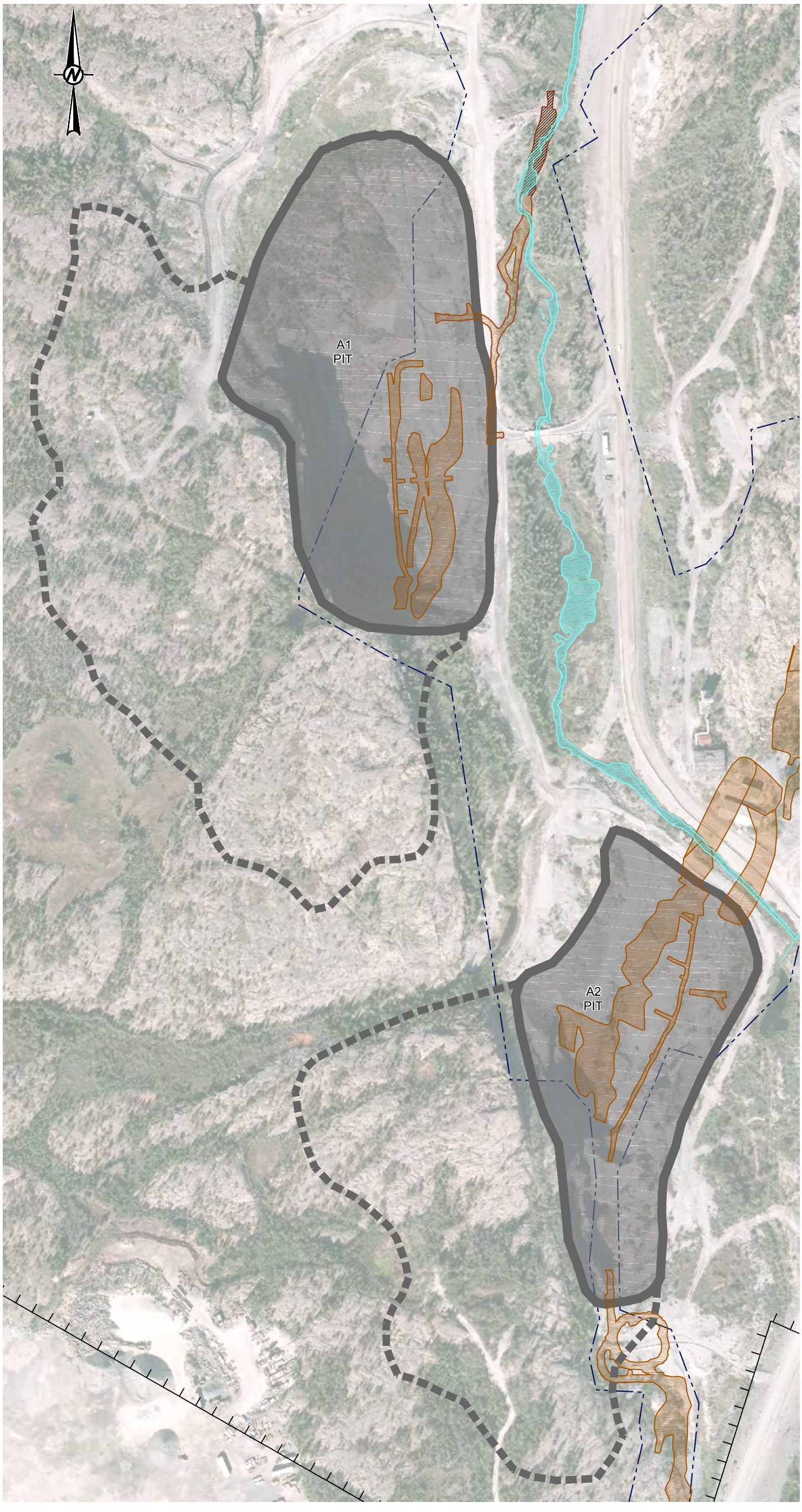
For some pits, access to the openings to surface is straightforward (e.g., the UBC portal in B2 Pit), but for others, hazard management and monitoring plans will be required during the Active Remediation and Adaptive Management Phase (e.g., C1 Pit) due to local stability hazards resulting from the partially filled nature of some of the openings.

5.3.5.3 Remnant Pit High Wall Recontouring

The walls of A1 and A2 pits that extend above the spill point of these pits will be recontoured by blasting to mitigate the risk of instability in these slopes. This activity will also provide rockfill that can be used for pit fill. Additional fill will be obtained from other on-site borrow sources (Section 5.7) or as by-products of other site works such as the new Baker Creek channel and spillways from the North Pond.

The remnant pit slope blasting and infill plans will be designed so that the remnant slopes are graded to between 2H:1V and 5H:1V. The grain size of material left at surface of the recontoured areas will be evaluated as part of detailed design. In some area, boulders or coarse rock may be left at ground surface to dissuade recreational use of the slopes. Figure 5.3-6 shows a schematic of a recontoured remnant high wall that would be present above a filled pit. Preliminary example blasted excavation boundaries for a slope of 5H:1V for both A1 and A2 pits, shown in Figure 5.3-6, provide approximately 1,300,000 m^3 of borrow. This shallow slope was used to maximize the potential borrow volume but would not dissuade public access over the stable bedrock area under the borrow cuts.

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LEGEND

- POSSIBLE EXTENT OF HIGHWALL RECONTOURING BORROW SOURCE (5:1)
- APPROXIMATE MAXIMUM STOPING EXTENT AT DEPTH
- PROJECT BOUNDARY
- NEAR SURFACE NON-ARSENIC STOPES (<35m DEPTH)
- OPEN PIT BOUNDARY
- BAKER CREEK
- BACKFILLED STOPES

NOTES

1. NOT ALL WORKINGS AND STOPES SHOWN.

REFERENCES

1. MINE LAYOUT, LEASE BOUNDARY AND 2015 AERIAL PHOTO IMAGE PROVIDED BY PUBLIC SERVICES AND PROCUREMENT CANADA (PSPC).

0 250 500
1:15,000 METRES

PROPONENT

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

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-24
DESIGNED	MICHAEL PAK
PREPARED	MICHAEL PAK / ALAN FARLOW
REVIEWED	DARREN KENNARD
APPROVED	BJÖRN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

PRELIMINARY SHAPE OF EXCAVATIONS REQUIRED TO RECONTOUR HIGHWALLS ABOVE A1 AND A2 PITS AT AN ANGLE OF 5H:1V

REV. 0

FIGURE 5.3-6

5.3.5.4 Pit Filling

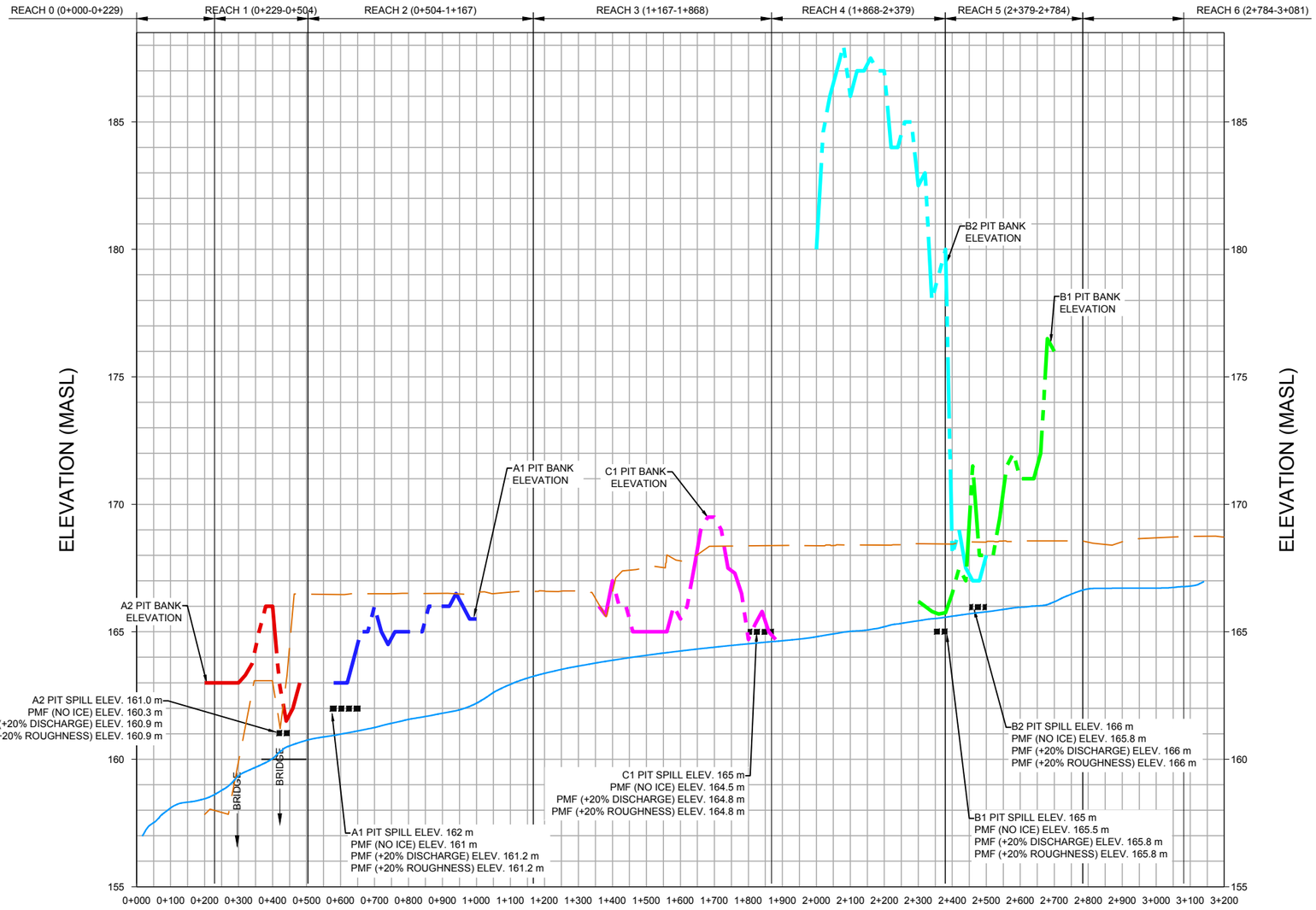
The pits will be fully or partially filled with either quarried coarse rock borrow or contaminated granular fill. Pits may be filled relatively full, with a flat profile at an elevation near the spill point elevation, or with a slope grading from the pit rim down to the center of the pit. A sloping pit fill angle of approximately 5H:1V is shown in Figure 5.3-6. The final decisions on pit slope material type, fill slope angles, and final volumes of pit fill material will be based on underground stabilization decisions and implementation outcomes, required contaminated material storage volumes, and borrow decisions.

Scour resistant water diversions / berms will be incorporated into the pit fill design where required to protect the underground from flooding during a Baker Creek flood. Future engineering work will be carried out to determine where localized water diversions / berms are required and the suitable permeability of such structures. This work will be carried out using the elevations of various Baker Creek floods as outlined in the Baker Creek Flood Hazard Assessment (Golder 2018c). Figure 5.3-7 shows the maximum extent of Baker Creek PMF flood elevations, and the points where this elevation comes close to the pit rims; this is labelled as pit banks in Figure 5.3-7, which are illustrating the elevation of the pit crest at approximately two metre spacings determined by taking a perpendicular line from Baker Creek to the pit. The flood elevations in this assessment reflect the configuration of the Baker Creek channel after improvements carried out as part of closure works (Section 5.5). This is also shown in Figure 5.3-8 to show the extent areas of risk to pits post-alignment of Baker Creek.

Placement of fill in the open pits could require up to an estimated 2,210,000 m^3 of fill material. This upper limit volume would correspond to filling the pits to the top of the pit as referenced by the spill point elevation (Table 5.3-1). Approximately 52,000 m^3 of highly contaminated granular fill from the roaster area will be excavated and placed in a frozen zone (Section 5.4). Studies are currently underway to determine if these materials can be placed in B1 Pit and frozen to the required criteria (Appendix 5.1A; Newman's 2018), or if there are effective means to reduce the amount of material that needs to be frozen. These approaches could include soil washing or finding additional areas for disposal such as Chamber 15 or other underground areas (Section 5.1) near areas that will be frozen. This would include the open void portions of existing arsenic stopes and chambers (Appendix 5.1A) and as discussed in Section 5.1.

An estimated 2.1 million m^3 of arsenic-impacted materials will require disposal from the Site (see Sections 5.4 and 5.6). As shown in Table 5.6-6 of Section 5.6, an estimated total of 1.3 million m^3 will be relocated to within the TCAs (Golder 2017d). The remaining 0.8 million m^3 will be disposed of within A1 and B1 pits. If additional arsenic-impacted materials are discovered, they could also be disposed of in B2 Pit.

Table 5.3-5 summarizes the estimated upper limit of material quantities required for pit filling, which are based on the volume of material that will fit in the pit from the spill point elevation on the rim to the current base of the pit, as summarized in the materials balance work (Golder 2017d). Note that the numbers in Table 5.3-5 were rounded relative to those in Table 5.3-1 for, which includes the maximum volume of material that each pit can accept, as they reflect the numbers used in the materials balance work.



0 5 10
1:200 VERTICAL METRES

0 250 500
1:15,000 HORIZONTAL METRES

WATER SURFACE PROFILES OF BAKER CREEK - OPTION 3A

HORIZONTAL SCALE 1:15,000
VERTICAL SCALE 1:200

LEGEND

- A1 BANK ELEVATION
- A2 BANK ELEVATION
- B1 BANK ELEVATION
- B2 BANK ELEVATION
- C1 BANK ELEVATION
- FUTURE BAKER CREEK ALIGNMENT PMF (GOLDER 2018)
- EXISTING BAKER CREEK ALIGNMENT PMF (NHC 2007)
- PIT SPILL ELEVATION AND APPROXIMATE POSITIONS

REFERENCES

1. NHC. 2007. BAKER CREEK CHANNEL SURVEY AND NUMERICAL HYDRAULIC MODELLING. PREPARED BY NORTHWEST HYDRAULIC CONSULTANTS FOR SRK CONSULTING, MARCH 2007, 13 P + FIGURES + 1 APPENDIX.
2. GOLDER 2018. GIANT MINE - BAKER CREEK FLOOD HAZARD ASSESSMENT, GIANT MINE REMEDIATION PROJECT, NT. PREPARED FOR PUBLIC SERVICES AND PROCUREMENT CANADA, MARCH 2018, REPORT NUMBER 1313770115-123-R-REV0-15000.

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YYYY-MM-DD	2019-01-24
DESIGNED	MICHAEL PAK
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REVIEWED	DARREN KENNARD
APPROVED	BJÖRN WEEKS

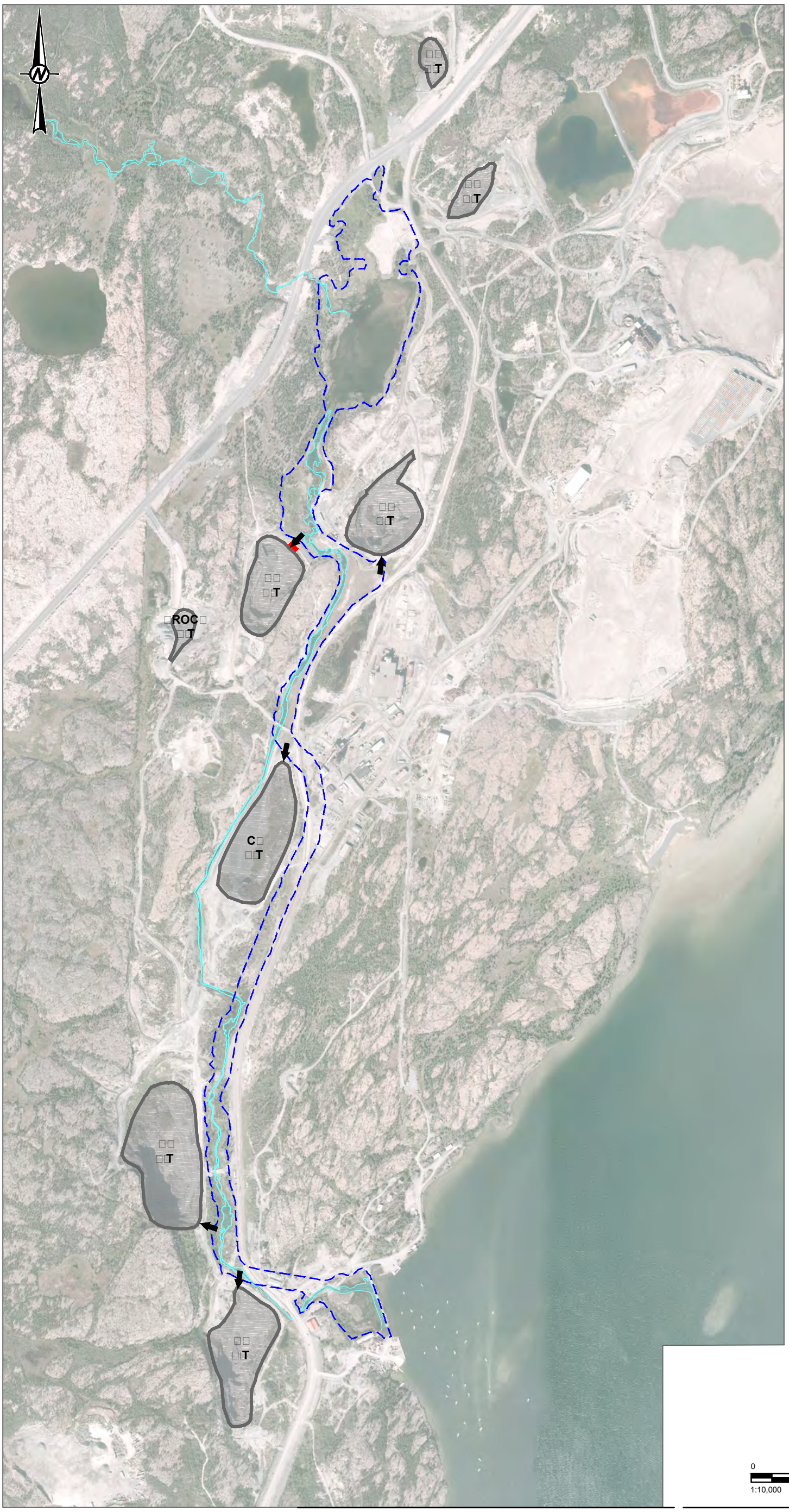
PROJECT
Giant Mine Remediation Project

TITLE
PROBABLE MAXIMUM FLOOD FOR BAKER CREEK AT CLOSURE WITH PIT SPILL ELEVATIONS

REV. 0
FIGURE 5.3-7

Y:\burnaby\CAD-GIS\Client\PWGSC\Giant_Mine\99_PROJECTS\13-1426-0010\Phase 28000\TASK 28202\PRODUCTION\DOC. XXX\1314260010_28000_Fig_5_3 - 7 - Probable Maximum Flood for Baker Creek at Closure With Pit Spill Elevations.dwg

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LEGEND

- BAKER CREEK
- OPEN PIT BOUNDARY
- LOCAL PORTION OF OPEN PIT RIM ELEVATION CLOSE TO PROBABLE MAXIMUM FLOOD (PMF)
- PROBABLE MAXIMUM FLOOD FUTURE ALIGNMENT (GOLDER 2018)
- STRUCTURE VULNERABLE TO FLOODING THAT REQUIRES ADDITIONAL PIT FILL TO SECURE

REFERENCES

1. 2015 AERIAL PHOTO IMAGE PROVIDED BY PUBLIC SERVICES AND PROCUREMENT CANADA (PSPC).
2. GOLDER 2018. GIANT MINE - BAKER CREEK FLOOD HAZARD ASSESSMENT, GIANT MINE REMEDIATION PROJECT, NT. PREPARED FOR PUBLIC SERVICES AND PROCUREMENT CANADA, MARCH 2018, REPORT NUMBER 1313770115-123-R-REV0-15000.

0 250 500
1:10,000 METRES

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Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

PROJECT

Giant Mine Remediation Project

YYYY-MM-DD	2019-01-24
DESIGNED	MICHAEL PAK
PREPARED	MICHAEL PAK / JACOB HOPSON
REVIEWED	DARREN KENNARD
APPROVED	BJÖRN WEEKS

TITLE

FLOOD EXTENT FOR THE FUTURE ALIGNMENT, PROBABLE MAXIMUM FLOOD AND REQUIREMENT FOR FLOOD PROTECTION

REV. 0

FIGURE 5.3-8

Table 5.3-5: Estimated Pit Fill Material Quantities

Pit	Borrow Requirements (m^3)	Contaminated Granular Fill to be Placed (m^3)	Heavily Contaminated Granular Fill (m^3)
A1		~775,000	
A2	~500,000		
B1 (to be frozen)	0 to ~300,000 (as needed)	Up to 300,000, depending on strategy to dispose of containerized waste and heavily contaminated granular fill as well	Up to ~52,000 (TBD)
B2	~200,000	Option for Up to 200,000, but none assumed at this time	
B3	Up to 60,000		
B4	0 to ~10,000 (0 reflects possible condition once pit walls recontoured)		
C1	~325,000		
Total	**~1,095,000 to ~1,395,000**	**~800,000 to ~1,200,000**	**Up to ~52,000 (TBD)**

TBD = to be determined

The contaminated granular fill will primarily be derived from the remediation of the Site Developed Areas (Section 5.4), and the borrow will be derived from borrow sources as discussed in Section 5.7. Additional material will be derived as by-products of other site activities, such as recontouring the high walls above A1 and A2 pits (Figure 5.3-6).

All B1 Pit fill needs to allow freeze hole drilling and limit movement of thermosyphon piping required to isolate the arsenic trioxide waste placed there. This will require additional work to develop specifications for the required geotechnical characteristics of fill material (Section 5.2).

Detailed designs will be developed for pit fill placement adjacent to existing dams and berms adjacent to Baker Creek. Final pit fill surfaces will be designed to make existing dams and berms adjacent to Baker Creek redundant by adding material behind them during pit filling. Pit fill elevations may grade gradually downward away from Baker Creek and existing dams and berms to a lower elevation than the PMF. Detailed engineering studies that combine Baker Creek hydrology, pit filling, and pit covering will be required to determine final pit filling and covering configurations (more in Section 5.3.5.5).

Pit fills will be placed by loading borrow or contaminated granular fill from the source closest to the targeted pit. Fill will be transported and dumped with haul trucks. Where possible and safe, compaction of pit fill material will be carried out to reduce the potential for settlement of the pit covers. This is done to reduce the requirement for future maintenance. Where equipment access to the pit bottoms is not possible, for example in C1 Pit, end dumping of fill material into the targeted pit will be carried out and dust control measures will be required. Where contaminated granular fill is used for pit filling, end dumping will not be employed, and the material will be placed with dust control.

5.3.5.5 Pit Covering

Pit covers may be needed in selected pits for specific purposes. In the pits where contaminated granular fill is placed, clean granular fill may be placed as a cover to reduce the risk of human and wildlife contact with the contaminated materials. In specific circumstances it may be necessary to consider the use of infiltration-reducing

covers as well in selected areas. Infiltration-reducing pit covers may be considered in the case that there is a need to:

- Reduce the volume of infiltration through the pit fill needs to limit seasonal minewater fluctuations.
- Limit the amount of infiltration through the pit fill if future studies suggest that it could negatively impact water treat processes (Section 5.8).

Engineering design studies including trade-offs and options analyses will be conducted to evaluate the type and extent of pit covers needed.

5.3.6 Final Site Conditions

The final site condition for open pits is as follows:

- The accessible openings to surface present in the pits will be plugged with rock borrow in a manner that does not allow movement of pit fill material into the underground, enhances drainage, and does not allow excess pore pressure to build up in the pit fills.
- The underground voids under and adjacent to pits will be stabilized in a manner that precludes unacceptable hazards due to sinkholes forming in the pit fill material (Section 5.1). Should this not be achievable, localized fencing or berms will be installed to reduce public exposure to risk on the pit surfaces above the hazard area.
- The underground voids under and adjacent to pits will be stabilized to a level required to reduce the potential for excessive settlement (Section 5.1) that could damage or cause excessive maintenance requirements of the pit covers, should they be required. Should this not be achievable, some forms of pit cover may not be suitable.
- The pits will be fully or partially filled with a combination of new quarried rock material and contaminated granular fill from the Site that makes them safe but dissuades public use. The fill approach will use techniques that reduces long-term settlement. Contaminated granular fill that does not need to be frozen will be used to fill A1 Pit, portions of B1 Pit, and if necessary B2 Pit.
- Pit fills will include local scour-resistant water diversions / berms where required to protect the underground from flooding during a Baker Creek flood.
- Pits filled with contaminated granular material will be covered by a layer of coarse quarried material to minimize human and wildlife contact.
- If and where required, full or partial pit covers will include infiltration-reducing features to reduce the volume of infiltration to the underground and/or the addition of excessive contamination to the minewater.
- Remnant pit high walls will be recontoured in selected areas for public and worker safety.

Open pit closure work will require the movement of large volumes of existing material from other locations on the Site or the production of new material from on-site borrow sources. Recontouring high walls above specific pits has been identified as an activity that would improve the safety of the pit access areas and reduce the need for the generation of new borrow areas.

5.3.7 Uncertainties

Engineering designs for the CRP are currently at a conceptual level. As such, the basis for estimates and analyses include engineering judgement. Additional design works are planned to address key assumptions and reduce relevant uncertainties. The important uncertainties that affect pits are summarized in Table 5.3-6, together with the engineering studies and other activities planned to address these uncertainties.

Table 5.3-6: Open Pits Mine Workings Uncertainties

Uncertainty	Potential Impact of Uncertainty	Plan to Address Uncertainty
For some pits, it is not known if the desired stability can be achieved due worker safety concerns in the implementation of underground stabilization. For C1 Pit, underground stabilization may be difficult.	C1 Pit may need to be filled using end dumping resulting in differential settlement of pit fills and difficulty in placing and maintaining a low flux cover, should one be required.	Underground stabilization design (Section 5.1) underway to address stabilization requirement.
The extent to which placing new contaminated material into A1 and B1 pits will impact groundwater and minewater quality and the WTP is uncertain.	There could be adverse effects to minewater quality and operation of the WTP	Minewater elevation will be maintained so that the mine area remains a local groundwater sink. Minewater is treated. Further study is planned to confirm the current assumption that placement of this material will not have significant impacts on minewater treatment (Minewater Level Reclamation Research Plan, Appendix 5.1B). Further testing will be completed in 2018 to continue to investigate this uncertainty.

WTP = water treatment plant.

SECTION 5.4
Contaminated Soils and Sediments

5.4 Contaminated Soils and Sediments

5.4.1 Description

Fifty years of operations at the Site have resulted in the widespread contamination of surficial soils and sediments. The aerial discharge of arsenic-rich roaster stack emissions during mining operations represents the primary anthropogenic source of arsenic in soil. Additional sources include the deposition and blending of contaminated granular fill (i.e., sand and gravel with angular cobbles and boulders) with shallow surficial soils and remobilization of contaminants from the TCAs. Petroleum hydrocarbons (PHCs) are also a contaminant of concern at the Site. Although arsenic and PHCs are the main contaminants of concern, elevated concentrations of other metals (i.e., antimony, copper, lead, and zinc) are also present at the Site; however, these metals typically coincide with elevated arsenic concentrations.

Tailings and calcine deposits outside of the TCAs are also present at several locations. These deposits have the consistency of silt or sand and contain elevated concentrations of arsenic and other metals. This section only discusses tailings and calcine deposits located outside the existing TCAs and the Polishing and Settling ponds. Tailings currently located within the TCAs, Polishing and Settling ponds, and the Foreshore Tailings Area are discussed in Section 5.6.

A variety of sources of environmental impairment have also resulted in elevated concentrations of arsenic in sediment within Baker Creek and Yellowknife Bay. Elevated concentrations of antimony, chromium, copper, nickel, vanadium, zinc, lead, selenium, and cobalt have also been recorded in sediment; however, arsenic is the primary contaminant of concern.

Section 5.4 describes the activities planned for the closure and reclamation of contaminated soils and sediments. These activities include the following:

- Contaminated granular fill will be excavated and disposed of in A1 Pit, B1 Pit, and/or the TCAs (an estimated 922,000 m^3 of material).
- Four areas of contaminated granular fill within the Developed Areas, where the depth of contamination makes excavation impractical, will be capped with engineered covers.
- Heavily contaminated granular fill from the mill/roaster area will be frozen in B1 Pit or within another suitable frozen zone (an estimated 52,000 m^3 of material).
- Contaminated fine-grained soil and PHC-contaminated soil will be excavated and disposed of in the TCAs (an estimated 164,000 m^3 of material).
- Engineered covers will be placed over tailings located west of the Polishing and Settling ponds and within the Mill Pond.
- Placement of an engineered cover over Calcine located in the former Calcine Pond.
- Tailings located in historical Jo-Jo Lake will be excavated and disposed of in the TCAs (an estimated 32,000 m^3 of material).
- Contaminated sediment located in Baker Creek Reaches 0 through 6 will be excavated and disposed of in the TCAs (an estimated 119,500 m^3 of material).

- Contaminated sediment located along the shoreline of Yellowknife Bay, adjacent to the Townsite/Marina and Shoreline Lands, (i.e., nearshore sediment) will be partially excavated and an engineered cover constructed (an estimated partial excavation of 10,000 m^3).
- A fence will be installed to restrict public access to the majority of bedrock/forest/wetland terrain where soils have been most impacted by arsenic from former stack emissions. The location of the fence has been developed to establish a zone with a low risk of human exposure to contaminated soils. The location of the fence has been selected based on multiple lines of evidence, with confirmation through the HHERA that the fence will result in low to very low risks to human health.

Table 5.4-1 provides a summary of the contaminated material types, volumes, and disposal locations for contaminated soils and sediments at the Site. Additional details on the contaminant sources and locations are provided in Sections 5.4.3 and 5.4.4.

Table 5.4-1: Summary of Contaminated Material Types, Volumes, and Disposal Locations

Material Types	Description	Volume (m^3)	Disposal Location
Contaminated granular fill	This heterogeneous material is typically dominated by sand (0.425 to 2 mm) and gravel (4.75 to 19 mm) with angular cobbles (75 to 300 mm) and boulders (>300 mm) and minor to some silt and clay. Contaminant sources include arsenic-rich roaster stack emissions and/or mineralized waste rock. These sources have resulted in total arsenic concentrations >340 mg/kg (>160 mg/kg within the Townsite/Marina). This material is located within the Developed Areas (refer to Section 5.4.4.1).	922,000	Combination of A1 Pit (622,000 m^3), B1 Pit (100,000 m^3), and TCAs (200,000 m^3).
Heavily contaminated granular fill	This material is a subset of the contaminated granular fill and is located in the mill/roaster area. This material represents contaminated granular fill with total arsenic concentrations greater than 4,500 mg/kg, the maximum total arsenic concentration of tailings. Samples collected from the granular fill material consisted of the fine-grained matrix (i.e., sands, gravels) rather than the mineralized rock matrix (i.e., cobbles and boulders). As a result, the arsenic concentrations reported are representative of the fine-grained matrix, however these materials will be left co-mingled for practicality.	52,000	Frozen portion of B1 Pit or within another suitable frozen zone.
Contaminated fine-grained soil	This material is composed of silt and clay with minor to some sand and is identified as glacial till / lacustrine native soil. This material is located within the Developed Areas (below the contaminated granular fill) and the bedrock/forest/wetland terrain (refer to Section 5.4.4.2). Within the bedrock/forest/wetland terrain, this material is typically overlain by peaty organic soil of variable thickness. Contaminant sources for this material are associated with arsenic leaching from overlying contaminated granular fill within the Developed Areas and arsenic-rich roaster stack emissions within the bedrock/forest/wetland terrain. Total arsenic concentrations are >340 mg/kg (>160 mg/kg within the Townsite/Marina).	143,000	TCAs

Table 5.4-1: Summary of Contaminated Material Types, Volumes, and Disposal Locations

Material Types	Description	Volume (m^3)	Disposal Location
PHC-contaminated soil	This material is a subset of the contaminated fine-grained soil and contaminated granular fill located within the Developed Areas (Section 5.4.4.1); however, the primary contaminant source is PHCs. Concentrations of PHC parameters are greater than the applicable guidelines.	21,000	TCAs
Tailings and calcine	This material is tailings and/or calcine that has been deposited outside of the existing TCAs. Tailings are located west of the Polishing and Settling ponds towards Baker Pond (i.e., Area 4), within historical Jo-Jo Lake, and within the Mill Pond. Calcine was historically deposited within the former Calcine Pond located adjacent to B1 Pit.	32,000	Tailings within historical Jo-Jo Lake will be disposed of within the TCAs. Tailings within Area 4 and the Mill Pond, along with calcine within the former Calcine Pond will be left in place and engineered covers constructed.
Contaminated sediment	This material is composed of a mix of coarse sand and silt which grades towards a finer sand and silt with depth. Contaminated sediment is located within Baker Creek and along the shoreline of Yellowknife Bay (i.e., nearshore sediment). Contaminant sources for this material are described in Section 5.4.3.4.	129,500	TCAs
	Total	**1,299,500**	

mm = millimetre; mg/kg = milligrams per kilogram; PHC = petroleum hydrocarbon; TCA = Tailings Containment Area.

5.4.2 Pre-disturbance and Existing Site Conditions – Terrain

Minimal photographic evidence is available with respect to terrain conditions prior to development of the Site. The pre-disturbance conditions may have been generally consistent with the bedrock/forest/wetland terrain currently present at the Site. The following description is based on the existing terrain conditions. Terrain conditions consist predominantly of bedrock outcrops, with organic materials composed of peaty organic soils, scrub forest, and wetlands constituting the remainder of the terrain. A description of the terrain conditions is provided in Chapter 2; however, brief summaries are provided below.

Bedrock outcrops are predominant at higher elevations. The main portions of the outcrop typically consist of bare, smooth rock surfaces with crevasses or hollows, which collect soil. Vegetation within the outcrop areas is limited to the outcrop crevasses or hollows (typically less than 10% of the outcrop area) and the lower lying areas between outcrops.

Forested areas occur in lower lying areas between the outcrops. The forested areas typically consist of small and stunted spruce and birch, with small shrubs frequently intermixed. The subsurface soil conditions in the vegetated areas generally consist of organic deposits that are typically less than 0.5 m thick underlain by glaciolacustrine clays and silts. These materials overlay glacial till, which is discontinuous and typically less than 2.0 m thick.

Wetlands occur in poorly drained areas between the outcrops. The wetlands are small, marshy areas situated on the edges of surface waterbodies and within hollows. Vegetation in these areas typically consists of small bushes, cattails, mosses, and grasses. The subsurface soil conditions in the wetlands generally consist of organic deposits that are typically over 1.0 m thick underlain by glaciolacustrine clays and silts.

5.4.3 Existing Site Conditions – Contaminant Sources

Numerous soil and sediment investigations have been completed at the Site (Appendix 5.4-A). Based on these investigations, volumes of contaminated materials have been calculated, as presented in Table 5.4-1. Definitions of the contaminated material types are also provided in Table 5.4-1 and the Glossary. The sections below provide a detailed discussion of the four primary sources of contaminated materials at the Site.

5.4.3.1 Arsenic-Contaminated Soil

The presence of arsenic in shallow soil may be broadly grouped into either natural or anthropogenic categories. Natural concentrations of arsenic are elevated at the Site and surrounding areas as a result of the presence of the arsenic-rich Greenstone Belt. The Greenstone Belt is characterized by arsenopyrite (FeAsS) deposits close to surface, which has resulted in an elevated background arsenic concentration of approximately 94 mg/kg (CanNorth 2018).

The aerial discharge of arsenic-rich roaster stack emissions during historical mining operations added to the naturally occurring arsenic in shallow soils. During the initial two years of operation, roaster stack emissions were discharged directly to the atmosphere, as described in Chapter 3. Recent studies have estimated that the aerial extent of roaster stack emissions may extend 20 to 30 km from the historical roaster stack (Jamieson et al. 2017). Emission controls were optimized between 1951 and 1954, and were in place until 1999, when the roaster ceased operations. The roaster stack emissions consisted of two components:

- **Arsenic trioxide (As_2O_3)**—the primary constituent of roaster emissions (typically 80% of emissions) and occurs in two typical mineral habits (arsenolite and clauderite). Antimony-bearing arsenic trioxide ($[As,Sb]_2O_3$) is also present.
- **Roaster-derived iron-oxides**—may contain up to 7% arsenic mixed as arsenite and arsenate. These nanocrystalline iron oxide structures are composed of maghemite, hematite, and magnetite.

The presence of other arsenic-related materials in roaster particles is secondary in terms of occurrence and concentration in the environment. Recent soil quality studies (Wrye 2008; Bromstad 2011; Bromstad et al. 2017) have shown that each of the two components defined above can be identified due to their unique mineralogy.

A secondary anthropogenic source of arsenic in contaminated soils is the blending of contaminated granular fill with shallow surficial soils. Mining operations generated mineralized granular fill with elevated arsenic concentrations. This fill was used at various locations in the site for surface regrading, maintenance, and construction. Leaching from the fill also resulted in elevated arsenic concentration in underlying, fine-grained glaciolacustrine / glacial silts and clays.

5.4.3.2 Petroleum Hydrocarbon Contaminated Soil

PHC-contaminated soils have been encountered at the Site. Diesel fuel, Bunker C fuel oil, and/or waste oil were released into surficial soils as part of historical spills or improper maintenance of storage tanks. Storage tanks were used in historical operations for vehicles and machinery fuel, fuel for heating buildings, and used oil. The areas of PHC-contaminated soils typically coincide with areas of arsenic-contaminated soils (i.e., PHC and arsenic contaminated soils are “co-located”).

5.4.3.3 Tailings and Calcine Deposits

Tailings contain elevated concentrations of arsenic in the form of both arsenopyrite and roaster oxides (Golder 2016). These materials were deposited outside the existing TCAs west of the Polishing and Settling ponds into an area known as Area 4 in the Preliminary Design Basis (refer to Figure 5.4-1 and Appendix 5.4-A). These materials were also deposited into Baker Pond and historical Jo-Jo Lake (Figure 5.4-3), and the Mill Pond (Figure 5.4-1). In addition, tailings and tailings pond water were released downgradient of Dam 3 due to the following:

- **Tailings pond water management in the 1960s**—During the mid to late 1960s, the mine operator was allowed by the Federal Department of National Health to discharge/decant tailings pond water north over Dam 3, overland towards Yellowknife Bay.
- **Perimeter tailings dam integrity in the 1970s**—During the early to mid-1970s, both uncontrolled releases and overtopping of perimeter Dam 3 resulted in the release of tailings and pond water.

Calcine contains elevated concentrations of arsenic in the form of arsenic-rich iron oxides (INAC and GNWT 2010). This material was deposited within the former Calcine Pond, located west of the former roaster stack and adjacent to B1 Pit and Baker Creek. The pond was used to store calcine prior to the final stage of the gold extraction process.

A detailed discussion on the generation of tailings is provided in Section 5.6 and calcine in the DAR (INAC and GNWT 2010). Tailings currently located within the TCAs, Polishing and Settling ponds, and the Foreshore Tailings Area are discussed in Section 5.6.

5.4.3.4 Contaminated Sediment

Elevated concentrations of arsenic, antimony, chromium, copper, nickel, vanadium, zinc, lead, selenium, and cobalt have been recorded in shallow sediment in Baker Creek (Reaches 0 through 5), Baker Pond (Reach 6), and in Yellowknife Bay. Chapter 2 provides details on sediment particle size and metal concentrations. The primary sources of environmental impairment to sediment are briefly described below:

- **Effluent derived from TCAs**—Prior to the commissioning of the current ETP, untreated pond water from the TCAs was discharged directly to Baker Creek and flowed downstream into Yellowknife Bay. Historical documentation indicates that this management practice was carried out in the 1960s and 1970s and was discontinued following the commissioning of the current ETP in 1981 (GYML 1978).
- **Minewater discharge from underground**—Minewater from underground workings was historically pumped to the surface and subsequently discharged directly to Baker Creek and flowed downstream towards Yellowknife Bay. Historical documentation indicates that this practice commenced in the early years of mine operation and continued until 1981. Underground minewater has been subsequently treated at the ETP prior to discharge into Baker Creek (INAC and GNWT 2010). The treated effluent acts as an ongoing source of potential contamination to Baker Pond, Baker Creek, and Yellowknife Bay.
- **Tailings releases**—During early operations (1950s), tailings were placed within historical Jo-Jo Lake, located at the north end of Baker Pond. An erosion event associated with these tailings occurred in 2011, resulting in the mobilization of tailings into Baker Creek. In addition, flotation tailings were placed within Yellowknife Bay during the initial year of ore processing (i.e., Foreshore Tailings Area; see Section 5.6).

Engineered covers have subsequently been placed over parts of these tailings deposits; however, sediment within Baker Pond, Baker Creek, and Yellowknife Bay has been impacted by their historical deposition and erosion.

- **Historical mill/roaster operational process upsets**—Upsets, including tailing overflows and concentrate/calcine wash overflows, have resulted in the historical release of solid wastes into Baker Creek, which flowed downstream towards Yellowknife Bay. No additional information regarding the duration and rate of occurrence is available; however, historical documentation indicates that the mill/roaster operation upsets were corrected between 1976 and 1978 (GYML 1978).
- **Aerial emissions from the roaster stack**—Historical airborne releases of arsenic-rich roaster stack emissions represent the primary source of anthropogenic contaminant release to the environment. Natural environmental processes (i.e., wind and runoff) transported these arsenic-rich materials into Baker Pond, Baker Creek, and Yellowknife Bay.

5.4.4 Existing Site Conditions – Location of Contaminated Soils and Sediments

The Site has been separated into Developed Areas, bedrock/forest/wetland terrain, and Baker Creek for the purpose of identifying and evaluating closure options. Developed Areas are areas that were physically re-graded to support mining operations. The bedrock/forest/wetland terrain was not physically developed as part of the historical mining operations but these areas were impacted by aerial deposition of arsenic from roaster stack emissions. It is recognized that some areas of the Site were historically developed but may have re-vegetated and now appear undeveloped. For the purpose of the CRP, these areas are grouped with the bedrock/forest/wetland terrain for ease of reference. Baker Creek is subdivided into the lower reaches through the Site (Reaches 0 through 5), Baker Pond (Reach 6), and historical Jo-Jo Lake.

5.4.4.1 Developed Areas

The Developed Areas were constructed primarily with mineralized granular material and, as a result, soil conditions typically consist of contaminated granular fill, underlain by native glaciolacustrine clays / glacial till, silts, and/or bedrock. Additional contaminant sources in the Developed Areas include arsenic-rich roaster stack emissions, PHCs, and tailings and calcine deposits outside of the existing TCAs. Developed Areas currently include the following geographical locations (Figure 5.4-1 and Appendix 5.4-A):

- **Mill/roaster area**—This area is located in the south-central portion of the Site and contains the majority of mine structures, including the roasting and milling plants, C-Dry building, various maintenance buildings, C Shaft, and the Mill Pond. The average arsenic concentration in shallow soil in the mill/roaster area is approximately 2,300 mg/kg; however, it should be noted that the soil in the upper 0.5 m of the area contains arsenic concentrations >4,500 mg/kg. In addition, the area immediately surrounding the former Roaster Complex contains total arsenic concentrations >10,000 mg/kg in soil. This area is also the primary location for historical and current fuel storage at the Site. Soil quality exceedances of GNWT ENR Guidelines for toluene (maximum measured concentration of 3.7 mg/kg), ethylbenzene (maximum measured concentration of 76.3 mg/kg), xylenes (maximum measured concentration of 478 mg/kg), PHC Fraction F1 (maximum measured concentration of 7,160 mg/kg), PHC Fraction F2 (maximum measured concentration of 32,100 mg/kg), PHC Fraction F3 (maximum measured concentration of 63,500 mg/kg), and PHC Fraction F4 (maximum measured concentration of 31,000 mg/kg) have been recorded in this area.

- **Tailings retreatment plant (TRP)—**This area is located southwest of the North Pond and includes the TRP building, a small warehouse, adjacent laydown areas, and associated roadways. The average total arsenic concentration in soil around the TRP is approximately 1,700 mg/kg. An isolated location of PHC-contaminated soil has also been identified within a laydown area adjacent to the TRP, with exceedances of the guideline for PHC Fraction F2 (maximum concentration of 1,300 mg/kg), PHC Fraction F3 (maximum concentration of 50,800 mg/kg), and PHC Fraction F4 (maximum concentration of 25,600 mg/kg) having been recorded.

- **Area 4**—This area includes a series of roadways west of the Polishing and Settling ponds towards Baker Pond and adjacent to B3 Pit. A large portion of this area is underlain by tailings placed by the mine operator in the early 1950s. As a result, the average depth of contaminated materials (i.e., contaminated granular fill and tailings) within Area 4 extends deeper than 4.0 m. The average total arsenic concentration in Area 4 soil / tailings is approximately 1,100 mg/kg.

- **Townsite**—This area is located in the southeast portion of the Site and is situated north of Reach 0 and east of the Giant Mine Access Road. Existing infrastructure within the Townsite includes roadways, abandoned homes, a playground, a boat launch, and related infrastructure. The Yellowknife Historical Society (formerly the NWT Mining Heritage Society) also displays an outdoor museum in this area, which includes historical mining equipment and a historical log cabin. The average total arsenic concentration in shallow soil in the Townsite is approximately 1,000 mg/kg. An isolated location of PHC-contaminated soil has also been identified adjacent to the boat launch, as exceedances of the guidelines for PHC Fraction F2 (maximum concentration of 4,000 mg/kg), PHC Fraction F3 (maximum measured concentration of 17,000 mg/kg), and PHC Fraction F4 (maximum measured concentration of 6,700 mg/kg) have been recorded.

- **Marina**—This area is situated in the southeast portion of the Site, south of Reach 0 and east of the Giant Mine Access Road. The Marina is currently occupied by the Great Slave Sailing Club and includes a boat storage area, clubhouse, and dock area. The average total arsenic concentration in soil in the Marina is approximately 800 mg/kg.

- **Calcine Pond**—The former Calcine Pond is located northwest of B1 Pit, adjacent to Baker Creek. As some of the material deposited in the former Calcine Pond was difficult to use in the gold extraction process, residual calcine material was left in place and capped with soil from B1 Pit. As a result, the maximum depth of calcine is approximately 13.5 m and the average arsenic concentration in soil / calcine is approximately 4,000 mg/kg.

- **Roadway network**—The roadway network includes all roadways, excluding Vee Lake Road and the Giant Mine Access Road, which are present throughout the Site and are not captured within the other Developed Areas. This roadway network covers approximately 29 km with an average total arsenic concentration in granular roadway material of approximately 1,200 mg/kg.

- **Various laydown and material storage areas**—These areas are often located adjacent to open pits, TCAs, or underground shafts and have been designated as laydown areas for equipment and material storage. The average total arsenic concentration in soil within the various laydown and material storage areas is approximately 700 mg/kg. Some of these areas historically included fuel storage tanks. Exceedances of guidelines for PHC Fraction F2 (maximum concentration of 2,700 mg/kg), PHC Fraction F3

(maximum measured concentration of 51,000 mg/kg), and PHC Fraction F4 (maximum concentration of 23,000 mg/kg) have been recorded in these areas.

Soil data for the Developed Areas has been developed through a series of studies, including a preliminary design report focused on soil quality data collected within the Developed Areas (Golder 2012a). This data augmented previously collected soil quality data and provided a revised interpretation of the lateral and vertical extent of contaminated granular fill. Following completion of the preliminary design report, further investigation of the lateral extent of soil quality impairment associated with the road network was conducted (Golder 2017e), along with further assessment of the vertical and lateral extent of contaminated granular fill materials within several key Developed Areas (Golder 2017f). Further assessment of the potential remediation of the Townsite/Marina to residential soil quality criteria was also conducted (Golder 2017g).

The locations of different types of contaminated soils in the developed areas is presented in Figure 5.4-1.

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634000 636000 638000

6934000 6932000

Trapper Lake
Shot Lake
AKAITCHO SHAFT
Yellowknife River
Gar Lake
NORTHWEST POND
B4 PIT
Trapper Creek
SETTLING POND
B3 PIT
POLISHING POND
JO-JO LAKE
Baker Creek
AREA 4
NORTH POND
Pocket Lake
4
Baker Pond
TAILINGS RETREATMENT PLANT
CENTRAL POND
CALCINE POND
B1 PIT
B2 PIT (UBC)
SOUTH POND
BROCK PIT
MILL POND
MILL / ROASTER AREA
Baker Creek
C1 PIT
Handle Lake
A1 PIT
Yellowknife Bay
TOWNSITE
A2 PIT
MARINA

LEGEND

- BAKER CREEK
- BREAKWATER
- HIGHWAY
- GIANT MINE ACCESS ROAD
- GIANT MINE PROJECT BOUNDARY
- ROAD NETWORK
- WATERCOURSE
- BAKER POND
- DEVELOPED AREA
- PIT BOUNDARY
- TCA POND
- WATERBODY

0 250 500
1:20,000 METRES

REFERENCE(S)

HYDROLOGY AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-23
DESIGNED	SF
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

EXISTING SITE CONDITIONS – DEVELOPED AREAS

REV. 0

FIGURE 5.4-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0

5.4.4.2 Bedrock/Forest/Wetland Terrain

The bedrock/forest/wetland terrain at the Site has not been developed as part of historical mining operation. This terrain has however been impacted by aerial dispersion of arsenic-rich roaster stack emissions, tailings releases, and discharge of pond water from the TCAs. It is recognized that some areas of the Site were historically developed but may have re-vegetated and now appear undeveloped. For the purposes of the CRP, these areas are included in the bedrock/forest/wetland terrain for ease of reference. The current bedrock/forest/wetland terrain is generally consistent with the conditions described in Section 5.4.2. Historical roaster emissions have significantly impacted the health of vegetation in the bedrock/forest/wetland terrain (Hocking et al. 1978). Vegetation has recovered subsequent to termination of roaster operations in 1999; however, recovery to pre-disturbance conditions has not fully occurred.

The bedrock/forest/wetland terrain currently includes the following three geographical locations:

- **Shoreline Lands**—The Shoreline Lands are situated in the southeast portion of the Site and extend from the Townsite/Marina, north-northeast along Yellowknife Bay to the Foreshore Tailings Area. This area encompasses approximately 23 ha of bedrock/forest/wetland terrain along with approximately 8 ha of nearshore sediment. The average total arsenic concentration in soil within the Shoreline Lands is approximately 400 mg/kg, while the average arsenic concentration in the nearshore sediment is approximately 300 mg/kg.
- **Core Industrial Area**—The Core Industrial Area is defined as the lands surrounding the mill/roaster area which have been affected by the aerial dispersion of arsenic-rich roaster stack emissions. Open pits, waterbodies, and the Developed Areas located within the limits of the Core Industrial Area are not considered part of it. The Core Industrial Area encompasses approximately 218 ha and is dominated by bedrock/forest/wetland terrain (160 ha). The average total arsenic concentration in soil within the bedrock terrain is approximately 3,000 mg/kg; however localized areas of total arsenic concentrations >10,000 mg/kg in soil have been recorded within bedrock crevasses near the mill/roaster area. The average total arsenic concentration in soil within the forest/wetland terrain is approximately 700 mg/kg.
- **Downgradient of Dam 3**—The area downgradient of the North Pond consists of approximately 20 ha of bedrock/forest/wetland terrain to the north and northeast of Dam 3. Approximately 16 ha has been affected by the historical discharge of pond water from the North Pond and approximately 4 ha has experienced direct surface deposition of tailings solids. The average total arsenic concentration in soil within the pond water impacted areas is approximately 700 mg/kg, while the average total arsenic concentration in soil within the tailings impacted areas is approximately 2,300 mg/kg.

The average and maximum total arsenic concentrations for each terrain type in these areas is shown in Table 5.4-2.

Table 5.4-2: Total Arsenic Concentration In Each Terrain Type (Average and Maximum).

Location	Total Arsenic Concentration (mg/kg)					
	Bedrock (soils samples from within crevasses)		Forest		Wetland	
	Average	Maximum	Average	Maximum	Average	Maximum
Shoreline Lands	1,600	4,490	304	916	453	1,010
Core Industrial Area	1,501	23,100	389	12,000	443	5,500
Downgradient of Dam 3	ns	ns	3,790	695	ns	ns

ns – terrain not sampled

The interpretation of the distribution of arsenic in shallow bedrock/forest/wetland terrain was based on:

- forensic mineralogy
- additional soil quality investigations
- detailed terrain mapping
- comparison with case studies

The following sections briefly summarize the findings of various studies/investigations undertaken to define the source and lateral extent of soil quality impairment within the bedrock/forest/wetland terrain.

5.4.4.3 Forensic Mineralogy

Forensic mineralogy has been applied at the site beginning in 2008 with university researchers collecting shallow soil samples principally from bedrock crevasses near the historical roaster stack (Wrye 2008; Bromstad 2011; Bromstad et al. 2017). Forensic mineralogy techniques can often confirm, sort, and quantify on a grain-by-grain basis the mineralogy and chemistry of individual soil particles, allowing the identification of the likely source. Although separate soil samples obtained from roaster and tailings contaminated materials may have comparable bulk chemistry results, forensic mineralogy techniques may be used to visually and chemically distinguish the metal-rich oxides found in roaster emissions from the metal sulfide minerals common in tailings.

The research conducted at Giant concluded that elevated concentrations of arsenic present in shallow soils within bedrock crevasses was due to roaster stack emissions.

Forensic mineralogy techniques were also applied to soil samples collected across the Site in 2015, over a wide variety of terrain types. This assessment confirmed the persistent and widespread nature of arsenic trioxide particles originating from the historical roaster stack within shallow soil in the bedrock/forest/wetland terrain across the Site. The results also provided the initial insight into distinctive mineralogical variation of soil quality with distance from the historical roaster stack.

The linkage between terrain conditions and the preservation of arsenic rich contaminants was a significant finding of this research. Contaminants were found to be preferentially preserved and concentrated within poorly drained bedrock crevasses. While bedrock terrain covers a significant portion of the Site, the contaminated soil is isolated within narrow fractures that typically cover less than 10% for the total bedrock outcrop area. Outside of the bedrock crevasses, arsenic concentrations in shallow soil within the forest/wetland terrain were typically an order of magnitude lower.

The following key findings were confirmed through these forensic mineralogy studies:

- The highest concentrations of arsenic in soil typically occur within 1 km of the historical roaster stack and are dominantly present in shallow soil within bedrock crevasses. Within this geographic area, soil samples from bedrock crevasses typically contain thousands of grains of arsenic trioxide observed on a thin section slide analyzed using a mineral liberation analyser and scanning electron microscope. This zone is dominated by particle fallout from the historical roaster stack.
- Concentrations of arsenic in shallow soil decline rapidly beyond approximately 1 km from the historical roaster stack. Mineralogical evidence indicates that regional shallow soil samples typically contain less than one hundred grains of arsenic trioxide per section at distances beyond 1 km from the historical roaster stack. This zone is dominated by particle dispersion from the historical roaster stack.

5.4.4.4 Additional Soil Quality Investigations

Supplementary soil quality investigations, with several hundred samples collected, confirmed that the distribution of total arsenic concentrations declines roughly exponentially with distance from the former roaster stack.

The investigations confirmed that the operation of the former roaster had resulted in the widespread distribution of arsenic rich roaster stack emissions and residual shallow soil quality impairment within the bedrock/forest/wetland terrain. A detailed summary of these investigations is provided in Appendix 5.4A.

5.4.4.5 Detailed Terrain Mapping and Soil Quality Model Development

A digital terrain map was developed to support interpretation of the distribution of arsenic at the Site. Details on the production of the digital terrain map are provided in Appendix 5.4A. The terrain mapping was used to segregate the bedrock/forest/wetland terrain into specific surficial geology units based on interpretation of the existing terrain (Figure 2.2-2). The results of the terrain mapping and soil sampling were input into a GIS database for the purpose of modelling soil quality. The contaminant distribution within shallow soil was interpreted using a soil quality terrain model, developed using a GIS software application (ESRI ArcGIS).

Soil chemistry data for the bedrock/forest/wetland terrain was combined with the digital terrain map to produce a “heat map” that shows total arsenic concentrations in soil by colour gradation within the bedrock/forest/wetland terrain (Figure 5.4-2). ArcGIS software, applying the Kriging interpolation method, was used to interpret the discrete bedrock/forest/wetland soil chemistry data points. The Kriging method assumes the distance and direction between discrete sample locations represents a spatial correlation that can be used to explain variation in the surface arsenic concentrations. The presence of arsenic rich contaminants within bedrock terrain is restricted to narrow crevasses covering less than 10% of the rock mass area. A “vein pattern” as shown in Figure 5.4-2 for the concentrations provides a realistic field-based illustration of the soil quality impairment in bedrock terrain.

In the soil quality model, the interpolation of soil chemistry data points was completed separately on samples from each terrain type, to account for differences in processes acting in each area. Wrye (2008) theorized that the bedrock depressions trapped arsenic rich dust from historical roaster stack emissions via washing down from the bedrock surface, and that this process resulted in the accumulation of arsenic-containing particles over time in shallow outcrop soils. As such, natural processes create a mechanism by which contaminants from the

historical roaster stack emissions are concentrated. By contrast, forest and wetland terrain areas are subject to biological processes through interactions with vegetation and wildlife.

The soil quality model that underlies Figure 5.4-2 illustrates the exponential decline in total arsenic concentrations with distance from the historical roaster stack and supports the forensic mineralogy data, which roughly defines a 1 km zone of particle fallout centered around the historical roaster stack. Interpretation of the soil quality model indicates that total arsenic concentrations decline rapidly beyond the 1 km zone. Chemical outliers are present, with isolated occurrences of elevated arsenic concentrations (>3,000 mg/kg total arsenic) present in bedrock crevasses recorded at distances greater than 1 km from the historical roaster stack. These occurrences are sporadic and become less evident with increasing distance from the roaster.

5.4.4.6 Comparison with Case Studies

A review of case studies (Ettler 2005; Houben et al. 2016) at similar mining operations indicate that the spatial distribution of contaminants from historical smelter/roaster stacks measured in shallow soils follows an exponential decay from the source and is linked to three primary factors:

i. **Wind direction**—The prevailing wind directions and overall wind energy will dictate the pattern of soil quality impairment.

ii. **Size of particles emitted**—Larger particles frequently fall out near the stack, whereas smaller particles are carried/dispersed by wind.

iii. **Chemical and mineralogical composition of the particles**—The persistence/stability of contaminants in the environment is frequently linked to physical stability particle mineralogy.

In the case of the Site, data collected suggests that these factors all played a role. A distinctive northwest-southeast soil quality impairment pattern has been documented for the Site, which is consistent with the predominant wind direction. Forensic minerology at the site showed that larger particles were concentrated closer to the stack (Golder 2016). In terms of persistence of the contaminants, physical characteristics of the site has an important role, as arsenic-rich contaminants have been preserved preferentially within bedrock crevasse soils. Following the review of case studies, it was concluded that the overall investigation and model findings correlated well with the case study record.

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636000 638000

6936000 6934000 6932000

Trapper Lake
Shot Lake
Yellowknife River
Car Lake
NORTHWEST POND
4
B4 PIT
Trapper Creek
SETTLING POND
B3 PIT
POLISHING POND
Baker Creek
JO-JO LAKE
NORTH POND
Pocket Lake
Baker Pond
CENTRAL POND
B1 PIT
B2 PIT (UBC)
SOUTH POND
BROCK PIT
CORE INDUSTRIAL AREA
C1 PIT
Baker Creek
Yellowknife Bay
A1 PIT
A2 PIT

DETAIL MAP: CORE INDUSTRIAL AREA (SCALE 1:10,0000)

B1 PIT
B2 PIT (UBC)
Baker Creek
SOUTH POND

636000 638000

LEGEND

- BAKER CREEK
- BREAKWATER
- GIANT MINE PROJECT BOUNDARY
- GIANT MINE ACCESS ROAD
- HIGHWAY
- WATERCOURSE
- BAKER POND
- DOWNGRADIENT OF DAM 3
- PIT BOUNDARY
- SHORELINE LANDS AND NEARSHORE
- TCA POND

BEDROCK CREVASSE ARSENIC CONCENTRATION (mg/kg)

- 0 - 340
- 340 - 3000
- 3000 - 4500
- 4500 +

FOREST/WETLAND ARSENIC CONCENTRATION (mg/kg)

- 0 - 340
- 340 - 3000
- 3000 - 4500
- 4500 +

NOTE(S)

ARCGIS SOFTWARE USED KRIGING INTERPOLATION METHOD TO INTERPRET DISCRETE SOIL CHEMISTRY DATA POINTS. KRIGING METHOD ASSUMES THE DISTANCE AND DIRECTION BETWEEN SAMPLES REPRESENTS A SPATIAL CORRELATION THAT CAN BE USED TO EXPLAIN VARIATION IN THE SURFACE. GIS TERRAIN MODEL COMBINED WITH INTERPOLATED SOIL CHEMISTRY DATA TO CREATE HEAT MAPS, BY TERRAIN TYPE. KRIGING INTERPOLATION IS LIMITED TO THE EXTENT OF SAMPLE POINTS. AS A RESULT, THE INTERPRETATION DOES NOT COVER THE FULL EXTENT OF THE PROJECT AREA.

0 250 500

1:20,000 METRES

REFERENCE(S)

HYDROLOGY AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-23
DESIGNED	SF
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

EXISTING SITE CONDITIONS – BEDROCK/FOREST/WETLAND SOIL CHEMISTRY

REV. 0

FIGURE 5.4-2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0

5.4.4.7 Baker Creek

Baker Creek is located in the central portion of the Site. Baker Creek on Site includes the lower reaches through the Site (Reaches 0 through 5), Baker Pond (Reach 6), and historical Jo-Jo Lake (refer to Figure 2.5-1 in Chapter 2). Baker Creek has undergone realignment in Reaches 1, 3, and 4 due to expanding mining activities and stability concerns, as well as fish habitat improvements within Reach 4 (refer to Chapter 2, Chapter 4, and Section 5.5 for further information). Baker Pond covers an area of 6.3 ha and is relatively shallow, with a current mean depth of less than 1.5 m and a maximum depth of approximately 3.0 m. Historical Jo-Jo Lake covers 1.2 ha and contains the Jo-Jo Lake tailings that currently have an engineered cover in place (refer to Chapter 4 for additional details).

Engineering work to further assess sediment quality within Baker Creek, Baker Pond, and the tailings within historical Jo-Jo Lake was completed in 2017 (Golder 2017j). A summary of the investigations of contaminated materials within Baker Creek is provided in Appendix 5.4-A.

Elevated concentrations of arsenic, antimony, chromium, copper, nickel, vanadium, zinc, lead, selenium, and cobalt exist within sediment throughout Baker Creek. Total arsenic concentrations within the contaminated sediment vary throughout Baker Creek (refer to Table 5.4-2 and Golder 2017j). Reach 4 was previously remediated as part of restoration activities in 2007; however, recent sediment sampling data (Golder 2017j) has identified a small of volume of contaminated sediment within Reach 4, likely caused by incoming sediments from the upstream reaches.

Small pockets of tailings are present throughout the sediment within Baker Creek. For the purpose of this discussion, these tailings are captured under the volumes presented for contaminated sediments (Table 5.4-3).

Table 5.4-3: Arsenic Concentrations within Baker Creek

Reach	Maximum Recorded Total Arsenic Concentration (mg/kg)
Reach 0	3,830
Reach 1	5,030
Reach 2	13,700
Reach 3	21,300
Reach 4	2,370
Reach 5	6,970
Baker Pond (Reach 6)	5,070

During early operations (1950s), tailings were placed within Jo-Jo Lake. An engineered cover was placed over these tailings in 2011 after erosion event mobilized tailings into Baker Creek. The tailings within historical Jo-Jo Lake extend to an approximate depth of 3.0 m and the maximum recorded total arsenic concentration of the tailings is 3,850 mg/kg.

5.4.5 Closure Objectives and Criteria

Based on the goals and principles for the GMRP, closure objectives were identified specifically for the closure and reclamation of the contaminated soils and sediment component. The objectives and criteria of the GMRP relating specifically to reclamation of the contaminated soils and sediment are presented in Table 5.4-4.

Table 5.4-4: Contaminated Soils and Sediment Closure Objectives and Criteria

Closure Objectives	Closure Activity	Closure Criteria	Monitoring/Maintenance and Inspection

CS1. Contaminated materials (i.e., soil, sediment, granular fill, and tailings) are remediated or risk managed to reduce risk to humans and to aquatic and terrestrial ecosystems	• Remove and dispose of heavily contaminated granular fill from the mill/roaster area in the frozen portion of B1 Pit or within another suitable frozen zone.
	• Remove and dispose of contaminated granular fill in A1 and B1 Pits and TCAs.
	• Remove and dispose of contaminated fine-grained soil in TCAs.
	• Remove and dispose of PHC contaminated soil in TCAs.
	• Excavate tailings-impacted fine-grained soil downgradient of Dam 3 and place within the TCAs.
	• Excavate Baker Pond contaminated sediment and Jo-Jo Lake tailings and dispose of in the TCAs.
	• Remove contaminated sediment from Baker Creek and dispose of in the TCAs.
	• Backfill excavated areas with new quarried rock.
	• Construct engineered soil covers in areas where contaminated materials remain at a depth significantly greater than 2 m (e.g., Mill Pond, former Calcine Pond, and Area 4).
	• Partially excavate and/or cover nearshore sediments with clean backfill material.
	• Construct fence in the core area of site, surrounding area of primary roaster stack deposition
		• **CS1-1**: Industrial soil quality standard of 340 mg/kg for total arsenic is met in Developed Areas
		• **CS1-2:** Residential soil quality standard of 160 mg/kg for total arsenic is met in the Townsite, Shoreline Lands, and Marina area.
		• **CS1-3**: Runoff from engineered soil covers meets surface runoff quality criteria as per the approved Water Management and Monitoring Plan
		• **CS1-4*:*** Fence installed to encompass area most impacted by roaster emissions fallout.
		• *Refer to Objective SW4;* Administrative controls in place; such as signs
		• **CS1-5:** Contaminated sediment in Baker Creek removed down to bedrock or underlying native soil
		• **CS1-6** Final backfill grading will not permanently retain ponded water
		• **CS1-7** Design engineering drawings for soil covers are signed and sealed by a Qualified Professional and the specifications outlined therein are met
		
		Criterion in Development with Contamination Downgradient of Dam 3 Reclamation Research Plan
		• **CS1-8**: Tailings-impacted area downgradient of Dam 3 TBD
		
		Criteria in Development related to Fisheries Act Authorization
		• **CS1-9** Shoreline lands sediment cover TBD
			Active Remediation Phase:
			• As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB.
			• Satisfactory final inspection by a Qualified Professional
			• Soil sampling:
			  • In Developed Areas, confirmatory soil samples obtained from the limits of excavations to verify GNWT ENR guidelines for industrial land use are met.
			  • In the tailings-impacted area downgradient of Dam 3, confirmatory soils samples obtained from the limits of excavations to verify appropriate criterion is met.
			  • In the Townsite, Shoreline Lands, and Marina area, confirmatory soil samples obtained from the limits of excavations to verify GNWT ENR guidelines for residential land use are met.
			• Sediment inspection in Baker Creek confirms contaminated sediment was removed
			
			Adaptive Management and Post-Closure Phase:
			• Aquatic Effects Monitoring Program - sediment and water sampling in Baker Creek and Yellowknife Bay
			• Operational Monitoring Plan - Soil/sediment cover monitoring for settlement and erosion by a Qualified Professional

PHCs = petroleum hydrocarbons; TCA = Tailings Containment Area; MVLWB = Mackenzie Valley Land and Water Board; GNWT = Government of the Northwest Territories; ENR = Environment and Natural Resources; TBD = to be determined

5.4.6 Consideration of Closure Options and Selection of Closure Activities

As noted in Chapter 1, CIRNAC conducted community engagement for the purpose of obtaining feedback on potential closure options and activities for surface design components, including contaminated soils and sediment. The SDE process (SRK 2016) provided key input with respect to the selection of closure activities for the Developed Areas, bedrock/forest/wetland terrain, and Baker Creek. The following sections provide details on the selection of closure options and activities for these areas, along with details on the selection of disposal locations for the contaminated materials. Drivers for the selection of contaminated soils options are summarized in Figure 5.4-3, and drivers for the selection of sediment options are summarized in Figure 5.4-4.

Contaminated Soils – Key Drivers for Closure Decisions

Higher ↑ Priority ↓ Lower

Driver

Input from Surface Design Engagement & affected parties

Technical Feasibility

Design Considerations

- Preference for options during SDE that included:
  - Townsite/Marina/Shoreline areas to residential soil quality standards
  - Industrial soil quality standards for developed areas
- Identification of further assessment required in Dam 3 spill area
- Preference for options during SDE that consolidated waste on site, consider filling pits with contaminated material
- Preference during SDE for options that ensured human health and ecological risks are managed in bedrock / forest / wetland areas. Verify through HHERA.
- Feasibility of remediation, specifically access of heavy equipment for excavation of soils and depth of excavation
- Feasibility of excavation in bedrock / forest / wetlands, would not significantly reduce risks and require extensive environmental damage, therefore consideration of administrative controls barriers such as a fence. Verify through HHERA

Selected Options

- Remediate Townsite/Marina to residential soil criteria
- Remediate remaining developed areas to industrial soil criteria

Contaminated fill excavated and disposed of in pits/TCAs

Deep pockets of contaminated fill excavated where possible, graded, and covered

Fence areas within 1 km of former roaster stack in central area of site with highest impacts to bedrock / forest / wetland areas

Reclamation Research Plan for Dam 3 Area to determine closure activities

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2018-12-19
DESIGNED	H. Machtans
PREPARED	D. Pahl
REVIEWED	J. Amphlett
APPROVED	J. Amphlett

PROJECT

Giant Mine Remediation Project

TITLE

KEY CONSIDERATIONS DRIVING THE SELECTION OF CLOSURE ACTIVITIES FOR CONTAMINATED SOILS

REV. 0

FIGURE 5.4-3

Contaminated Sediment – Key Drivers for Closure Decisions

Higher ↑ Priority ↓ Lower

Drivers	Design Considerations	Selected Options
Input from Surface Design Engagement & affected parties	➢ Townsite/Marina/Shoreline remediation to meet residential soil quality standards based on SDE input and therefore need to address sediments along shoreline lands to prevent human contact in this area	Baker Creek & Baker Pond sediment excavated and disposed of in TCAs Sediment replaced by suitable borrow material
Health and Safety for humans and environment	➢ Affected parties input to reduce contaminant loading in Baker Creek and risk of tailings in creek to humans and environment ➢ Use HHERA to verify closure decision	Shoreline sediments partially excavated and capped with an engineered cover
Technical Feasibility	➢ Closure activity must not worsen Yellowknife Bay water quality ➢ Ice and wave action on Yellowknife Bay shoreline need to be considered	

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2018-12-19
DESIGNED	H. Machtans
PREPARED	D. Pahl
REVIEWED	J. Amphlett
APPROVED	J. Amphlett

PROJECT

Giant Mine Remediation Project

TITLE

KEY CONSIDERATIONS DRIVING THE SELECTION OF CLOSURE ACTIVITIES FOR CONTAMINATED SEDIMENT

REV. 0

FIGURE 5.4-4

5.4.6.1 Developed Areas

The Developed Areas are dominated by contaminated granular fill distributed over large geographic areas. These areas are typically accessible to conventional construction equipment (i.e., excavators, haul trucks, and dozers). As the majority of the Developed Areas contain contaminated granular fill less than 2.0 m thick, the closure options considered included conventional removal (i.e., excavation) and capping with an engineered cover. These options are consistent with previous closure plans presented for the Site (INAC and GNWT 2010). During the SDE process many supported options that included remediation of the Developed Areas to the industrial soil quality standards. Remediation of the Townsite/Marina to residential soil quality standards was also supported by many participants (SRK 2016). Therefore, the selected closure option for contaminated soils within the Developed Areas includes a combination of excavation and engineered covers to meet the residential standard in the Townsite / Marina and to meet the industrial standard in the remaining Developed Areas.

For the majority of the Developed Areas, the industrial soil quality standards can be achieved when contaminated materials are excavated to an approximate maximum depth of 2.0 m or less. At the Townsite/Marina, remediation to residential soil quality standards will require excavation to an approximate maximum depth of 2.5 m. Remediation of the Townsite/Marina to residential soil quality standards may result in increased use of the area and also of the adjacent Shoreline Lands. This potential public use affected the remedial options selected for Shoreline Lands and the nearshore sediment and is further discussed in Section 5.4.6.2.

Excavating to a depth of 2.0 m is not sufficient to remove all soils contaminated above industrial soil quality standards in the Developed Areas. These areas will be addressed as follows:

- There are six areas of limited extent (less than 3,000 m^2) where excavation to an approximate maximum depth of 3.5 m will be needed to meet the industrial soil quality standards. These areas will be capped.
- There are another four areas of limited extent where contaminants extend deeper, and it will not be practical to excavate all of the contaminated soils. In these areas, an engineered cover will be constructed to block exposure to the contaminants.
- For the following areas, the depth and extend of the contamination make excavation impractical. These areas will have engineered covers put in place (Figure 5.4-1):
- within the Mill Pond and Area 4, contaminated materials extend deeper than 4.0 m
- within the former Calcine Pond contaminated materials extend to an approximate maximum depth of 13.0 m.

5.4.6.2 Bedrock/Forest/Wetland Terrain

The bedrock/forest/wetland terrain contains shallow contaminated fine-grained soil distributed over a large geographic area. Forensic mineralogy studies and the results of the regional soil quality assessment (Appendix 5.4A) suggest a northwest-southeast oval shaped pattern of particle fallout surrounding the historical roaster stack. This pattern defines a “near stack” area approximately 1 km in radius. Within this area, the bedrock terrain exhibits the highest concentrations of contaminated fine-grained soil (accumulated in crevasses of bedrock), with arsenic concentrations within shallow soil in the forest/wetland terrain typically an order of magnitude lower. These contaminated materials are typically located in rugged terrain that is inaccessible to conventional construction equipment. The soil quality model was used for estimating soil volumes and supporting the development of remedial alternatives.

During the SDE process, affected parties supported an approach to the bedrock/forest/wetland terrain that addressed potential human health and ecological risks (SRK 2016). A range of closure options were considered for the bedrock/forest/wetland terrain. These closure options included administrative controls, engineered controls, in situ remediation, and ex situ remediation. Following review of the closure options, a shortlist of potential remedial scenarios were developed (Appendix 5.4-A). Scenarios combined the various closure options deemed to provide practical long-term solutions acceptable to affected parties.

Closure scenarios for the bedrock/forest/wetland terrain were evaluated during a technical workshop through the MAA decision analysis approach. The MAA decision-making process is a standard transparent process that ranks potential closure scenarios relative to each other using a numerical scoring system. Participants in the workshop included representatives from CIRNAC, PSPC, GNWT, Golder, AECOM, CanNorth, the Giant Mine Working Group Technical Advisor, and the GMOB. The workshop was structured to allow focused group discussion and involved the following format:

- review of problem definition, site characterization, closure scenarios, and the MAA process
- discussion of the proposed criteria and revision, where necessary, and modification of the proposed closure scenarios
- review of the proposed weighting of categories and criteria
- scoring of the closure scenarios

The workshop process defined account categories based on broader level considerations for the GMRP. Three categories were identified: environment, feasibility, and society. A framework for developing proposed criteria was obtained from the SDE process. The SDE process defined objectives, which were utilized as standards against which the proposed closure scenarios were evaluated. Each criterion was then weighted as either “low priority”, “required” or “high priority” and assigned a unique performance scoring on a scale of 1 to 10. The calculated scoring identified the highest scoring (preferred) closure scenario. Further details of the MAA decision-making process are provided in Appendix 5.4-A.

As noted above, the bedrock/forest/wetland terrain includes the following three geographical locations: 1) Shoreline Lands; 2) Core Industrial Area; and 3) downgradient of Dam 3. The MAA process was used to identify the preferred closure scenario for each of these geographical locations. The key drivers behind the closure scenario selection for contaminated soils in the bedrock/forest/wetland terrain can be visualized in Figure 5.4-4. In situ remediation was not selected for the bedrock/forest/wetland terrain as it was not technically feasible and would not meet industrial soil quality standards. A summary of the selected closure scenarios for these locations is provided below:

- **Shoreline Lands**— Public input through the SDE process was a key driver in the decision to remediate the Shoreline Lands to residential standards, as the area is immediately adjacent to the Townsite/Marina. Remediation to this standard would allow for flexible future land use. It was recognized that if the Shoreline Lands were remediated to residential standards, there would be an increased potential for public access to the Shoreline Lands and the nearshore sediment, through wading or swimming. As identified in the HHERA, a primary risk associated with the nearshore sediment is direct human contact through wading or swimming (CanNorth 2018). At the completion of the MAA process, remediation of the Shoreline Lands, up to the

Foreshore Tailings Area, to residential soil quality standards and the partial excavation and capping of the adjacent nearshore sediment scored more favourably and was identified as the preferred closure scenario. The HHERA supports this closure scenario as it concluded that the remediation of the Shoreline Lands will reduce total arsenic concentrations, with low residual risks to humans, and partial excavation of nearshore sediment and placement of an engineered will result in low risks to human health (CanNorth 2018).

- **Core Industrial Area**—The Core Industrial Area is dominated by bedrock/forest/wetland terrain that covers an approximate area of 160 ha. Excavation across this terrain to meet the industrial soil quality standards was determined to be impractical due to the size of the area and the inaccessibility of conventional construction equipment. Substantial damage to the terrestrial environment would also occur, with extensive removal of vegetation, leaving behind what has informally been described as a "moonscape". During the MAA process, the preferred option was to restrict public access to bedrock/forest/wetland terrain with elevated total arsenic concentrations in soil. The preferred closure scenario involves the installation of a physical barrier (i.e., fence) to restrict public access to bedrock/forest/wetland terrain with elevated total arsenic concentrations in soil. The rationale for the location of the physical barrier was developed based on the forensic mineralogy findings, the soil quality model, review of case studies, and input from the risk assessment team. The HHERA confirmed that with the installation of a fence, the risks to human health from contaminated soils would be low to very low. Limited risks to small mammals were identified as they can pass through/under a fence; this will be monitored post closure (CanNorth 2018).
- **Downgradient of Dam 3**—During the SDE process, YKDFN members identified this area as a concern related to historical tailings spills and pond water releases (SRK 2016). Closure options which involved excavation of contaminated fine-grained soil scored more favorably. The MAA process concluded that the preferred closure option involves the excavation of contaminated fine-grained soil that has been directly impacted by tailings (i.e., tailings impacted areas). The remedial excavation of this material will be completed to the industrial soil quality standards. It was also concluded that significant data gaps remain for the pond water impacted areas. As a result, a Reclamation Research Plan was prepared to determine the appropriate closure option for this larger area affected by historical pond water releases (Appendix 5.4-B).

5.4.6.3 Baker Creek

During the SDE process, affected parties supported closure options that included the excavation of contaminated sediment from Baker Creek (SRK 2016). This preference was an important factor in the choice to remove impacted sediments, and is supported by studies which have identified that exposure to contaminated sediment within Baker Creek has been principally responsible for effects to fish and benthos located in Baker Creek (Golder 2017a; CanNorth 2018). It was noted that the area of effects is likely limited to Baker Creek and that no adverse effects are expected in Yellowknife Bay (CanNorth 2018). In addition, studies have shown that the contaminated sediment in Baker Creek can potentially cause adverse effects to benthos and that the contaminated sediment is bioavailable for uptake by periphyton, benthos, and fish (Golder 2013). Based on these historical studies and the affected party feedback, closure options considered for Baker Creek included the removal of contaminated sediment from Reaches 0 through 5. The key drivers behind the selection of closure actions for contaminated sediment are shown in Figure 5.4-4.

Alternatives for Baker Pond (i.e., Reach 6) included excavation and/or placing an engineered cover and either leaving Baker Pond as pond habitat or conversion to a flood plain and/or wetland. Alternatives for the tailings located in historical Jo-Jo Lake were combined with the Baker Pond alternatives and included leaving the

existing tailings and cover in place (in conjunction with Baker Pond capping alternatives) and excavation of the tailings The MAA process identified excavation of Baker Pond and historical Jo-Jo Lake and potential application of passive or semi-passive water treatment systems (e.g., constructed wetland treatment) to reduce arsenic loading to the aquatic environment as the preferred closure option. Constructed wetland treatment is currently undergoing further evaluation as part of the *Reclamation Research Plan Passive and Semi-passive Treatment Systems* (Appendix 5.5-B). Preliminary findings related to constructed wetland treatment and their use at Giant Mine are provided in Contango 2016, 2017a, and 2018a,b. The specific location of a possible constructed wetland is still under review.

5.4.6.4 Disposal of Contaminated Materials

The disposal of contaminated materials within the open pits was considered as part of the contaminated materials disposal options analysis. Feedback from affected parties during the SDE process indicated a general preference to backfill the pits with waste, and that deposition of material in the pits may assist in protecting the underground from flooding by Baker Creek (SRK 2016). Disposal of contaminated materials in the TCAs was also evaluated. For the open pits, an options analysis was carried out where the costs and risks of backfilling the open pits with tailings, contaminated soils, and rockfill were considered (Golder 2017b). It was determined A1, B1, and B2 pits were suitable disposal locations for contaminated materials (refer to Section 5.3 for further information). Preliminary grading plans were developed that estimated a maximum storage capacity for contaminated materials in the TCAs at approximately 1.2 million m^3, assuming the perimeter dams were not raised and South Pond tailings are relocated to the remaining TCAs (discussed in Section 5.6).

Trade-offs between the disposal options were evaluated in a technical workshop (Golder 2017d). The disposal of contaminated granular fill in a combination of A1 Pit (622,000 m^3), B1 Pit (100,000 m^3), and TCAs (200,000 m^3) was the preferred alternative. Heavily contaminated granular fill will be frozen in a portion of B1 Pit or within another suitable frozen zone (52,000 m^3) (see below). The remaining contaminated materials will be disposed of in the TCAs (325,500 m^3). This preferred option will provide the lowest construction risk and preserve operational flexibility, with contingency volume available should the actual quantities of contaminated materials to be disposed of be greater than current estimates. The preferred option is summarized in Table 5.4-5, and the project material balance technical memorandum (Golder 2017d).

The disposal of the contaminated granular fill in A1 and B1 pits will provide the TCAs with contingency storage capacity and reduces the need for clean rockfill to backfill the open pits. Note that there is insufficient storage capacity to dispose all the contaminated materials in open pits. Disposal of all contaminated materials into the TCAs is theoretically feasible but would provide little or no contingency storage capacity if the volume of contaminated materials generated during remediation exceeds current estimates and would increase the amount of borrow material that would be needed to fill the open pits.

The disposal option for the heavily contaminated granular fill from the mill/roaster area was consistently to freeze the material. No other options were formally evaluated. The decision to freeze this material is consistent with the DAR (INAC and GNWT 2010). Granular fill from the mill/roaster area is heavily contaminated with arsenic concentrations >4,500 mg/kg, which is similar to the maximum total arsenic concentration of tailings. In addition, the heavily contaminated granular fill contains some of the highest recorded arsenic concentrations in soils at the Site (>10,000 mg/kg). As a result, it was determined that this material should be placed in the frozen portion of B1 Pit or within another suitable frozen zone. Further information on the freezing of the heavily contaminated granular fill are provided in Section 5.2.

The PHC contaminated soils are impacted with diesel fuel, Bunker C fuel oil, and/or waste oil, and the contamination consists predominantly of petroleum hydrocarbon fractions F2, F3, and F4. These fractions contain carbon chains C10 through C50, which are difficult to remediate through land farming. It is anticipated that land farming of these materials will not significantly improve the soil quality. In addition, the majority of the hydrocarbon impacted soils are also impacted with arsenic, which may become mobilized during the land farming process.

As a result, the preferred option is to dispose of hydrocarbon impacted soils in a dedicated location within the North or Central TCA. This will provide isolation of the impacted soils. As they are heavy fractions, they are not expected to be especially mobile, and they will be covered in the TCA, limiting the possibility of leaching/mobilization of hydrocarbons, as well as eliminating pathways for direct contact with the contaminants.

Table 5.4-5: Summary of Contaminated Materials Disposal

Material Types	Volume (m^3)	Disposal Location
Contaminated granular fill	922,000	Combination of A1 Pit (622,000 m^3), B1 Pit (100,000 m^3), and TCAs (200,000 m^3).
Heavily contaminated granular fill	52,000	Frozen portion of B1 Pit or another suitable frozen zone
Contaminated fine-grained soil	143,000	TCAs.
PHC-contaminated soil	21,000	TCA
Tailings (historical Jo-Jo Lake)	32,000	TCAs
Contaminated sediment	129,500	TCAs
Total	**1,299,500**	

PHC = petroleum hydrocarbon; TCAs = Tailings Containment Areas.

5.4.7 Engineering Work

5.4.7.1 Developed Areas

Approximately 1,070,000 m^3 of contaminated materials will be excavated from the Developed Areas using conventional remedial equipment (i.e., excavators, haul trucks, dozers, and light weight track mounted equipment). Table 5.4-6 presents the material types and disposal locations for this volume of contaminated materials. It is anticipated that the excavated areas will be backfilled with approximately 0.5 m of new quarried rock and re-graded to support surface water management. In addition, a combined area of approximately 178,000 m^2 will have engineered covers placed. This area includes the four areas of limited extent that contain contaminated materials significantly beyond a depth of 3.5 m and the three larger areas (i.e., the Mill Pond, Area 4, and the former Calcine Pond) where a substantial volume of contaminated materials extends significantly beyond a depth of 2.0 m. The design of the engineered covers within these areas is currently being developed. Further evaluation and design of the final configuration of these areas is underway.

Table 5.4-6: Volumes and Disposal Locations of Contaminated Materials – Developed Areas

Material Types	Volume (m^3)	Disposal Location
Contaminated granular fill	922,000	Combination of A1 Pit (622,000 m^3), B1 Pit (100,000 m^3), and TCAs (200,000 m^3)
Heavily contaminated granular fill	52,000	Frozen portion of B1 Pit or within another suitable frozen zone
Contaminated fine-grained soil	75,000	TCAs
PHC-contaminated soil	21,000	TCAs
Tailings and calcine	0	Tailings in the Mill Pond and Area 4, along with calcine in the former Calcine Pond will be capped with engineered covers
Total	**1,070,000**	

TCAs = Tailings Containment Areas; PHC = petroleum hydrocarbon.

5.4.7.2 Bedrock/Forest/Wetland Terrain

The remedial volumes and disposal locations for these materials are presented in Table 5.4-7, while Figure 5.4-5 indicates the final condition of the bedrock/forest/wetland terrain post-remediation.

Table 5.4-7: Volumes of Contaminated Materials and Disposal Locations – Bedrock/Forest/Wetland Terrain

Material Types	Volume (m^3)	Disposal Location
Contaminated fine-grained soil	68,000	TCAs
Contaminated sediment	10,000[(a)]	TCAs
Total	**78,000**	

a) Partial excavation of the nearshore sediment will be completed to allow an engineered cover to be installed.
TCAs = Tailings Containment Areas.

The following sections describe the planned remedial work associated with these three geographical locations: 1) Shoreline Lands, 2) Core Industrial Area, and 3) downgradient of Dam 3.

5.4.7.3 Shoreline Lands

The remediation of approximately 40,000 m^3 of contaminated fine-grained soil in the Shoreline Lands will be completed to the residential soil quality guidelines through excavation using specialized and conventional remedial techniques. Specialized remedial techniques are required due to the rugged and steep bedrock dominated terrain within the Shoreline Lands. Given the limited equipment access to the Shoreline Lands, access roadways will be developed from the Townsite to the Shoreline Lands. For the bedrock terrain, soil remediation will be completed using a combination of hand tools (i.e., small trowels, narrow shovels, and small brooms), lightweight track mounted equipment, haul trucks and portable equipment. Portable equipment may include the use of small portable compressors to mobilize soil from bedrock crevasses and hand-held vacuums to collect soil. For the forest and wetland terrain, soil remediation will be completed using medium sized haul trucks and conventional track mounted equipment (i.e., excavators and dozers). It is anticipated that forest and wetland terrain within the Shoreline Lands will be backfilled with approximately 35,000 m^3 of fine-grained material graded to re-establish surface drainage. Fine-grained soils exposed at surface will be vegetated to prevent erosion.

Engineering work to be completed within the Shoreline Lands, includes the collection of additional soil quality data from the bedrock/forest/wetland terrain, as well as the completion of detailed mapping of the bedrock terrain. The primary purpose of this work is to refine the estimated volume of contaminated-fine grained soil within the Shoreline Lands through the collection of additional soil quality data and refining the lateral and vertical extent of the bedrock crevasses within the Shoreline Lands. The secondary purpose of this work is to identify areas of steep bedrock terrain which will be challenging to access during remediation and will require specific health and safety controls to mitigate risks to workers.

The nearshore sediment will be addressed through a combination of an engineered cover and limited shoreline excavation. It is anticipated that contaminated sediment, located immediately adjacent to the shoreline will be excavated to allow the engineered cover to be installed over the remaining nearshore sediment (Figure 5.4-5). The design of the engineered cover is currently under development. Engineering work being completed to support the cover design includes the collection of updated bathymetry from Yellowknife Bay, a review of the coastal engineering design parameters (i.e., wave action, water levels, and ice interactions), and the completion of a model to develop engineering design parameters for the engineered cover. The engineered cover will also consider the design and closure objectives of the Foreshore Tailings Area cover.

5.4.7.4 Core Industrial Area

A fence will be installed to restrict public access to bedrock/forest/wetland in the Core Industrial Area that has been most impacted by arsenic (Figure 5.4-5). The location of the fence is based on multiple lines of evidence, with confirmation through the HHERA that the fence will control access and will reduce risks of exposure to human receptors to acceptable levels. The fence design may range from a metal chain link fence, similar to those currently on the Site, to a palisade fence consisting of vertical bars or pales incorporating natural features. It has been assumed that an 8 km fence with a typical height of 2 to 3 m will be installed using a fencing drill rig. In order to allow for the installation of the fence, vegetation removal and re-grading activities will be completed along the selected fence alignment to allow drill rig access for the installation of the fence posts.

The final routing of the fence is under evaluation and ground truthing of the proposed route will be completed as part of the engineering work. Additional soil sampling will be completed to refine the definition of arsenic impacts in the bedrock/forest/wetland terrain areas for consideration in the fence routing.

5.4.7.5 Downgradient of Dam 3

Approximately 28,000 m^3 of contaminated fine-grained soil will be excavated from the area contaminated by direct surface deposition of tailings (approximately 4 ha). Remediation will be completed to the industrial soil quality standards through excavation using conventional equipment (i.e., excavators, haul trucks, and dozers). Access roadways will be developed from Dam 3 to the remedial excavation areas where required. In addition, due to the wetland and forest dominated terrain, lightweight track-mounted equipment may be required to safely access the excavation areas. It is anticipated that the remedial excavations will be backfilled with approximately 20,000 m^3 of new quarried rock and 12,000 m^3 of fine-grained material, graded to support surface water management. Exposed fine-grained soils will be vegetated to stabilize against erosion.

Approximately 112,000 m^3 of contaminated fine-grained soil is present within the larger area (approximately 16 ha) affected by pond water releases from the North Pond. A Reclamation Research Plan has been prepared to select the appropriate closure option for the larger area affected by pond water releases. The Reclamation Research Plan (Appendix 5.4-B) will further characterize the soil, surface water, groundwater, and sediment quality in this area and assess appropriate closure options.

5.4.7.6 Baker Creek

The remedial volumes for Baker Creek are provided in Table 5.4-8, while Figure 5.4-5 indicates the final condition of Baker Creek post-remediation.

Table 5.4-8: Volumes of Contaminated Materials and Disposal Locations – Baker Creek

Material Types	Volume (m^3)	Disposal Location
Contaminated sediment (Reaches 0 through 5)	43,500	TCAs
Contaminated sediment (Reach 6)	76,000	TCAs
Tailings (historical Jo-Jo Lake)	32,000	TCAs
Total	**151,500**	

Note this total volume excludes 10,000 m3 from nearshore sediment which is in Yellowknife Bay.
TCAs = Tailings Containment Areas.

Engineering work being completed to support the remediation of Baker Creek includes the collection of additional sediment and tailings samples from Baker Pond and historical Jo-Jo Lake, along with the collection of additional soil/sediment samples from the flood plains of Baker Creek to refine the volume estimates presented herein.

It has been assumed that the majority of the excavation work will occur in the autumn and winter when fish are not present in Baker Creek, to allow for easier access to the area, and to reduce the volume of water which will require diversion during the closure activities. In addition, as the improvements to Baker Creek will result in the re-alignment of existing Reaches 1 and 3 (Section 5.5), the excavation of Reaches 1 and 3 will occur after the re-alignment work is complete.

Excavation of historical Jo-Jo Lake, Baker Pond, and Reaches 0, 1, and 3 will be completed using earth moving equipment (i.e., excavators and haul trucks); however, use of this equipment may require extensive site preparation. Excavation of Reaches 2, 4, and 5 will be completed using specialized excavation techniques, including dredging. It is anticipated that Reaches 0 through 5 will be backfilled with approximately 28,000 m^3 of coarse-grained material and 16,000 m^3 of fine-grained material to support the reestablishment of fisheries habitat.

Baker Pond and historical Jo-Jo Lake will be backfilled with a channelized flow path to allow for seasonal high-water flows. Baker Pond and historical Jo-Jo Lake will be backfilled with approximately 121,000 m^3 of coarse-grained material and 26,000 m^3 of fine-grained material to support establishment of vegetation (see Section 5.5) to control erosion.

5.4.8 Final Site Conditions

The final site conditions with respect to soil and sediment are outlined below and shown in Figure 5.4-5. Future management of Site land, including these areas, is discussed in Section 1.5.

- **Developed Areas**—Contaminated materials within the Developed Areas will be excavated to meet the industrial soil quality standards and/or capped with engineered covers. The exception is the Townsite/Marina, which will be excavated to meet the residential soil quality standards. These excavated areas will be backfilled with approximately 0.5 m of new quarried rock and re-graded to support surface water management. Four areas that contain contaminated materials significantly beyond a depth of 3.5 m will be capped with engineered covers. In addition, three large areas (i.e., the Mill Pond, Area 4, and the former Calcine Pond) where a substantial volume of contaminated materials extend significantly beyond a depth of 2.0 m will also have engineered covers placed.
- **Shoreline Lands**—Contaminated soils will be excavated to meet residential soil quality standards and the forest and wetland terrain will be backfilled with fine-grained material to support vegetation establishment. The backfilled excavations will also be re-graded to support surface water management. In addition, the nearshore sediment will be partially excavated and capped with an engineered cover.
- **Core Industrial Area**—A fence will restrict public access to the area of bedrock/forest/wetland terrain characterized by areas with higher arsenic concentrations.
- **Downgradient of Dam 3**—Soils contaminated by direct surface deposition of tailings (approximately 4 ha) will be remediated to the industrial soil quality standards. The remedial excavations will be backfilled with a combination of new quarried rock and fine-grained material to establish final topography for surface water management. A Reclamation Research Plan is planned to finalize the closure option for the larger area (approximately 16 ha) affected by pond water releases. The Reclamation Research Plan (Appendix 5.4-B) will further characterize the soil, surface water, groundwater, and sediment quality in this area and assess appropriate closure options.
- **Baker Creek**—Contaminated sediment within Baker Creek will be excavated. In addition, tailings located in historical Jo-Jo Lake will also be excavated. Reaches 0 through 5 of Baker Creek will be backfilled with a combination of coarse-grained and fine-grained material to support the re-establishment of fisheries habitat. Baker Pond and historical Jo-Jo Lake will be backfilled with a combination of coarse-grained and fine-grained material to construct a channelized flow path to allow for seasonal high-water flows (refer to Section 5.5 for more detail).

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6936000 6934000 6932000

Trapper Lake
Shot Lake
Yellowknife River
Gar Lake
NORTHWEST POND
Trapper Creek
B4 PIT
B3 PIT
SETTLING POND
POLISHING POND
AREA 4
NORTH POND
Baker Creek
Pocket Lake
CENTRAL POND
CALCINE POND
B1 PIT
B2 PIT (UBC)
BROCK PIT
SOUTH POND
MILL POND
C1 PIT
Yellowknife Bay
Handle Lake
A1 PIT
A2 PIT

LEGEND

- BREAKWATER
- FENCE
- PROJECT BOUNDARY
- HIGHWAY
- POST-CLOSURE ROAD
- REMEDIATED TO INDUSTRIAL STANDARDS
- WATERCOURSE
- REMEDIATED BAKER CREEK CHANNEL
- APPROXIMATE FORESHORE TAILINGS CAP
- APPROXIMATE SHORELINE CAP
- CAPPED WITH ENGINEERED COVER
- CLOSED PIT
- COVERED TAILINGS POND
- EXCAVATED SPILLWAY
- RECLAIMED SOUTH POND
- REMEDIATED TO INDUSTRIAL STANDARDS
- REMEDIATED TO RESIDENTIAL STANDARDS
- SOIL RECLAMATION RESEARCH AREA

0 250 500
1:20,000 METRES

REFERENCE(S)

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DATUM: NAD 83 PROJECTION: UTM ZONE 11

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Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-23
DESIGNED	SF
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

POST-CLOSURE SITE CONDITIONS

REV. 0

FIGURE 5.4-5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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5.4.9 Uncertainties

Engineering designs for the closure plan are currently at a conceptual level. As such, the basis for estimates and analyses include engineering judgement. Additional design works are planned to address key assumptions and reduce relevant uncertainties. The important uncertainties that affect contaminated soils are summarized in Table 5.4-9, together with the engineering studies and other activities planned to address these uncertainties.

Table 5.4-9: Contaminated Soils and Sediments Uncertainties

Uncertainty	Potential Impact of Uncertainty	Plan to Address Uncertainty
The actual volume of contaminated soils and sediment requiring remediation is uncertain. It is possible that additional contaminated materials will be encountered as remedial works are completed.	A greater volume than anticipated of contaminated soil and sediment could potentially be encountered.	A contingency allowance has been developed within the disposal strategy for the contaminated materials to accommodate additional materials to be disposed of in the TCAs and/or the open pits.
The volume of contaminated granular fill that will require remediation and/or risk management is uncertain. The current characterization of granular fill is based upon laboratory analysis of the fines (i.e., sands and gravels) rather than the coarser portion of the fill (i.e., cobbles and boulders).	The current volume estimate and disposal strategy for contaminated granular fill may be overly conservative (high).	Geochemical leachate analysis of the coarse materials will be completed prior to remedial activities. Based on the results of the geochemical analysis, the volume and disposal options for contaminated granular fill may be revised to exclude the coarse materials (i.e., cobbles and boulders).
The environmental risks and closure options for contaminated areas located downgradient of Dam 3 are uncertain.	The appropriate closure option for this area is currently unknown.	The Reclamation Research Plan (Appendix 5.4-B) will further characterize the soil, surface water, groundwater, and sediment quality in this area and assess appropriate closure options.

TCAs = Tailings Containment Areas.

SECTION 5.5
Baker Creek and Surface Water Drainage

5.5 Baker Creek and Surface Water Drainage

5.5.1 Description

The closure and reclamation of the Site includes management of surface runoff from various contaminated areas within the project boundary, management of water entering the Site, and remediation and reconstruction of the reaches of Baker Creek that are on site. This section describes the proposed closure and reclamation activities for Baker Creek and surface water drainage. These activities were developed based on consideration of Measures and Recommendations presented in the Report of EA (MVEIRB 2013; INAC 2014), as well as engineering studies and alternative evaluations described in this section.

This section describes the activities planned for the closure and reclamation of Baker Creek and surface drainage. These activities include keeping Baker Creek on site, with realignment of several reaches of Baker Creek and removal of sediment (Section 5.4). The Baker Creek flood plain will be designed to allow the probable maximum flood (PMF) to pass. Runoff from upstream reclaimed areas (i.e., tailings) will be diverted to the existing managed water system until runoff water quality is confirmed acceptable, and then released to Baker Creek (and its tributaries) or Yellowknife Bay. Construction and operation of alternative passive treatment technologies to reduce arsenic loading from upstream sources to remediated areas of Baker Creek are the subject of a Reclamation Research Plan, presented in Appendix 5.5-B.

Closure activities for Baker Creek and surface drainage will be integrated with other closure activities, including closure of TCAs (Section 5.6) and open pits (Section 5.3) and remediation of contaminated soils (Section 5.4). The GMRP's closure activities include the removal of contaminated sediment and tailings from Baker Creek during closure (Section 5.4).

5.5.2 Pre-disturbance and Existing Site Conditions

Pre-disturbance at Baker Creek

Baker Creek and its tributaries are a key feature of the Giant Mine. Baker Creek is a unique stream draining to Yellowknife Bay with a protected Arctic Grayling sport-fishery and a long history of traditional land use before mining.

An aerial photograph of Baker Creek from Yellowknife Bay to above Baker Pond prior to development (1945) is provided in Figure 5.5-1, with the locations of future mine pits and the Ingraham Trail (Northwest Territories Highway 4) indicated. Prior to the development of the Site, Baker Creek descended from higher ground to the west, into Jo-Jo Lake, and then Joe Lake, which is presently known locally as Baker Pond. Baker Creek flowed through a broad valley with bedrock exposed at the margins and outcropping in some locations in the valley.

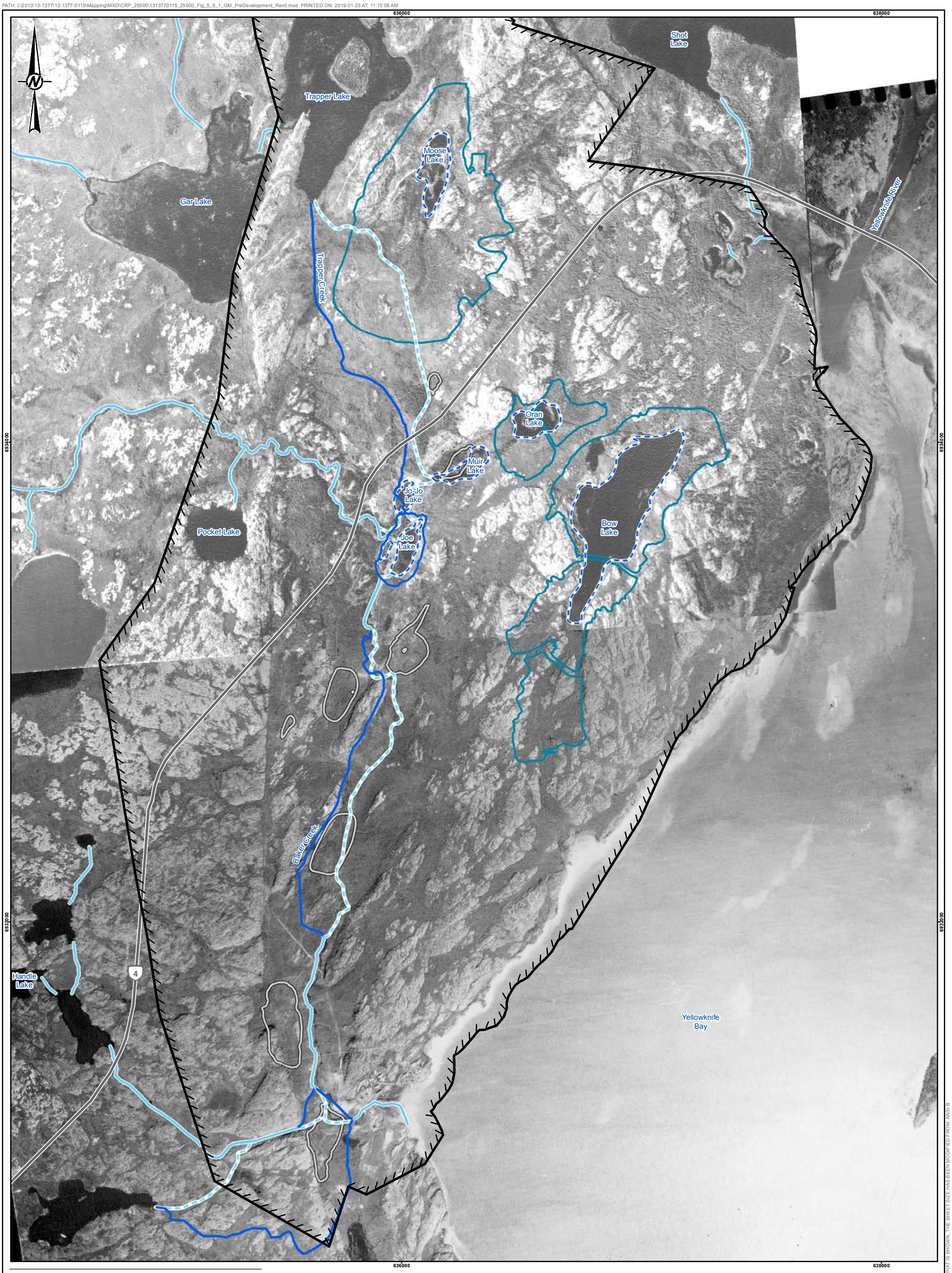
Northwest Hydraulic Consultants (NHC 2005) stated that "Baker Creek has a similar morphological setting and characteristics to many other stream systems in the Greater Northwest Territories due predominantly to the physiographic setting of the Canadian Shield. Since continental glaciation and retreat, Baker Creek system has been relatively static morphologically. Largely controlled by bedrock outcrops, the suspended and bed loads of these systems are relatively low due to glaciation, weathering processes, terrain and influence of lakes in the systems. Ice and freeze-thaw weathering processes dominate surface runoff and erosion, and fluvial processes. In Baker Creek, alluvial sediments are limited, and stream structure and features are relatively immobile."

Traditional Knowledge of the area indicates the creek was locally known as Jackfish Creek, and that the creek was a significant fishing and hunting area for the local population (YKDFNLEC 2005).

Pre-disturbance Surface Drainage

Documentation of pre-development surface drainage at the Site is sparse, and mainly informed by available mapping and aerial photographs (see Figure 5.5-1 and Section 5.6 for historical air photo with lake names). Within developed areas, it is understood that:

- The area presently occupied by the South Pond drained naturally to the south, to Yellowknife Bay.
- The area presently occupied by the Central and North Ponds comprised Bow Lake, which drained north to Oran Lake, the area presently occupied by the Settling and Polishing ponds.
- The area presently occupied by the Settling and Polishing ponds comprised Oran Lake, which drained west to the existing B3 Pit area.
- The area presently occupied by the B3 Pit area comprised Muir Lake, which drained west to Jo-Jo Lake.
- Trapper Creek joined the Muir Lake outlet channel, upstream of Jo-Jo Lake.
- The area occupied by the Northwest Pond comprised Moose Lake, which drained west to Trapper Creek.



LEGEND

- GIANT MINE PROJECT BOUNDARY
- HIGHWAY
- PIT BOUNDARY [CURRENT]

WATERCOURSES

- ORIGINAL AND CURRENT
- CURRENT
- ORIGINAL

WATERBODIES

- CURRENT
- ORIGINAL
- TAILINGS POND [CURRENT]

0 250 500

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REFERENCE(S)

HYDROLOGY AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. HISTORIC AIR PHOTOS CAPTURED JULY JULY 13, 1945 (A8666-74) AND JULY 22, 1945 (A8668-71), OBTAINED FROM THE NATIONAL AIR PHOTO LIBRARY, LIBRARY AND INFORMATION SERVICES.
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YYYY-MM-DD	2019-01-23
DESIGNED	NS
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

PRE-DEVELOPMENT AERIAL PHOTOGRAPH OF BAKER CREEK AT GIANT MINE SHOWING SELECTED FEATURES

REV. 0

FIGURE 5.5-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
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Existing Conditions

The Site presently contains various forms of runoff storage and conveyance that include:

- Baker Creek, which enters the Site in the northwest and runs through the site into Yellowknife Bay. Baker Creek is presently located in its pre-development valley, but several reaches were diverted during mining and post-mining to allow development of open pits; tailings and contaminated soils and sediments are also present in some reaches of the creek.
- Named and unnamed tributaries of Baker Creek, including Trapper Creek. These watercourses convey runoff from bedrock / forest / wetland terrain and developed areas within the Site, as well as water entering from off-Site.
- Presently controlled runoff areas, including tailings ponds, open pits, and existing ETP areas. Water in these areas is collected and conveyed via the TCAs and then the ETP prior to discharge. These areas will be reclaimed and allowed to drain to Baker Creek or Yellowknife Bay once water quality is improved.

Historical mining activities at the Giant Mine changed surface water drainage at the Site and the alignment and morphology of Baker Creek. Physical changes to Baker Creek included realignments to allow open pit development, some involving channelization, as well as construction of a breakwater at the mouth of the creek; Reach 4 of Baker Creek, located between B1 and C1 pits, was reconstructed after mining activities (see Chapter 2, Chapter 4, and Section 5.5.4.2 for more details).

The presence of Baker Creek on the Site with adjacent open pits and portals presents a risk of flooding of the underground mine from extreme flow events. This is particularly a concern within channelized reaches which do not have flood plains to convey extreme flows without overtopping and which are also more susceptible to blockages which could also generate overtopping of the channel banks. Sediment within Baker Creek and Baker Pond is contaminated from historical discharge of tailings and both untreated and treated effluent. Implementing the CRP will involve activities to improve Baker Creek and the site surface water drainage to stabilize the site, isolate contaminants from the environment, and establish safe site conditions that allow for the restoration of ecological processes.

Baker Creek

Considerable data has been collected to characterize Baker Creek (Chapter 2). Key elements are summarized below.

Hydrology

Two Water Survey of Canada (WSC) hydrometric stations have operated on Baker Creek upstream of the Site since 1968. Station 07SB013 is currently located where Baker Creek exits Lower Martin Lake (Chapter 2) and has operated since 1983. Prior to that, Station 07SB009, located just above Baker Pond, had operated since 1968. These stations together provide more than 40 years of records to characterize the flow regime of Baker Creek (Chapter 2). Local runoff contributing to Baker Creek on the Site is expected to increase peak flows above those measured upstream of the project boundary at the outlet of Lower Martin Lake. Estimates of the maximum instantaneous discharges at the Lower Martin Lake outlet, Baker Pond outlet, and the mouth of Baker Creek (at its confluence with Yellowknife Bay) are provided in Table 5.5-1.

Table 5.5-1: Derived Maximum Instantaneous Flows at Baker Creek

Return Period (years)	Maximum Instantaneous Flow (m^3/s)		
	At Lower Martin Lake Outlet (Drainage Area 154 km^2)	At Baker Pond (Drainage Area 168 km^2)	At Mouth of Baker Creek (Drainage Area 176 km^2)[a]
2	1.32	1.34	1.48
5	2.79	2.82	3.33
10	4.10	4.16	5.00
25	6.14	6.24	7.62
50	7.97	8.11	9.99
100	10.1	10.2	12.7
200	12.5	12.7	15.9
500	16.2	16.5	20.8
1,000	19.4	19.8	25.1

a) Baker Creek at Mouth of Baker Creek (Yellowknife Bay) does not include the Fault Lake drainage area of 1.1 km^2, which joins with Yellowknife Bay and Baker Creek at the mouth.

A PMP and PMF study for Baker Creek was completed as part of the *Giant Mine – Baker Creek Flood Hazard Assessment* (Appendix 5.5-C). Based on that study, the critical PMF[1] for Baker Creek at the Site is estimated to be the 48-hour rainfall event combined with melt of the 100-year snow accumulation, with a discharge of 164 m^3/s at the outlet of Lower Martin Lake, 184 m^3/s at Baker Pond, and 193 m^3/s at the mouth of Baker Creek, as presented in Table 5.5-2.

Table 5.5-2: Probable Maximum Flood Estimates based on Critical Probable Maximum Precipitation and 100-year Snow Accumulation Event at Giant Mine

Assessment Node	Drainage Area (km^2)	PMF[a] (m^3/s)
Baker Creek at the outlet of Lower Martin Lake	154	164
Baker Creek at Baker Pond	168	184
Mouth of Baker Creek at Yellowknife Bay	176[b]	193

a) PMF results based on a runoff coefficient of 0.75.
b) Baker Creek at Yellowknife Bay does not include the Fault Lake drainage area of 1.1 km^2, which joins with Yellowknife Bay and Baker Creek near the mouth.

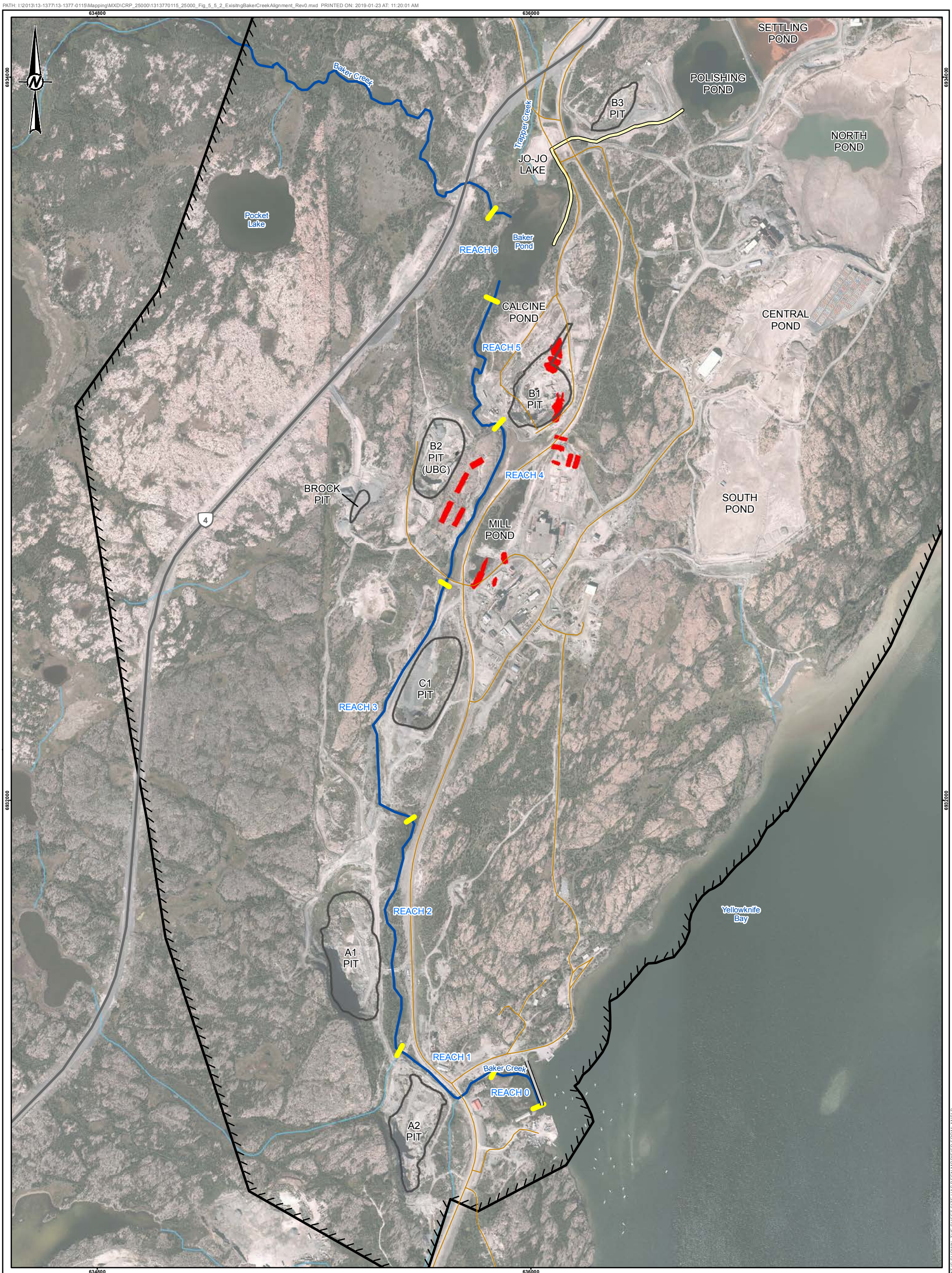
PMF = probable maximum flood.

[1] PMF calculations considered combinations of PMP durations from 6 to 72 hours with 100-year snowpack, and combinations of 100-year rainfall depths for durations from 6 to 72 hours with Probable Maximum Snow Accumulation. The critical PMF was the largest flood magnitude resulting from these combinations of inputs, and was attributed to the 48 hour duration PMP combined with the 100-year snowpack.

The existing Baker Creek alignment is shown in Figure 5.5-2 and in Figure 2.5-1. Baker Creek presently conveys flow through the Site. The Site was subject to historical activities that included channelized diversions, watercourse crossings, and waste deposition. In the event of extreme flooding of Baker Creek, the following are mine installations which could be affected by flood waters, or could constrain closure activities for the creek:

- **Open pits**—Most open pits are located in close proximity to Baker Creek, and extreme flood events could overtop the pit rims, flooding the pit (Section 5.3 and Figure 5.3-3).
- **Arsenic chambers and stopes**—These are used to store highly soluble arsenic trioxide dust, which must be protected from mobilization by flowing water. These chambers and stopes will be stabilized by implementing permanent freeze infrastructure during closure, including gravel pads on the surface which may create a constraint on the Baker Creek corridor.
- **Shallow underground mine infrastructure**—Underground mine shafts, drifts, stopes, vents, raises, and boreholes are located near the existing Baker Creek channel, and many of these may have the potential to convey flow to the underground mine during extreme floods. Shallow underground stopes immediately below Baker Creek with the potential for crown pillar collapse have been backfilled to mitigate that concern (see Chapter 4 for more detail).
- **Tailings Containment Areas**—The South, Central, North, and Northwest ponds at the Site are located away from Baker Creek, with sufficient vertical separation to mitigate flood potential from Baker Creek. Uncontained tailings present in Jo-Jo Lake will be removed during closure.
- **Calcine Pond**—Calcines produced during Mine operations were deposited in the Calcine Pond, now covered, located north of B1 Pit. The perimeter of this area adjacent to Baker Creek Reach 5 may need to be armoured to protect against erosion.
- **Roads**—The Ingraham Trail (Northwest Territories Highway 4) was realigned away from the majority of the Site in 2014 but remains on its previous alignment in the area north and to the east of Baker Pond. Other mine roads on site, including the Giant Mine Access Road, remain in close proximity to Baker Creek and Baker Pond. Three Baker Creek crossings are present on site, including the Giant Mine Access Road bridge (Reach 1), the guardhouse bridge (Reach 2), and the UBC bridge (Reach 4), with the new Ingraham Trail bridge located above Baker Pond (Reach 7).
- **Other mine infrastructure**—Other areas of the existing Mine with potential Baker Creek interactions include components of the existing effluent treatment system, including the Polishing Pond, Settling Pond, and treated effluent discharge line to Baker Pond. Runoff paths from the Mill area may also become inundated during extreme high water on Baker Creek, depending on the final grading in that area.

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LEGEND

- BAKER CREEK
- REACH BREAK
- WATERCOURSE
- BREAKWATER
- ETP DISCHARGE LINE
- GIANT MINE PROJECT BOUNDARY
- HIGHWAY
- ROAD
- ARSENIC STOPES / CHAMBERS
- PIT BOUNDARY

0 250 500

1:10,000 METRES

REFERENCE(S)

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YYYY-MM-DD	2019-01-23
DESIGNED	NS
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

BAKER CREEK EXISTING ALIGNMENT

REV. 0

FIGURE 5.5-2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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Quality

Water quality in Baker Creek has been impacted by historical spills, current discharge of treated effluent to Baker Creek, surface runoff, and upstream inputs from the Lower Martin Lake and Trapper Lake watersheds. A discussion of the present-day and future loading sources to Baker Creek is provided in Effluent Quality Criteria Report for Giant Mine (CIRNAC and GNWT 2019a). During the open-water season, when treated effluent is not present in Baker Creek (late winter and spring), the water quality in Baker Creek on the Site is characterized as very clear, containing limited salts, nutrients, and metals. Arsenic is one of the few metals that is consistently above the aquatic life guideline when effluent is absent. When effluent is discharged to Baker Creek each summer, the creek contains concentrations of metals (e.g., arsenic and copper), and TDS and its constituent anions (e.g., chloride and sulphate), that are elevated above reference areas and relevant aquatic life water quality guidelines. Chapter 2 provides detailed information on existing conditions and trends in Baker Creek water quality. General patterns include the following:

- Inputs from watersheds located upstream of the Site influence water quality in Baker Creek. Water quality in Baker Creek upstream of the Site is affected by inflow from tributaries subject to historical aerial deposition of arsenic trioxide, or to interactions with local geology. Surface water in Upper Baker Creek (above Baker Creek Pond) and Trapper Creek (tributary feeding into Baker Creek Pond) is a continued source of arsenic and other contaminants to Baker Creek, although at lower concentrations than in the effluent.
- When treated effluent is discharging to Baker Creek during summer, the treated effluent accounts for a substantial portion of the volume of water in lower Baker Creek. The highest contaminant concentrations are, therefore, present immediately downstream of the discharge location, with decreasing contaminant concentrations present in Yellowknife Bay and reference areas (i.e., increased dilution with distance from the source).
- Contaminants in the water of Baker Creek historically have generally decreased with time as water treatment practices became more rigorous and lower volumes of effluent were released.

Biological

The existing conditions of biological communities in Baker Creek are summarized in Chapter 2. This includes habitat maps and information on fish species. Key points include the following:

- Surface water in Baker Creek above the Site is not acutely toxic to Rainbow Trout or the water flea *Daphnia magna*, nor does it tend to cause sublethal effects on water flea (*Ceriodaphnia dubia*) or alga (*Pseudokirchneriella subcapitata*) growth and/or reproduction in the laboratory. When treated effluent is being discharged, laboratory testing indicates that the surface water downstream of the discharge is also not acutely toxic but causes sublethal effects to water flea reproduction and an aquatic plant (duckweed; *Lemna minor* growth [biomass]).
- Baker Creek at the Site remains a spring spawning stream, with key migratory species such as Arctic Grayling and Longnose Sucker using multiple reaches on the Site (Golder 2010). Stream flow reduces in late spring, and most adults and young-of-the year fish out-migrate. Few fish remain on the reaches of Baker Creek on the Site by early July.
- The mouth of Baker Creek connects directly to Yellowknife Bay. It offers a spring refuge due to water temperatures. Numerous fish species visit this area of Baker Creek in spring. This area is closed to sport fishing, after a regulation change in 2013 (see Chapter 2 for more details).

Surface Drainage

Data has been collected with respect to existing surface drainage at the site outside of Baker Creek, including detailed data on water quantity and quality, along with characterization of the creek biology. Aspects of this relevant to the CRP are summarized below.

Hydrology

Overall drainage at the Site largely follows pre-development drainage patterns, with diversions as described below.

Many areas of the Site are presently managed within a managed water system that conveys contact water to the underground mine and ultimately to the ETP for treatment and release. Managed water areas include:

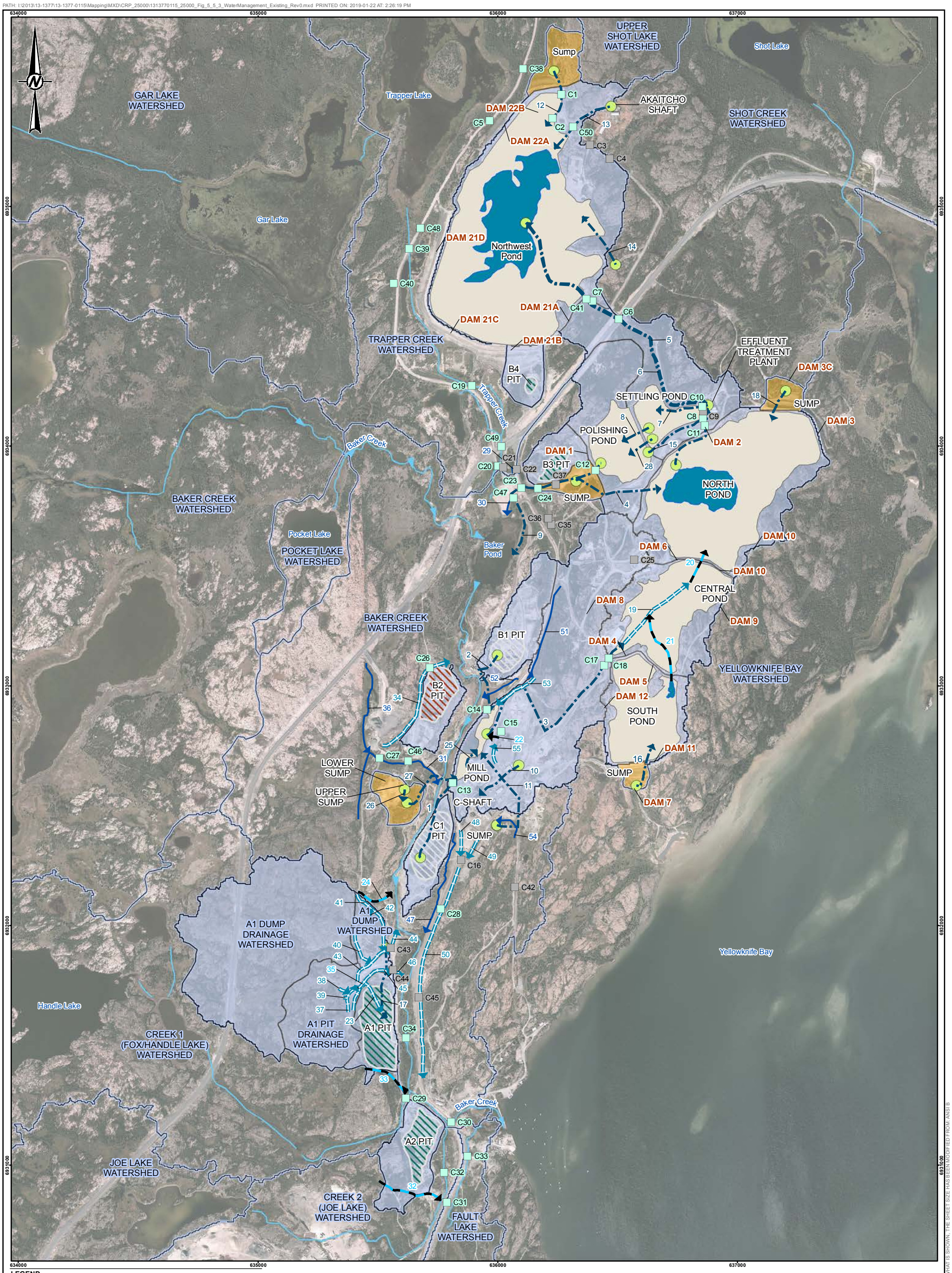
- TCAs (South, Central, North, and Northwest ponds); the Northwest Pond presently serves as the primary water management pond for the Site
- areas reporting to open pits, from which water is pumped from sumps or drains directly to the underground mine
- the mill site and other developed areas on the east side of Baker Creek, which presently drain to the Mill Pond and are pumped to the Central Pond
- the Settling and Polishing ponds, which are used to store treated minewater (from the existing ETP) prior to controlled release to Baker Pond

Some managed water areas, including TCAs, release limited amounts of contact water to natural drainage paths via seepages. Areas with large seepage potential (e.g., Dam 3C, Dam 7, Dam 22B) are equipped with reclaim sumps to intercept seepage water and return it to the upstream TCA.

Other developed and bedrock / forest / wetland areas at the Site generally drain freely by gravity to Baker Creek or Yellowknife Bay. These include areas contributing arsenic loading to Baker Creek and Yellowknife Bay (CIRNAC and GNWT 2019a). Flow paths include natural drainage paths through bedrock / forest / wetland areas and modified flow paths along roadside ditches and culverts, as well as a limited number of diversion ditches in areas including those north of A1 Pit and north and south of A2 Pit.

A schematic of the existing surface water management system relative to mine components at the Site is provided in Figure 5.5-3. Note that camp water and sewage will be trucked in and out and are not included in this schematic. Full details are found in the Water Management and Monitoring Plan (CIRNAC and GNWT 2019b).

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LEGEND

- PUMP STATION

CULVERT

- ACTIVE
- NOT ACTIVE

FLOW PATHS

- DITCH
- NATURAL DRAINAGE
- PIPE (GRAVITY)
- PIPE (PUMPED)
- WATERCOURSE

GIANT MINE WORKS

- PIT (ACTIVE PUMPING TO UNDERGROUND)
- PIT (RUNOFF INFILTRATION TO UNDERGROUND, NO PUMPING)
- PIT (ACTIVE PUMPING TO SURFACE TCA PONDS)
- TCA/MILL POND (FOOTPRINT)
- TCA POND (TYPICAL WETTED AREA)

SURFACE WATER WATERSHED TYPE

- MANAGED WATERSHED AREA
- UNMANAGED WATERSHED AREA
- SITE SUMP CATCHMENT

0 250 500

1:15,000 METRES

REFERENCE(S)

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YYYY-MM-DD	2019-01-22
DESIGNED	JL
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

EXISTING WATER MANAGEMENT SYSTEMS

REV. 0

FIGURE 5.5-3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B

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Quality

Surface runoff quality characterization at the Site was updated in 2014, 2015, and 2017. The objective of the programs was to characterize surface water quality conditions across the Site and to provide input to the water quality model used to calculate loadings to Baker Creek and Yellowknife Bay (CIRNAC and GNWT 2019a). The programs focused on Baker Creek and adjacent watersheds, as well as various runoff channels into Yellowknife Bay on Great Slave Lake.

Runoff on-site as both ponded water and flowing water contains elevated concentrations of metals, ions, and nutrients. The signature of runoff was similar to minewater and treated effluent in terms of the presence of chloride and metals. Chapter 2 provides a general summary of surface runoff water quality, with further information provided in Golder (2015, 2016a,b, 2017c) and the EQC report (CIRNAC and GNWT 2019a).

5.5.3 Closure Objectives and Criteria

Based on the Goals and Principles for the GMRP, closure objectives were identified specifically for the closure and reclamation of the Baker Creek and surface water component. The objectives and criteria of the GMRP relating specifically to reclamation of Baker Creek and surface water are presented in Table 5.5-3.

Table 5.5-3: Baker Creek and Surface Water Closure Objectives and Criteria

Closure Objectives	Closure Activity	Closure Criteria	Monitoring/Maintenance and Inspection
BC1. Baker Creek is prevented from entering the underground workings and the arsenic chambers	• Build a geomorphic channel and flood plain that accommodates the probable maximum flood (PMF). • Realign reaches to avoid openings to the underground and pits and to provide adequate channel and flood plain dimensions and straighter flow path. • Install surface water diversions where required in large sub watersheds to convey runoff around pits to Baker Creek (refer to Objective P1). • Seal openings to surface from underground (refer to Objective UG1).	• **BC1-1** Design engineering drawings for Baker Creek are signed and sealed by a Qualified Professional and the specifications outlined therein are met, including accommodation of a geomorphic channel and flood plain that allows passage of the probable maximum flood (PMF). • **BC1-2** Geomorphic low flow channel designed to convey frequent flood events. • **BC1-3** No sinkholes or openings to underground are observed below PMF elevation in annual inspections. *Criteria in Development with engineering works* • *Refer to P1-5 - scour protection criterion* • Slopes of berms and diversions will be designed with a minimum static geotechnical factor of safety of 1.3.	*Active Remediation Phase:* • As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB. • Satisfactory final inspection by a Qualified Professional. *Active Remediation, Adaptive Management and Post-Closure Phases:* • Annual pre- and post-freshet inspections of Baker Creek channel by a Qualified Professional to identify and document changes from as-built conditions (e.g., erosion, sinkhole formation).

BC2. Baker Creek is physically stabilized and capable of providing adequate flood conveyance throughout the site without long-term active care/maintenance	• Construct a flood plain in various reaches of Baker Creek to convey extreme flood (PMF), with mitigation for channel ice deposits.
	• Construct channel bed foundation such that it mitigates potential subsurface instabilities due to changes in thermal regime.
	• Construct erosion resistant channel to be dynamically stable during PMF events.
		• **BC2-1** Design engineering drawings for Baker Creek are signed and sealed by a Qualified Professional and the specifications outlined therein are met, including accommodation for the PMF.
		BC2-2 Flood plain design geometry provides capacity for ice storage.
		• **BC2-3** Low flow channel lateral migration does not impinge on vulnerable topography*.
		• Refer to BC1-3 - No sinkholes or openings to underground are observed below PMF elevation in annual inspections.
		
		Criteria in Development with engineering works
		• **BC2-4** Permeable channel substrates; granular channel bed material provides for interstitial seepage as mitigation for channel ice deposits.
		• **BC2-5** Design includes geotechnical and permafrost evaluation for alignment selection, design considers appropriate mitigations for vulnerable topography*.
			Active Remediation Phase:
			• As-built engineering drawings signed and sealed by Qualified Professional.
			• Satisfactory final inspection by a Qualified Professional.
			
			Active Remediation, Adaptive Management and Post-Closure Phases:
			• Inspections by a Qualified Professional
			• Operational Monitoring Plan
			  • Annual pre- and post-freshet inspections of Baker Creek channel.
			  • Hydrometric monitoring of Baker Creek and Trapper Creek, and updates to flood models as required.
			  • Monitoring and inspection for build up of channel ice.

BC3. Surface natural drainage patterns are re-established to the extent practicable and to provide conveyance of site runoff, while managing flood risk to closure infrastructure	• Restore pre-development drainage patterns, to the extent practicable. • Design conveyance channels, ponds, and wetlands with appropriate erosion resistance to mitigate surface runoff flood risk to closure infrastructure. • Eliminate permanent surface storage of minewater and runoff (refer to Objective WTP1).	• **BC3-1** Design engineering drawings are signed and sealed by a Qualified Professional and the specifications outlined therein are met, such that natural drainage patterns are reinstated, and surface water is conveyed. • **BC3-2** Baker Creek inflow locations in the final configuration are similar to pre-development based on natural topography and sub-watersheds. • **BC3-3** Surface runoff is conveyed by natural watercourses to the extent practicable.	*Active Remediation Phase:* • As-built engineering drawings signed and sealed by Qualified Professional. • Satisfactory final inspection by a Qualified Professional. *Active Remediation, Adaptive Management and Post-Closure Phases:* • Inspections by Qualified Professional. • Water Management and Monitoring Plan, Operational Monitoring Plan • Annual pre- and post-freshet inspections.

Table 5.5-3: Baker Creek and Surface Water Closure Objectives and Criteria

Closure Objectives	Closure Activity	Closure Criteria	Monitoring/Maintenance and Inspection
BC4. Water quality and sediment quality in Baker Creek are improved to reduce exposure of aquatic and terrestrial organisms to contaminants	• Stop effluent discharge into Baker Creek from the existing ETP and install and operate new WTP with outfall to Yellowknife Bay (refer to Objectives WTP1 and WTP2). • Remove sediments in Baker Creek and backfill the area with uncontaminated material. • Dispose camp water and sewage off site. • Implement site remediation activities to reduce loadings to surface water in Baker Creek (cover TCAs and pits, decommission settling and polishing ponds, excavate contaminated soil areas and backfill). • Collect runoff from engineered structures and convey to the minewater pool until it meets Surface runoff quality criteria, as per the approved Water Management and Monitoring Plan.	• **BC4-1** Meet approved effluent quality criteria (refer to Objective WTP2). • **BC4-2** Site-specific water quality objectives are met in Yellowknife Bay, in the vicinity of the outlet of Baker Creek. • **BC4-3** Approved surface runoff quality criteria are met, as per the approved Water Management and Monitoring Plan. • *Refer to CS1 for sediment excavation* • ***BC4-4*** Concentrations of total arsenic in Baker Creek are reduced in comparison to pre-remediation conditions. *Passive and Semi-Passive Treatment Technology Reclamation Research Plan* • *Refer to SW2-5.* • **BC4-5:** Water quality in lower Baker Creek is similar to upstream concentrations after remediation activities are complete.	*Active Remediation, Adaptive Management and Post-Closure Phases:* • Surveillance Network Program: Water quality monitoring of treated effluent, Baker Creek, and runoff water. • Aquatic Effects Monitoring Program - Sediment quality monitoring of Baker Creek post-construction and intermittently as required. • Aquatic Effects Monitoring Program and/or *Fisheries Act* Authorization Monitoring: Small-bodied, resident fish tissue monitoring post-construction and intermittently as required.
BC5. Once realigned, Baker Creek is restored to a state that encourages natural rehabilitation	• Perform grading according to overall site surface drainage plan. • Provide physical habitat modifications to the channel to provide appropriate habitat and re-colonization for a range of aquatic species at relevant life stages; as per *Fisheries Act* Authorization requirements; including the removal of culvert in Reach 2. • Revegetate shoreline with native species to reduce erosion and increase fish habitat features. • Restore natural drainage patterns, where possible.	• **BC5-1** Design and build the physical habitat modifications as per the requirements of *Fisheries Act* Authorisation. *Criteria in Development* through the outcomes of *Fisheries Act* Authorisation • **BC5-2** Fish and benthos are present after Baker Creek realignment and sediment replacement. • **BC5-3** Aquatic monitoring confirms spring spawning in Baker Creek by Longnose Sucker and Arctic Grayling including presence of adults, eggs, and young of year that out migrate out of creek in late spring.	*Active Remediation Phase:* • Satisfactory final inspection is carried out by a Qualified Professional. • As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB and Fisheries and Oceans Canada. *Active Remediation, Adaptive Management and Post-Closure Phases:* • *Fisheries Act* Authorization monitoring of fish and benthos in frequency defined by Fisheries and Oceans Canada.

PMF = Probable Maximum Flood; MVLWB = Mackenzie Valley Land and Water Board; ETP = effluent treatment plant; TCA = Tailings Containment Area; WTP = water treatment plant; TBD = to be determined; * Vulnerable topography = landforms or infrastructure that are susceptible to flooding either because they are in a flow path, are easily erodible or have high value aesthetically or for the community and require protection from flooding

5.5.4 Consideration of Closure Options and Selection of Closure Activities

5.5.4.1 Review of Baker Creek Closure Options

The closure options for Baker Creek have been shaped through various studies, as well as specific measures from the Report of EA (MVEIRB 2013; INAC 2014). EA measures are discussed below, with the studies and options evaluations discussed in the following subsections

EA Measures

The safe conveyance of Baker Creek through the Site is a requirement of the Report of EA (MVEIRB 2013; INAC 2014), indicated in Measure 11. This measure has been fundamental in shaping the approach to Baker Creek in the CRP, and is as follows:

- Measure 11 - The Developer, with meaningful participation from the Oversight Body and other parties, will thoroughly assess options for, and the environmental impacts of, diversion of Baker Creek to a north diversion route previously considered by the Developer or another route that avoids the mine site and is determined appropriate by the Developer. Within one year of the project receiving its water licence, a report outlining a comparison of options including the current on-site realignment will be provided to the appropriate regulatory authorities, the Oversight Body and the public.

  Once informed by the advice of the Oversight Body and regulatory authorities, the Developer will determine and implement the preferred option. In doing so, the Developer will consider the advice of the Oversight Body, regulatory authorities, and the public, and will ensure that the primary considerations in selecting an option are to:

  a) *Minimize the likelihood of Baker Creek flooding and entering the arsenic chambers, stopes and underground workings; and*
  b) *Minimize the exposure of fish in Baker Creek to arsenic from existing contaminated sediments on the minesite, surface drainage from the minesite or tailings runoff. If off-site diversion is selected, the Developer will seek required regulatory approvals to implement the diversion within five years of receiving its initial water licence.*

The historical mining operations have caused concentrations of salts, nutrients, arsenic and some other metals in Baker Creek and surface drainage to be elevated above natural concentrations in the region. The effect of these elevated concentrations on water quality and aquatic life in Baker Creek has been a long-term concern for local residents (MVEIRB 2013). Remediation is expected to reduce the release of contaminants from the Site to the surrounding environment such that Report of EA Measures 12 and 13, which relate to Baker Creek, are met.

- Measure 12 - To prevent significant adverse impacts on Great Slave Lake from contaminated surface waters in the existing or former channel of Baker Creek, should it be re-routed to avoid the mine site, the Developer will ensure that water quality at the outlet of Baker Creek channel will meet site-specific water quality objectives based on the CCME Guidance on the Site-Specific Application of Water Quality Guidelines in Canada.

- Measure 13 - The Developer will design and, with the applicable regulators, manage the Project to ensure that, with respect to arsenic and any other contaminants of potential concern, the following water quality objectives are achieved in the vicinity of the outlet of the existing or former channel of Baker Creek, should it be re-routed to avoid the mine site, excluding Reach 0:

  a) *Water quality changes due to discharge from Baker Creek will not reduce benthic invertebrate and plankton abundance or diversity*
  b) *Water quality changes due to discharge from Baker Creek will not harm fish health, abundance or diversity*
  c) *Water quality changes due to discharge from Baker Creek will not adversely affect areas used as drinking water sources*
  d) *Water quality changes due to discharge from Baker Creek will not adversely affect any traditional or recreational users*
  e) *There is no increase in arsenic levels in Great Slave Lake due to discharge from Baker Creek beyond the parameters described in Measure 12*

Studies and Design Options

The need to restore Baker Creek was earlier identified in the *Baker Creek Restoration Concepts* report (NHC 2005), which compiled background information and identified planning concepts for a closure design of Baker Creek at the Site. Its objective was to develop a conceptual plan incorporating restoration concepts that were compatible with the overall Mine closure design. NHC (2005) provided reach-specific restoration prescriptions, for Reach 1 through Reach 6, considering channel stability, channel and habitat restoration, riparian and tributary rehabilitation, channel connectivity and fish use, and water and sediment quality. The realignment and restoration of Baker Creek Reach 4, as recommended in the restoration concepts report, was completed in 2006 (see Chapter 4 for more details).

After completion of Reach 4 restoration activities, Baker Creek was surveyed and a one-dimensional hydraulic model was developed (NHC 2007). The modelling identified numerous flood hazards for the existing channel, including potential overtopping of the creek into open pits during extreme floods, mainly as a result of constricted flows in Reach 1, Reach 3, and lower Reach 5. Recommended future mitigation included:

- providing low flow channels and/or sufficient flood plain area to mitigate ice effects
- providing sufficient flood plain area to convey extreme flood discharges
- providing bank protection, berms, and dyking to mitigate high water levels / overflows
- removing constrictions to mitigate high water levels / overflows

The *Baker Creek Remediation Design Compilation and Options* report (SRK 2009) presented additional background information and preliminary design alternatives, at a conceptual level. The objective of the report was to inform decision making for the Baker Creek restoration and Mine closure planning activities. The report also identified design requirements to meet sustainability and ecological restoration, including discussions of geotechnical conditions, water and sediment quality, and constraints associated with adjacent infrastructure. SRK (2009) noted that the Baker Creek remediation was expected to be an aspect of the Site remediation of great interest to the public, with enhanced expectations due to the observed increase in fish presence and

spawning in the realigned Reach 4 channel. The alignment and design presented by SRK (2009) was incorporated into the DAR (INAC and GNWT 2010).

The Baker Creek preliminary design report (Golder 2012a) was developed during the EA to provide a basis for budget estimates for the closure design. It presented a design philosophy, background from previous work, and alternatives identified for each reach of Baker Creek. The preliminary design report outlined design criteria for the creek and presented a preliminary engineering design on a reach-by-reach basis, considering constraints on the design. The design proposed a geomorphic channel with flood plain to convey extreme flows through the Site at closure, including replacement of the presently constricted Reach 1, Reach 3, and lower Reach 5. The design was intended to provide fish habitat, with removal of all fine sediments from Baker Creek to mitigate water and sediment quality issues due to the presence of tailings and contaminated sediments. The design also considered an alternative alignment to that presented in the DAR for Reach 3, to the west of C1 Pit instead of the east.

The present design carries through the diversions at Reach 1, Reach 3 and Reach 5. The diversions at Reach 1 and Reach 3 were intended to provide separation from nearby open pits, but also to provide sufficient space to expand the existing constricted channels into broader channels with flood plains sufficient to convey the probable maximum flood, and also to remove sharp bends introduced by previous operational diversions.

Baker Creek planning and design efforts subsequent to the preliminary design report are discussed in Section 5.5.3.1 and Section 5.5.4.1. These efforts considered the prior work described in this section to mitigate flood hazards and contamination, and to provide fish habitat in the Baker Creek closure design.

Work completed since the preliminary design report in 2012 (Golder 2012a) built on the above studies and further examined closure alternatives and design criteria for Baker Creek. This is summarized below:

- **Surface Design Engagement (SDE)**—As noted in Chapter 1, the Giant Mine SDE program was carried out in 2015 and 2016 (SRK 2016). The purpose of the program was to provide an opportunity for affected parties to voice concerns, identify objectives, and provide direct input into the planning of the Site surface remediation and to provide input on the EA Measures (INAC 2015). The SDE explored closure concepts for open pits, TCAs, contaminated soils, and Baker Creek. The SDE identified a preference for Baker Creek remaining on site, in part to avoid contaminating off-site waterbodies. The SDE also identified a preference to place fill in open pits (Section 5.3).
- **Baker Creek diversion alternatives evaluation**—Incorporating the inputs from SDE, an MAA process to examine 24 potential alignments to convey Baker Creek from above the Site to receiving waterbodies below the Site was conducted in 2016 (Appendix 5.5-A). These included on-site and off-site diversion alternatives, with the objective of the process being a recommendation on whether Baker Creek should remain on or off site. The MAA applied a screening process to remove unacceptable alternatives, which reduced the number of alignments for detailed assessment to three, including the two on-site alignments identified by the preliminary design report and a third alignment running south of the Site, near Handle Lake with an outlet at the existing Baker Creek mouth. These alternatives were evaluated using an MAA based on criteria in environment, feasibility, and society categories. The two on-site alternatives (Baker Creek Reach 3 Option A and Option C) were rated highest, and on that basis the decision was made to carry an on-site alternative forward in closure planning and design. This MAA received input and review from the GMOB, GMAC, and Working Group, considering the perspectives of a broad range of regulators and affected parties including community groups and First Nations.

- **Baker Creek sediment removal**—Based on SDE and a formal MAA evaluation (Golder 2017a; Section 5.4) and the HHERA (CanNorth 2018), options for potential remediation of the contaminated sediment and tailings in Baker Creek were reviewed. The decision was to excavate Baker Pond and the Jo-Jo Lake tailings area and potential application of alternative technologies (e.g., constructed wetland) to reduce arsenic loading to the aquatic environment. The potential for this portion of Baker Pond to be developed as a treatment wetland will be investigated further as part of a Reclamation Research Plan (Appendix 5.5-B). Further, the decision was made to remove contaminated sediments from Reach 0 to 5 of Baker Creek. This is discussed further in Section 5.4 (Soils) but is relevant here as this related to the final configuration of Baker Pond and Jo-Jo Lake to handle the PMF.
- **Giant Mine closure material balance**—Once the decision was made to proceed with an on-site option for Baker Creek, an evaluation of which alignment of Reach 3 would be most beneficial was undertaken. Reach 3 was identified as a candidate for realignment in the Baker Creek preliminary design report (Golder 2012a) due to its proximity to C1 Pit, with three options evaluated. Option A followed the DAR alignment to the east of C1 Pit, Option B followed the existing alignment immediately west of C1 Pit, and Option C followed an alignment beyond the bedrock outcrop west of C1 Pit. Option B was not considered due to the close proximity to C1 Pit and limited space within which to construct a flood plain and maintain separation from the C1 Pit cover; it would also be more difficult to construct without a substantial temporary diversion. The primary difference between Baker Creek Reach 3 Option A and Option C was the amount of borrow material (rock and fine-grained soils) that could be provided from the valley, flood plain, and channel excavation, with Option 3C providing substantially more borrow material. Option A was selected as there were other feasible options available to obtain the needed borrow material from the development of on-site sources.

Based on the SDE, closure option evaluations and engineering work completed since 2012, an on-site creek alignment following the preliminary design report (Golder 2012a) Reach 3 Option A has been selected. Tailings and contaminated sediments will be removed, where present, from Baker Pond and Baker Creek, and a portion of Baker Pond will be reconstructed as a flood plain. This alignment has been shown to be able to convey the PMF through the post-closure Mine site without flooding the underground mine. Additional actions have been identified to mitigate seepage and erosion potential at Baker Creek.

The question of whether fish should be excluded from Baker Creek at closure was also discussed in the SDE sessions. Baker Creek is a regulated fishery, and exclusion of fish would require changes to regulations within the jurisdiction of DFO. The CRP considers unrestricted fish movement in Baker Creek up to the natural barrier upstream of Reach 6. The extent of fish habitat and offsetting requirements are topics of current discussions with DFO.

The key drivers leading to the selection of closure activities for Baker Creek are shown in Figure 5.5-4.

Baker Creek & Surface Water – Key Drivers for Closure Decisions

Higher ↑ Priority ↓ Lower

Drivers

Meet regulatory requirements:
- Measures 11, 12 & 13
- Suggestion 10
- *Fisheries Act* Authorization

Input from Surface Design Engagement process & affected parties

Align with other remediation activities

Design Considerations

- Reduce potential to flood underground
- Reduce exposure of fish in Baker Creek to arsenic; Reduce contaminant loading in Baker Creek
- Reduce impacts to Great Slave Lake (SSWQOs)
- Habitat offsetting
- Requirements of Arctic Grayling fishery
- Preference that Baker Creek to remain on-site to avoid contamination of off-site water bodies
- Preference to remove contaminated sediments from Baker Creek
- Open pits closure design for fill, grading, berms and covers to mitigate for PMF entering underground through pits
- Cease discharge of treated effluent to Baker Creek

Selected Options

Keep Baker Creek on-site
- Realign select reaches
- Reconfigure floodplain to accommodate possible flooding and ice buildup
- Remove and replace sediment
- Replace/enhance fish habitat

Surface Water Management
- Discharge surface runoff to Baker Creek when it meets criteria

Reclamation Research Plan on Alternative Treatment options including wetland treatment

Note: Specific fish habitat offsetting in Baker Creek requires additional consultation with affected parties and Fisheries and Oceans

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2018-12-19
DESIGNED	H. Machtans
PREPARED	D. Pahl
REVIEWED	J. Amphlett
APPROVED	J. Amphlett

PROJECT

Giant Mine Remediation Project

TITLE

KEY CONSIDERATIONS DRIVING THE SELECTION OF CLOSURE ACTIVITIES FOR BAKER CREEK AND SURFACE WATER MANAGEMENT

REV. 0

FIGURE 5.5-4

5.5.4.2 Selected Closure Activities for Baker Creek

Planned closure activities include the following:

- Baker Creek to stay on site and the flood plain to pass the PMF; this could also pass a 1:500 year plus 2 m ice in the channel.
- At Reach 0, no channel realignment is planned. Fine sediments will be removed during closure and replaced with clean substrates. The existing breakwater is to remain in place. See Section 5.4 for more information on contaminated sediment removal.
- Reach 1 will be realigned away from A2 Pit to the north of the existing channel to provide a smooth transition between Reach 2 and Reach 0 and to reduce risk of flooding at A2 Pit. The existing culverts through the highway embankment will be removed and the local area will be recontoured to accommodate changes to the access road alignment. The new channel and flood plain will be closer to A Shaft and will be constructed over underground workings to the northeast of A2 Pit, requiring mitigation of potential seepage to the underground mine. Bridges will also be required to provide access to remaining mine infrastructure (e.g., ETP, freeze pads) and to the Townsite area and boat launch.
- At Reach 2, fine sediments will be removed and replaced with clean substrates (see Section 5.4 for more information on contaminated sediment removal). The two road embankments and culverts, as well as the temporary bridge, across Reach 2 will be removed during closure. No channel realignment is planned for Reach 2. The remediated channel and flood plain will be constructed over underground workings, with associated boreholes, to the northeast of A2 Pit, possibly requiring mitigation of potential seepage to the underground mine.
- Reach 3 will be realigned along the route that was originally identified in the DAR (INAC and GNWT 2010) and later examined in the preliminary design report (Golder 2012a) as Option A, along the east side of C1 Pit. The existing channel will be abandoned, backfilled, and recontoured.
- The remediated Reach 3 channel and flood plain will cross an area northeast of C1 Pit, possibly requiring mitigation of local geotechnical conditions, including permeable alluvium and ground ice. This area is also immediately adjacent to a planned gravel pad to support freeze infrastructure.
- At Reach 4, the lower portion of the reach will be reconstructed as part of the Reach 3 realignment at closure. No realignment is planned for Reach 4, except for the lower portion where it will transition into the Reach 3 realignment. This will include a portion of the bed and channel where subsidence has been observed. The reconstruction may extend further upstream than required for realignment if bed subsidence remediation is required. Contaminated sediment will be removed from this reach as required (see Section 5.4 for more detail).
- At Reach 5, closure activities will include removal of fine sediments from the reach alignment and replacement with clean substrates, and channel realignment to the east of the existing creek away from B2 Pit and to remove an existing sharp channel bend. The left downstream bank of upper Reach 5 is adjacent to the Calcine Pond, which will be covered; the creek design will accommodate erosion protection along any vulnerable areas to prevent lateral channel migration. The remediated channel and flood plain in the lower reach will be constructed over underground workings, with associated boreholes, between B1 Pit and B2 Pit, requiring mitigation of potential seepage to the underground mine. B Shaft is also located adjacent to the Reach 5 channel and flood plain and will be sealed during closure.

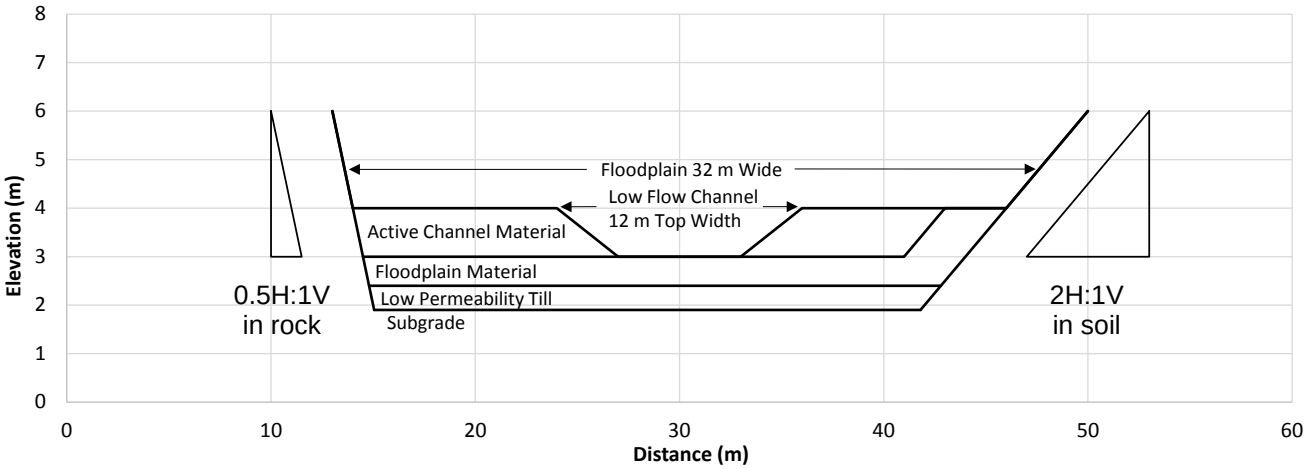
- Reach 6 (Baker Pond) will have contaminated fine sediments and tailings removed, including the Jo-Jo Lake area and its existing rock cap (See Section 5.4 for more information on contaminated sediment removal). Subject to the results of the *Reclamation Research Plan for Passive and Semi-Passive Treatment Options* (Appendix 5.5-B), clean fill will be placed in most of the east and central portion of Baker Pond to create a flood plain area separated by a placed berm, leaving a narrow pond along the west portion to convey flow from upstream to Reach 5. Several historical boreholes are present in Baker Pond, mainly around the perimeter. However, there are no underground workings below Baker Pond, so no mitigation of seepage potential is expected to be required in this area.

The preliminary design report (Golder 2012a) proposed a channel cross-sectional geometry that forms the basis for the design of constructed diversions at Baker Creek. This channel geometry is based on observations of local channel geometry as presented in the preliminary design report and will accommodate the design flood discharge regime at the Site. The channel cross-section, as shown in Figure 5.5-5, will include:

- **Excavation to competent subgrade**—The presence of organic or high-permeability materials may require over excavation, and permafrost mitigation will be considered where required.
- **Low permeability material**—A 0.5 m thick layer of low permeability till will be placed to minimize seepage from the Baker Creek channel and reduce the potential for inflow to the underground mine. Placement of an impermeable geotextile liner may be considered during future design.
- **Floodplain material**—A 0.6 m thick layer comprising mainly cobbles and small boulders (D_{50} = 120 to 250 mm) will be placed to provide an erosion resistant layer below the active channel. Where bedrock is present, the flood plain material and low permeability material may not be placed.
- **Active channel material**—A 1.0 m thick layer comprising gravel and cobbles (D_{50} = 120 mm) will be placed to create the active channel.
- **Channel substrates**—Guidance from DFO will be considered in developing prescriptions for channel substrate sizes and bedforms that may be placed at the bed of the active channel. Prescriptions will be developed during detailed design and may include features such as those present at the existing restored Reach 4 channel.
- **Floodplain organic material**—Guidance from DFO will be considered in developing prescriptions for soil placement in the flood plain, to support vegetation that could include grasses and shrubs.

Additionally, flood plain margins adjacent to vulnerable areas (e.g., open pits, calcine pond, mill pond, underground mine openings to surface) will be provided with river protection works (e.g., rock armour) to prevent lateral channel migration and mitigate the potential for increased risk of creating a direct flow path from Baker Creek flood waters to the underground mine. During channel construction, care will be taken to identify historical boreholes which could provide direct, though limited discharge capacity, flow paths to the underground mine. Boreholes will be located and seepage mitigation provided by grouting.

Figure 5.5-5: Typical Cross-Section of Baker Creek Channel at Constructed Diversions



5.5.4.3 Review of Surface Drainage Closure Options

Concerns with the water quality of runoff from Mine developed areas were originally focused on seepages from mine areas including tailings pond, waste rock dumps, the mill site, and other potentially contaminated areas. Sampling by Royal Oak Mines Inc. (SRK 2005a) was intended to determine whether soil contaminants were affecting runoff water quality; subsequent sampling by Golder (2001) focused on tailings seepages, but also examined locations in tailings ponds, open pits, Baker Creek and tributaries, and effluent discharge. SRK (2005a) sampled Baker Creek, as well as 41 seepage areas.

The DAR (INAC and GNWT 2010) proposed to direct all contaminated water to the underground mine for collection and treatment. This included runoff and seepage from TCAs, after cover placement and until water quality improved sufficiently to allow direct runoff to the environment. Existing clean water diversions at A1 and A2 pits were to be retained to reduce inflows to the underground mine. No collection of runoff from other areas was anticipated.

The DAR presented arsenic loading estimates based on the water management plan presented therein. The DAR estimates were updated using a new model framework and updated inputs; present-day estimates are reasonably aligned with the average arsenic loading value presented in the DAR. Post-remediation reductions in arsenic loading to Baker Creek and to Yellowknife Bay from surface runoff are expected (CIRNAC and GNWT 2019a).

The surface water management preliminary design report (Golder 2012b) was developed during the EA to provide a basis for the design and budget estimates for the closure design. It presented a design philosophy, background from previous work, and alternatives identified for surface water drainage. The preliminary design report outlined criteria for surface water drainage and presented a preliminary engineering design for primary drainage channels. The objective of the design was to convey non-contact water (i.e., that without contact to tailings or minewater) off site to receiving waterbodies and collecting contact water for treatment. Surface drainage planning and design efforts subsequent to the preliminary design report are discussed in Section 5.5.3.3 and Section 5.5.4.2.

Work completed since the preliminary design report in 2012 (Golder 2012b) to further inform the examination of closure alternatives for surface drainage includes a study for Trapper Creek. This study (Golder 2018c) examined options for sediment and water in Trapper Creek, applying an MAA process (see Section 5.4 for information). Based on the review therein, consideration of a wetland to improve sediment and water quality in Trapper Creek, similar to the results for Baker Pond was the preferred option (Golder 2017a). However, this selection is considered provisional, due to limited data on the area and feasibility of wetlands in the area. The feasibility of wetlands will be examined further in the *Reclamation Research Plan for Passive and Semi-Passive Treatment Options* (Appendix 5.5-B). This is also in support of the Report of EA Suggestion 10: *The Developer should investigate the potential advantages and disadvantages of adding an engineered wetland to the Project to reduce arsenic in surface drainage* (MVEIRB 2013). Preliminary findings related to wetlands are encouraging with regards to its feasibility and efficacy. (Contango 2016, 2017a, 2018a,b; Appendix 5.5-B).

The watersheds noted in Section 5.5.5.2 are those with substantial drainage areas and would generally have well-defined inflow channels at closure. Flows from each of these watersheds are expected to be ephemeral, with sustained dry-weather flow only expected at Trapper Creek and all flow ceasing under frozen conditions. Small, local areas adjacent to Baker Creek would also contribute runoff to the creek, though not through defined channels.

Runoff estimates at the Site were developed for the surface drainage preliminary design report (Golder 2012b) based on local rainfall and snowmelt records. These were defined for three design storms as described in Table 5.5-4 and will provide a basis for closure design.

Table 5.5-4: Preliminary Design Report Surface Drainage Design Storms

Design Storm	Depth (mm)	Component	Applies To
Minor	70.3	50-year, 24-hour rainfall	Culvert crossings at minor service roads not required to access critical facilities (e.g., effluent treatment plant; freeze control room)
Interim	91.5	100-year, 24-hour rainfall + average melt of the 100-year snowpack over 14 days	Contact water storage and conveyance infrastructure that will exist only in the near term (e.g., closure period)
Closure	114.5	500-year, 24-hour rainfall + average melt of the 100-year snowpack over 14 days	Closure drainage infrastructure where failure has the potential to cause environmental harm (e.g., by exposure of contaminated sediments)

5.5.4.4 Selected Closure Activities for Surface Drainage

The selected closure activities for the management of surface drainage include the following:

- constructing non-erodible spillways to convey runoff from the Northwest Pond and the North Pond to Baker Pond (Section 5.6)
- potentially reconstructing Trapper Creek as a series of wetlands to convey runoff from Trapper Lake and the Northwest Pond to Baker Pond (subject to the results of the *Reclamation Research Plan for Passive and Semi-Passive Treatment* [Appendix 5.5-B])
- improving runoff flow paths located in developed areas of the Site, including pit areas (Section 5.3), to resist erosion and manage runoff conveyance to Baker Creek and Yellowknife Bay

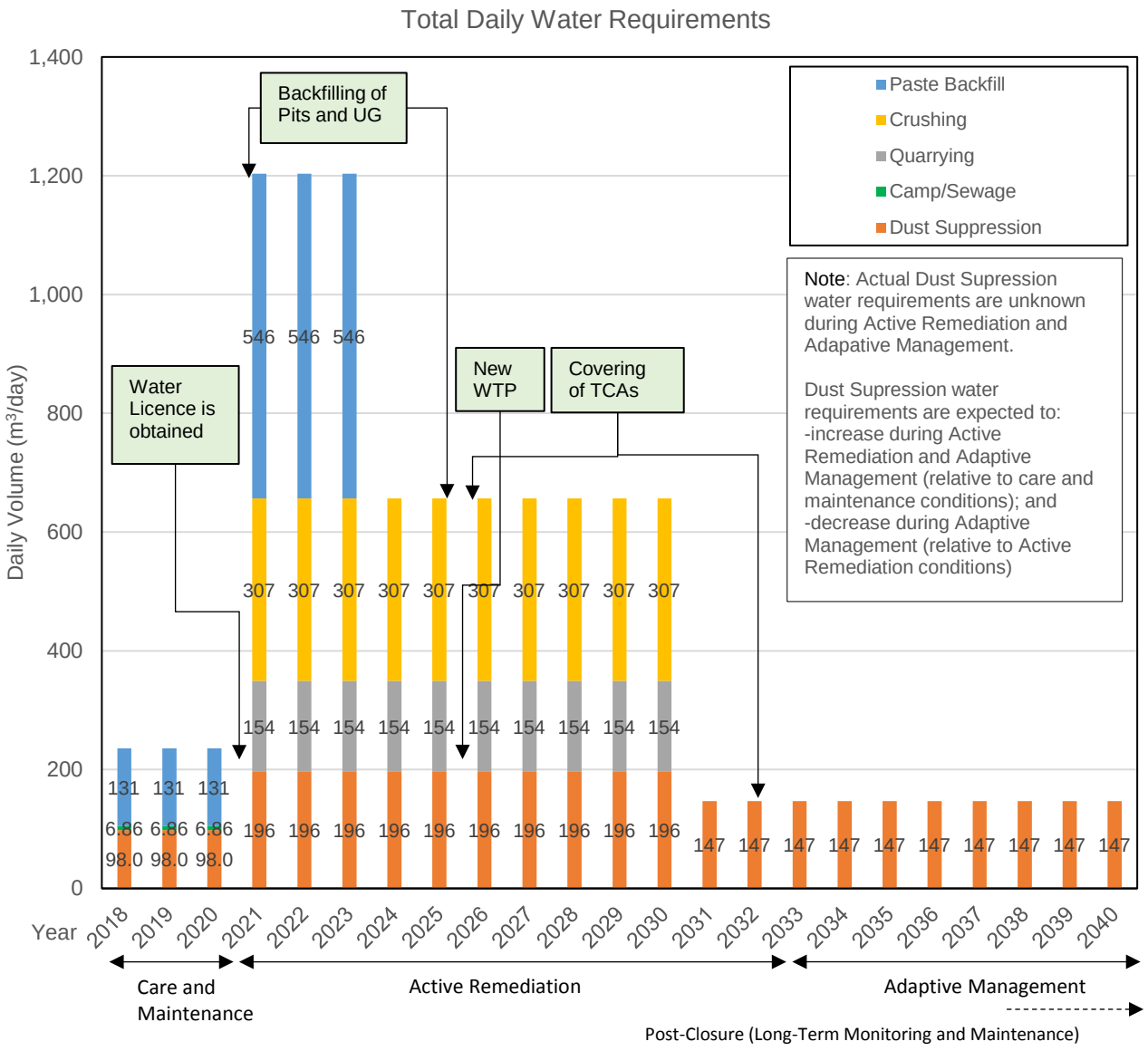
As part of these options, it will be necessary to confirm the stability of runoff flow paths located in bedrock / forest / wetland areas of the Site, to mitigate risks of erosion and changes to runoff patterns. It will also be necessary to verify that terminal points of drainage channels to Baker Creek are stable and integrated with the Baker Creek channel and flood plain, to allow effective monitoring of runoff water quality.

Runoff from remediated developed areas (e.g., tailings covers, pits, WTP area) will be collected, tested, and conveyed to the underground mine for treatment, until such time as its water quality is deemed suitable for discharge to the environment. Temporary runoff collection locations may include holding ponds or sumps at pits (as discussed in Sections 5.3.2.2 and 5.3.5.5) and for TCAs may include holding ponds or direct conveyance to the underground via unfilled pits (as discussed in Section 5.6.2.3.5). A temporary surface water management pond may be required to provide contingency contact water storage. This will be determined during detailed design stages when remediation and water management activities will be refined. The temporary water management pond would be sited in an appropriate location based on topographical constraints and proximity to the new WTP. Treatment wetlands for surface runoff are the subject of a Reclamation Research Plan (Appendix 5.5-B) and may be constructed along surface drainage flow paths, upstream of Baker Creek and Yellowknife Bay, where they have demonstrated potential for effective arsenic removal.

Water Needs for Remediation—Related to the surface drainage infrastructure, water will be needed for various remediation activities. As noted above, potable camp water will be trucked in and sewage water trucked out; freshwater is not needed for camp facilities. Fire suppression will be supported by the City of Yellowknife (agreement pending) and no additional site water will be used for this.

Water will be needed for dust suppression (inclusive of building demolition amongst other activities), crushing and quarrying, and paste backfill. This water use will be approximately 1 million m^3 in the first years of Active Remediation (Figure 5.5-6). The bulk of this water will come from on-site sources and as such limited freshwater use is required. The Water Management and Monitoring Plan provides further detail (CIRNAC and GNWT 2019b).

Figure 5.5-6: Estimated Total Daily Water requirements during remediation phases



5.5.5 Engineering Work

5.5.5.1 Baker Creek

During closure, Baker Creek will be remediated and realigned according to the outcomes of the alternatives evaluations and planning studies described in Section 5.5.3. The closure design is largely guided by the Baker Creek preliminary design report (Golder 2012a) and subsequent work performed, with input from regulators and community and First Nations affected parties. Work completed since the preliminary design report in 2012 to advance engineering design for Baker Creek included the following:

- **Reach 4 hydrotechnical assessment**—This study (Golder 2014) was completed to review the condition of the Baker Creek Reach 4 diversion, constructed in 2006, including bed and bank topography and the condition of the impermeable liner installed in the lower portion of the diversion. The bituminous liner was visually inspected and determined to be in good condition. In high-subsidence areas, the liner was estimated to have been stretched by 1% to 5% compared to its specification limit of 7%. Topographical surveys were compared to as-built surveys and indicated areas of channel and flood plain subsidence on the order of 2 m in some areas. The subsidence could potentially be attributed to thawing of frozen ground or ground ice and indicates that the future detailed channel design should consider this in areas without shallow bedrock.
- **Reach 3 geophysical/geotechnical assessment**—To support the closure material balance and selection of a preferred alignment for Baker Creek Reach 3 (Section 5.5.3.1), geophysical surveys were completed to characterize the location of the soil-bedrock interface along Reach 3 Option A and Option C (Golder 2018a). These surveys were used to develop estimates of potential borrow material volumes for each option but will also inform detailed design.
- **Baker Creek flood hazard assessment**—Report of EA (MVEIRB 2013) Measure 11 stated that a primary consideration in selecting a Baker Creek alignment was to "minimize the likelihood of Baker Creek flooding and entering the arsenic chambers, stopes and underground workings." To verify that the proposed alignment complies with that measure, a flood hazard assessment for Baker Creek (Golder 2018b) was completed. This assessment considered the proposed channel alignment through the Site (Section 5.5.2.3.1) and included an update to Baker Creek hydrology. The study considered the PMF and shows that it can be conveyed through the post-closure Mine site without flooding the underground mine. The study includes recommendations to inform detailed design, including mitigation of seepage and erosion potential.
- **Baker Creek ecosystem synthesis report**—The objectives of this report (Appendix 2B) were to compile background information about Baker Creek at the Site; define spatial and temporal boundaries of the information; provide a general overview of historical aquatic ecosystem conditions; and describe the existing aquatic ecosystem in terms of recent changes to the creek alignment, climate, hydrology, water temperature, water quality, sediment quality, aquatic life and habitat, benthic community, and fish health and tissue chemistry. This work is intended to inform closure planning and design, including discussions with regulatory agencies.

Key design considerations for Baker Creek include:

- The preliminary design report and present closure design incorporates a low flow channel and flood plain to mitigate flood risk; recent updates to hydrology and hydraulic assessments (Appendix 5.5-C) consider the PMF as a basis for closure planning.

- Open pits will be closed, as discussed in Section 5.3.6.4, and this will aid in the mitigation of the risk of direct inflow to the underground mine via openings to surface at open pits.
- Stabilization of the underground mine since the 2012 preliminary design report has mitigated the risk of failure of the creek to the underground mine.
- Affected party engagement (SRK 2016) indicated support for filling of mine pits, which has been incorporated into the CRP and further mitigates the flood risk to the underground mine.
- An MAA of Baker Creek closure alignment alternatives indicated a strong preference for keeping Baker Creek on the Site at closure.

Residual risks associated with the presence of ground ice, seepage to the underground mine via historical boreholes, and erosion during extreme flood events will be addressed during detailed design of the Baker Creek channel and flood plain.

A summary of completed and future work at Baker Creek is provided in Table 5.5-5.

Table 5.5-5: Summary of Completed and Future Engineering Work at Baker Creek

Year	Report or Study	Objective
2014	Reach 4 Hydrotechnical Assessment	Review condition of Reach 4 with a focus on subsidence and liner performance in the lower reach; intended to inform future engineering design.
2017	Reach 3 Geophysical/Geotechnical Assessment	Determine depth to bedrock and potential overburden and borrow volumes along Reach 3 diversion alternative alignments.
2018	Baker Creek Flood Hazard Assessment	Establish design flood regime up to PMF and develop hydraulic model to establish design flood water surface elevations and velocities along Baker Creek at closure.
2018	Baker Creek Ecosystem Synthesis Report	Compile background information about Baker Creek at the Site; define spatial and temporal boundaries of the information; provide a general overview of historical and existing aquatic ecosystem.
2018/19	Baker Creek Fish and Fish Habitat Plan	Engagement with regulatory agencies to establish fish and fish habitat objectives for Baker Creek and to define offsetting requirements, if any.
2018/19	Overburden and Openings to Surface Desktop Study	Examine existing geotechnical and borehole data to characterize subsurface materials and potential seepage conditions, and to identify gaps requiring additional field study. This study will also inform the seepage mitigation design.
2018/19	Permafrost Adaptive Management Desktop Study	Examine existing permafrost and soil ice data to characterize subsurface materials and potential subsidence areas, to identify gaps requiring additional field study, and to identify and evaluate potential mitigation measures to be considered in design.
2018/19	Baker Creek Geophysical Study	Geophysical field program to fill gaps identified in the overburden, openings to surface and permafrost desktop studies.

Table 5.5-5: Summary of Completed and Future Engineering Work at Baker Creek

Year	Report or Study	Objective
2018/19	Baker Creek 60% Draft Design	Develop a draft design for Baker Creek, including Baker Pond, considering all preceding studies, project linkages and engagement. Develop a Design Basis Report to identify a specific creek alignment, cross-sections and materials, including fish habitat and contaminated soils considerations.
2019/20	Baker Creek 90% Final Draft Design	Advance the 60% draft design considering additional information including finalized inputs from other project components and decommissioning of abandoned channels.
2020/21	Baker Creek Final Design	Finalize the Baker Creek design by advancing the 90% design.

PMF = probable maximum flood.

5.5.5.2 Surface Drainage

During closure, surface drainage at the Site will be reconstructed according to the outcomes of the alternatives evaluations and planning studies described in Section 5.5.3. Work completed since the preliminary design report in 2012 to advance engineering design for surface drainage included the following:

- **Runoff water quality studies**—Three years of runoff sampling was undertaken to provide a basis for updating the arsenic loading model at the Site (Golder 2015, 2016a, 2017c). This included sampling from 43 locations in 2014, 64 locations in 2015, and 27 locations in 2017. Sample locations remained consistent among years, where practicable. In 2014 and 2015, samples were collected under freshet and summer rain conditions; in 2017, only freshet samples were collected due to low rainfall yields in the fall. Samples were collected from off-site lakes, Baker Creek upstream of the Site, Baker Creek through the Site, Trapper Creek, the mill area and adjacent areas to the north, west, and south of the mill area, as well as near the North, Central, and South ponds. Samples were analyzed for a full suite of parameters (i.e., ions, nutrients, metals) and the data have been used to support modelling exercises and arsenic loading analyses. This study informed understanding of what current runoff water quality is and which waters would need to be contained and if any waters could be released to the environment. Given the elevated metals in runoff, the decision was to continue to pump water to the underground or the TCAs and then to water treatment from most areas for early remediation, wherever practicable. This study also informed the closure options for contaminated soils whereby the need to cover soils in areas with elevated metals to reduce loading to water was determined (see Section 5.4 for details on contaminated soil excavation and engineered covers). This information was also used to inform the need for a reclamation research plan to improve water quality in low flow areas (see *Reclamation Research Plan for Alternative Technologies to Reduce Arsenic Loading to the Aquatic Environment* (Appendix 5.5-B).
- **Giant Mine modelling**—A model was developed with the objective of updating estimates of arsenic loading from the Site to Baker Creek and Yellowknife Bay (Golder 2016b) as well as additional modelling to develop EQC and possible SSWQO (as per the Measures; CIRNAC and GNWT 2019a). This was the first update of arsenic loading estimates since the work completed for the DAR (SRK 2005b). See CIRNAC and GNWT (2019a) for more details on arsenic loading. Modelling information was used to inform the various MAA's for Baker Creek and Trapper Creek and the resultant decision to have a reclamation research plan to evaluate options to improve water quality in low flow areas of the Site (see *Reclamation Research Plan for Passive and Semi-Passive Treatment* (Appendix 5.5-B). This in turn informs the surface drainage patterns of the future site conditions, should the wetlands be installed.

- **Giant Mine Closure Water Management and Monitoring Plan**—A conceptual-level site-wide Water Management and Monitoring Plan was developed for the Site, addressing existing conditions, as well as those during closure and post-closure (CIRNAC and GNWT 2019b). Through the Water Management and Monitoring Plan process, closure options for water usage were reviewed. The use and need for freshwater versus recycled water was assessed. Based on the review, it is feasible to use recycled water from site for some remediation activities such as dust suppression during excavation of tailings, blasting, and paste backfill. Treated water from the polishing pond could be used for dust suppression on roads/pads, building demolition, aggregate/soil washing, pit filling, and landfill construction/operation. Freshwater will also be required to supply potable water to the workforce but that would be trucked in. To accommodate the water usage needed, A freshwater intake in Yellowknife Bay will be required, and it is proposed to be sited near the existing developed corridor, with final design details pending. Final surface drainage channels were designed based on the GMRP objective to return site drainage to as close as possible to pre-development conditions.

5.5.6 Final Site Conditions

The remedial planning process for Baker Creek and surface drainage resulted in a final design intended to meet closure objectives and criteria (Section 5.5.2) and to comply with measures identified by the Report of EA (MVEIRB 2013).

5.5.6.1 Final Conditions for Baker Creek

Hydrology

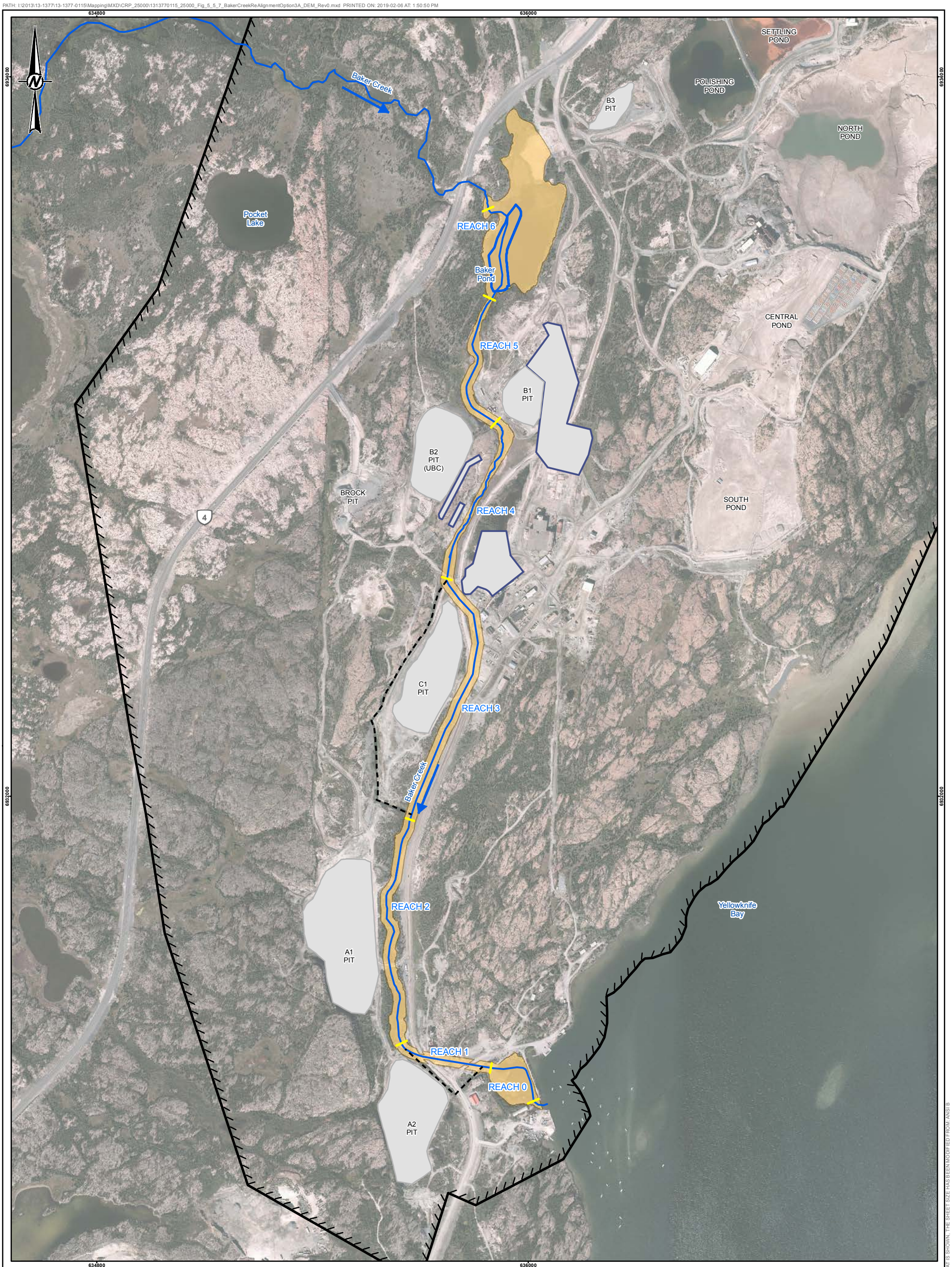
The planned final alignment of Baker Creek at the Site will be similar to that presented in the DAR (INAC and GNWT 2010) and the Reach 3 Option A alignment identified in the preliminary design report (Golder 2012a) and shown in Figure 5.5-7. This alignment was presented during the SDE (SRK 2016) and selected based on the SDE outcomes and subsequent Baker Creek options analysis (Appendix 5.5-A) to meet the requirements of Report of EA (MVEIRB 2013) Measure 11.

The planned final alignment includes conversion of most of Baker Pond (Baker Creek Reach 6) and all of the adjacent Jo-Jo Lake into a flood plain or constructed wetland, pending the results of the *Reclamation Research Plan for Passive and Semi-Passive Treatment* (Appendix 5.5-B) and approval by DFO. Downstream reaches of Baker Creek will have enhanced flood conveyance for the PMF including:

- expansion of the channel and flood plain in lower Reach 5
- retention of the existing reconstructed channel and flood plain in Reach 4, with realignment of the lower reach to match the Reach 3 realignment
- full realignment of Reach 3 including a constructed flood plain
- retention of the existing, largely natural, channel and flood plain in Reach 2
- expansion and realignment of the channel and flood plain in Reach 1

Tailings and fine sediments will be removed from Baker Creek and Baker Pond, as described in Section 5.4.6.3, and replaced with clean substrates. The on-site alignment for Baker Creek will incorporate a geomorphic channel design with low flow channel and overbank flood plain for conveyance of extreme flows up to the PMF. The alignment will keep the low-flow channel away from the closed pits, TCAs, arsenic chambers, freeze pads and calcine pond; all shallow underground mine areas below Baker Creek will be stabilized during closure. These actions will comply with the Measure 11 closure design requirements from the Report of EA (MVEIRB 2013).

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LEGEND

- BAKER CREEK
- GIANT MINE PROJECT BOUNDARY
- INFILLED BAKER CREEK CHANNEL
- REACH BREAK
- APPROXIMATE EXTENT OF FLOODPLAIN CONSTRUCTION AND SEDIMENT EXCAVATION
- BAKER POND, FUTURE CONDITION
- FREEZE PAD
- CLOSED PIT

0 250 500

1:10,000 METRES

REFERENCE(S)

HYDROLOGY AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROPONENT

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

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

PROJECT

Giant Mine Remediation Project

TITLE

BAKER CREEK FUTURE ALIGNMENT CONSTRUCTED AREA

YYYY-MM-DD	2019-02-06
DESIGNED	CV
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

REV. 0

FIGURE 5.5-7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

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The Baker Creek design will mitigate the risk of direct inflow to the underground mine by conveying the PMF within the flood plain margins. The lateral extent of inundation by the PMF, as well as depth-averaged flow velocities, at Baker Creek post-closure are presented in Figure 5.5-8 and Figure 5.5-9. These show that during the PMF, flow will generally be held within the constructed flood plain except where adjacent topography allows water to spill and create shallow, low velocity flow areas (dark blue shaded areas in Figures 5.5-8 and 5.5-9). Figure 5.5-10 shows profiles of the flood hazard assessment model results, which shows that at some open pits, the PMF water surface exceeds the existing low point of the open pit rim. This is the case at B1 Pit for the PMF and at B2 Pit and at C1 Pit there is little contingency elevation above the PMF.

Open pits will be provided with flood mitigation, as discussed in Section 5.3.5.4, to prevent overtopping into open pits during events up to and including the PMF. Should open pits be filled and covered, low areas that provide drainage outlets to Baker Creek may be subject to inundation. These will be provided with scour protection to prevent lateral migration. Should open pits be partially filled, pit drainage will be incorporated into the minewater pool and scour protection will be provided to prevent erosion of pit fill embankments adjacent to Baker Creek.

Other vulnerable areas adjacent to the Baker Creek flood plain (e.g., calcine pond, mill pond, underground mine openings to surface) will also be provided with river protection works (e.g., bank armour) sufficient to prevent lateral migration that could potentially place those areas at risk of erosion and expansion of the inundation zone. This is compatible with the design concept which allows for migration of the low flow channel within the flood plain.

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635500 636000 636500

6934000 6933500 6933000 6932500

Baker Creek

REACH 6

REACH 5

REACH 4

REACH 3

POLISHING POND

B3 PIT

B1 PIT

B2 PIT (UBC)

BROCK PIT

SOUTH POND

LEGEND

- BAKER CREEK
- FLOW DIRECTION
- REACH BREAK
- INUNDATION EXTENT
- MODEL DOMAIN
- CAPPED WITH ENGINEERED COVER
- CLOSED PIT
- FREEZE PAD

DEPTH AVERAGED FLOW VELOCITY (m/s)

- 0.0 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- > 6.0

0 100 200

1:5,000 METRES

REFERENCE(S)

HYDROLOGY AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

PROJECT

Giant Mine Remediation Project

YYYY-MM-DD	2019-01-23
DESIGNED	NS
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

TITLE

BAKER CREEK AT CLOSURE - PROBABLE MAXIMUM FLOOD INUNDATION EXTENT AND FLOW VELOCITY, UPSTREAM REACHES

REV. 0

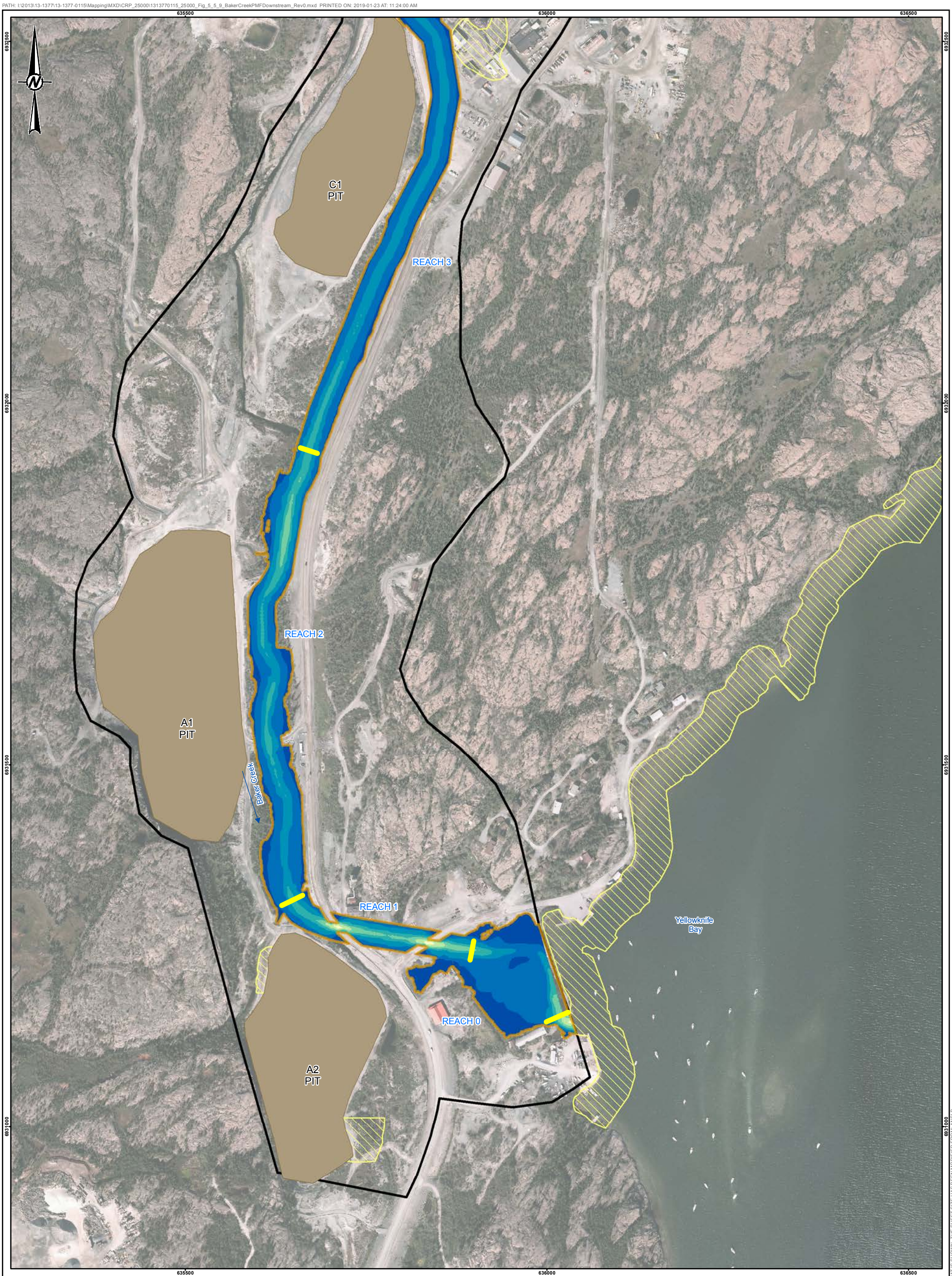
FIGURE 5.5-8

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LEGEND

- BAKER CREEK
- FLOW DIRECTION
- REACH BREAK
- INUNDATION EXTENT
- MODEL DOMAIN
- CAPPED WITH ENGINEERED COVER
- CLOSED PIT

DEPTH AVERAGED FLOW VELOCITY (m/s)

- 0.0 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- > 6.0

0 100 200

1:5,000 METRES

REFERENCE(S)

HYDROLOGY AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

PROJECT

Giant Mine Remediation Project

YYYY-MM-DD	2019-01-23
DESIGNED	NS
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

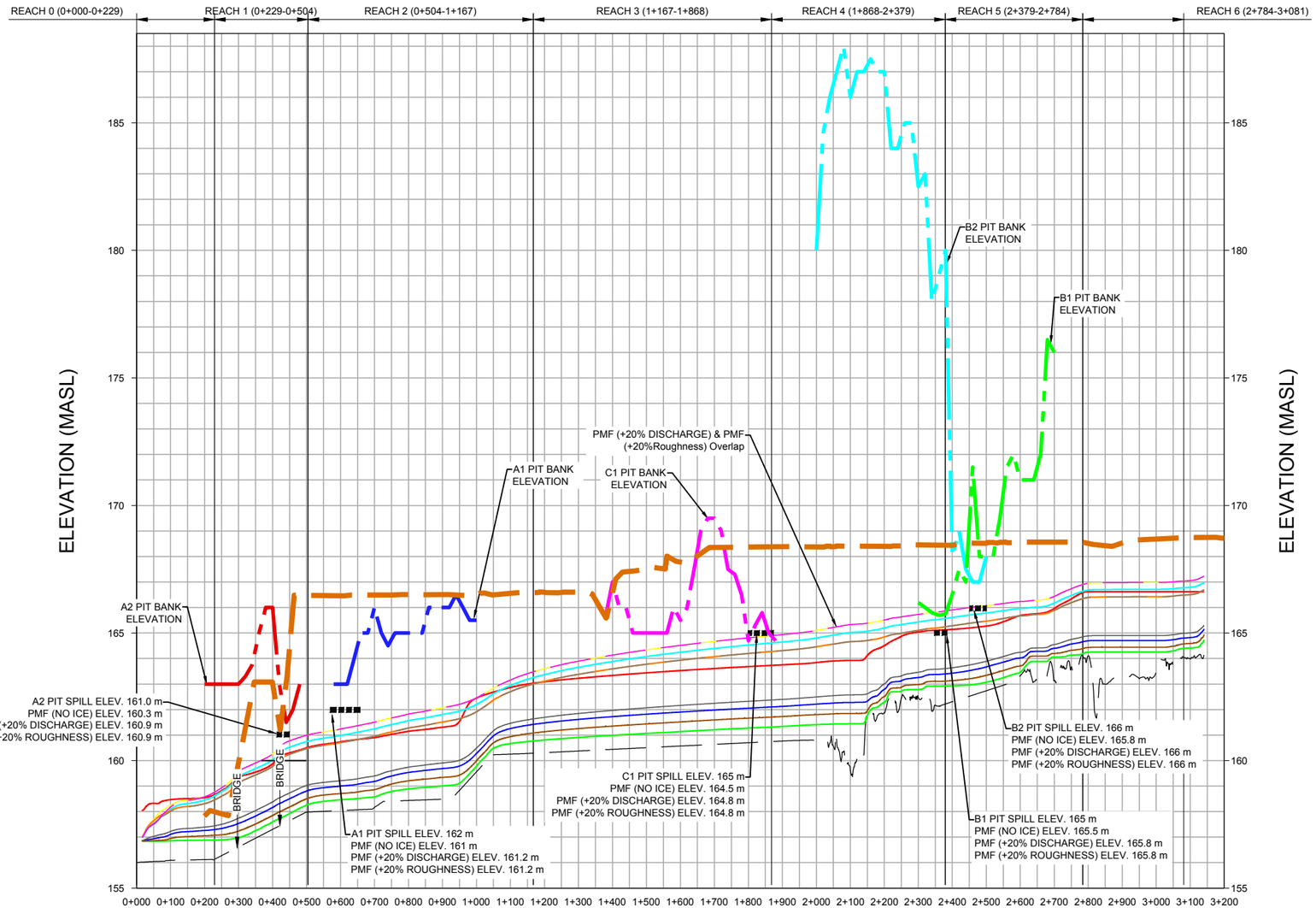
TITLE

BAKER CREEK AT CLOSURE - PROBABLE MAXIMUM FLOOD INUNDATION EXTENT AND FLOW VELOCITY, DOWNSTREAM REACHES

REV. 0

FIGURE 5.5-9

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B
25mm
0



0 250 500
VERTICAL METRES
1:1,000

0 250 500
1:15,000 HORIZONTAL METRES

WATER SURFACE PROFILES OF BAKER CREEK - OPTION 3A

HORIZONTAL SCALE 1:15,000
VERTICAL SCALE 1:200

LEGEND

- A1 BANK ELEVATION
- A2 BANK ELEVATION
- B1 BANK ELEVATION
- B2 BANK ELEVATION
- C1 BANK ELEVATION
- FUTURE BAKER CREEK ALIGNMENT PMF (GOLDER 2018)
- EXISTING BAKER CREEK ALIGNMENT PMF (NHC 2007)
- PIT SPILL ELEVATION AND APPROXIMATE POSITIONS
- BAKER CREEK THALWEG AT CLOSURE
- PMF (-20% DISCHARGE)
- PMF (-20% ROUGHNESS)
- PMF (+20% DISCHARGE)
- PMF (+20% ROUGHNESS)
- 2 YEAR
- 10 YEAR
- 100 YEAR
- 500 YEAR (ICE CONSIDERATIONS)
- 500 YEAR

REFERENCES

1. GOLDER 2018. GIANT MINE - BAKER CREEK FLOOD HAZARD ASSESSMENT, GIANT MINE REMEDIATION PROJECT, NT. PREPARED FOR PUBLIC SERVICES AND PROCUREMENT CANADA, MARCH 2018, REPORT NUMBER 1313770115-123-R-REV0-15000.
2. NHC. 2007. BAKER CREEK CHANNEL SURVEY AND NUMERICAL HYDRAULIC MODELLING. PREPARED BY NORTHWEST HYDRAULIC CONSULTANTS FOR SRK CONSULTING, MARCH 2007, 13 P + FIGURES + 1 APPENDIX.

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-24
DESIGNED	MBP
PREPARED	MBP
REVIEWED	HILARY MACHTANS
APPROVED	BJÖRN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

BAKER CREEK AT CLOSURE - FLOOD HAZARD ASSESSMENT WATER SURFACE PROFILES WITH PIT SPILL ELEVATIONS AND ADJACENT BANK ELEVATIONS

REV.	FIGURE
0	5.5-10

N:\Client\PWGSC\Giant_Mine\99_PROJECTS\13-1426-0010\Phase 28000\TASK 28202\PRODUCTION\DOC. XXX\1314260010_28000_Fig_5_5 - 10 - Flood hazard assessment Water Surface Profiles.dwg

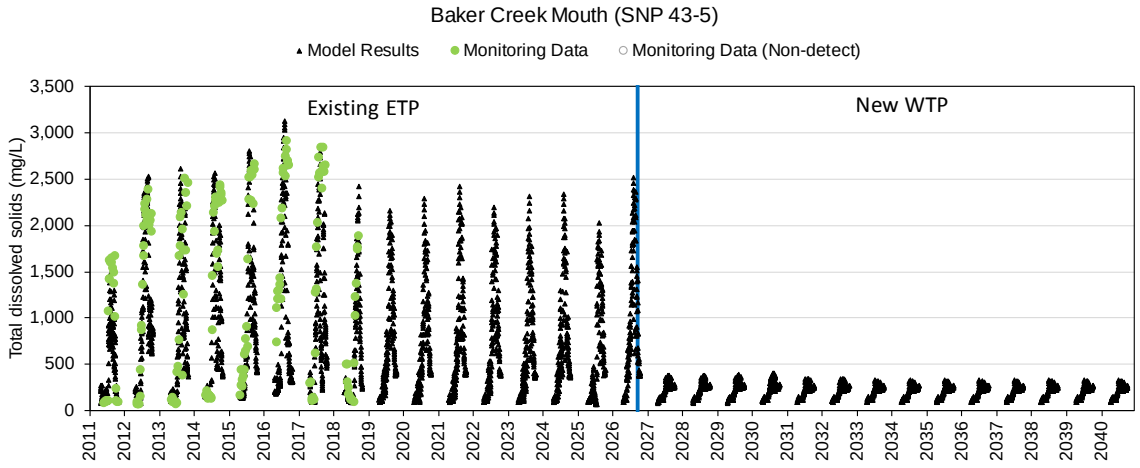
Quality

Water quality in Baker Creek is predicted to improve as closure activities are completed; the largest reduction in concentrations will occur when the existing ETP ceases operations and no longer discharges to Baker Creek (i.e., once the new, more effective WTP is commissioned and the effluent discharge is redirected to Yellowknife Bay; Section 5.8). Early in remediation, the creek will continue to receive a seasonal discharge from the existing ETP, which will dominate concentrations in Baker Creek during the open-water season until the new WTP is operational. Contaminant loadings to Baker Creek will gradually reduce as remediation activities occur, including the removal of contaminated sediments from the creek bed and the remediation of tailings facilities, open pits, and contaminated soils (CIRNAC and GNWT 2019a).

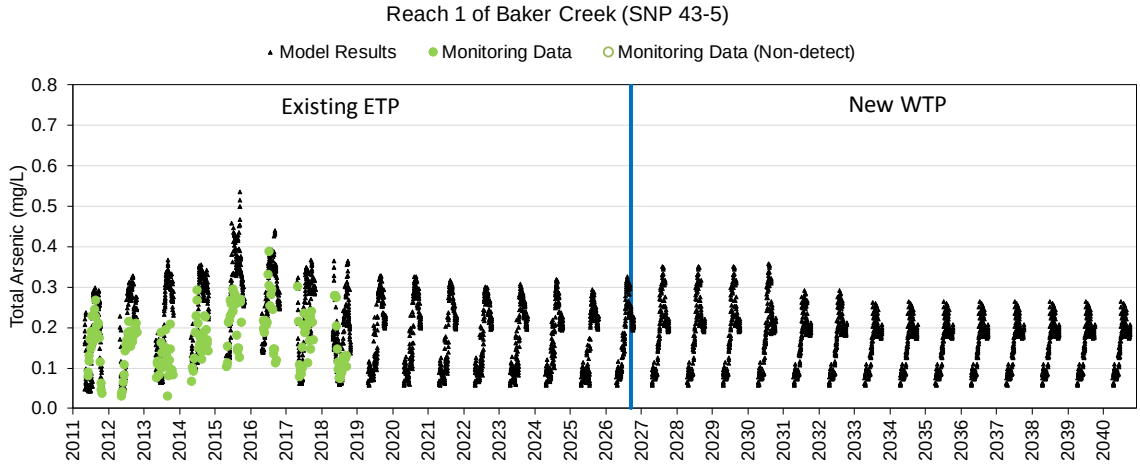
After closure activities are complete and the new WTP is online, water quality in Baker Creek is predicted to be marginally better than existing conditions, but generally similar to that entering the creek from upstream watersheds. Water quality predictions for Baker Creek are presented in the *Effluent Quality Criteria Report* (CIRNAC and GNWT 2019a); plots for key parameters (total dissolved solids, arsenic, and antimony) are provided here (Figure 5.5-11).

Figure 5.5-11: Predicted Future Concentrations of Total Dissolved Solids (a), Arsenic (b), and Antimony (c) in Baker Creek

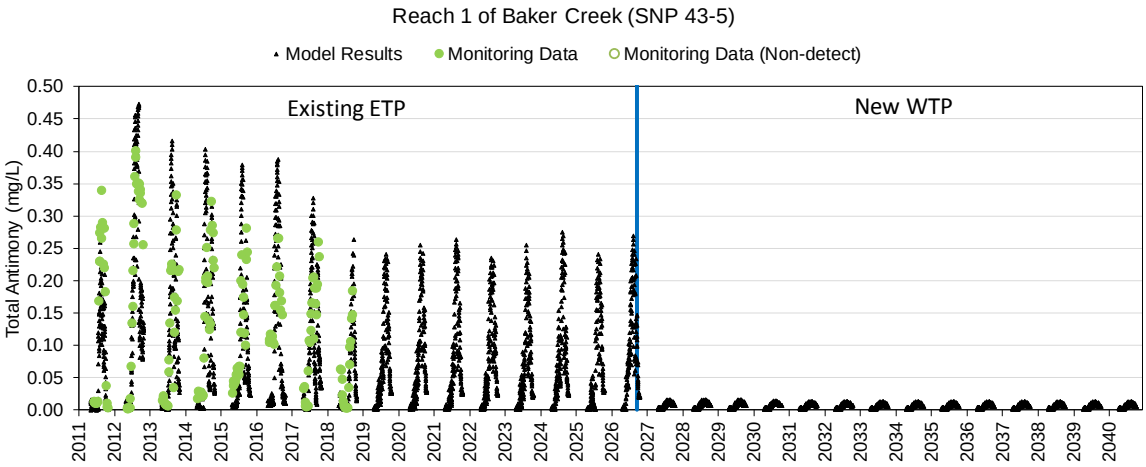
a)



b)



c)



Biological

At post-closure, the condition of Baker Creek at the Site will be a seasonal stream with improved sediment and water quality and surface drainage restored to pre-development conditions, to the extent practicable. Fish habitat will be available in all reaches. The specifics of the fish habitat design are still under review with DFO and affected parties. Fish and benthos will continue to use the stream during remediation because in-stream works will occur during winter/fall to avoid effects on fish. Benthos are expected to recolonize the new sediment from upstream inputs. It is expected that sport fishing will continue to occur in Baker Creek Reaches 1 and 0 with restrictions on spring Arctic Grayling sport fishing remaining (Chapter 2). There is confidence that this restoration is possible given the experience from re-aligning Reach 4, where fish recolonized the stream within a year and successfully spawned and reared young.

5.5.6.2 Final Conditions for Site Surface Drainage

Hydrology

Post-closure surface drainage patterns will be restored to approximate pre-development conditions at the Site. Watercourses reporting to Baker Creek under pre-development and post-closure conditions are described below, with watershed designations corresponding to those shown in Figure 5.5-12:

- **north and east side of Baker Creek**
- **Watershed A**—After closure, the existing Trapper Creek inflow to Baker Pond will include runoff from the Northwest Pond area. The post-closure flow path from Trapper Lake will follow the existing diverted alignment, between Vee Lake Road and the Northwest Pond, and crossing the Giant Mine Access Road to flow into Baker Pond. Prior to development, Moose Lake existed at the present location of the Northwest Pond, and Trapper Creek followed a nearby flow path now covered by the Northwest Pond, joining the Watershed B outflow just upstream of Jo-Jo Lake (at Baker Pond).

- **Watershed B**—After closure, the North Pond spillway will be constructed in the area south and west of the existing Polishing Pond and will convey runoff from the Central, North, Settling, and Polishing ponds, as well as adjacent areas, to Baker Pond. The post-closure flow path will cross the Giant Mine Access Road just east of Baker Pond. Prior to development, Muir Lake was present in this area and received runoff from upstream Oran and Bow lakes, located in the areas of the existing ponds. The Muir Lake outflow joined Trapper Creek outflow just upstream of Jo-Jo Lake (at Baker Pond).

- **Watershed C**—After closure, the existing mill site and adjacent areas to the east and north will drain to Baker Creek in lower Reach 4 or upper Reach 3. Prior to development, local topography suggests that runoff from this area would have reported to the same reaches of Baker Creek, though no defined channels are visible in the available air photos.

- **Watershed D**—After closure, areas south of the existing ETP will drain to Baker Creek in lower Reach 2 or upper Reach 1. Prior to development, local topography suggests that runoff from this area would have reported to the same reaches of Baker Creek, though no defined channels are visible in the available air photos.

- **west side of Baker Creek**
- **Watershed E**—After closure, runoff from the B2 Pit area and the bedrock / forest / wetland area to the north will drain to Baker Creek in Reach 5. Prior to development, local topography suggests that runoff from this area would have reported to the same reach of Baker Creek, though no defined channels are visible in the available air photos.

- **Watershed F**—After closure, runoff from the area west of the UBC bridge will drain to lower Reach 4, through a gap between two bedrock outcrops. Prior to development, local topography suggests that runoff from this area would have reported to the same reach of Baker Creek, though no defined channels are visible in the available air photos.

- **Watershed G**—After closure, runoff from the area north of A1 Pit, including bedrock / forest / wetland areas to the west, will drain to upper Reach 2. Prior to development, local topography suggests that runoff from this area would have reported to the same reach of Baker Creek, though no defined channels are visible in the available air photos.

- **Watershed H**—After closure, runoff from the area north of A2 Pit, including bedrock / forest / wetland areas to the west, will drain to lower Reach 2. The existing channel will be retained and may receive runoff diverted from the filled A1 and A2 pits, depending on the final fill configuration. Prior to development, local topography suggests that runoff from this area would have reported to the same reach of Baker Creek, though no defined channels are visible in the available air photos.

- **Watershed I**—After closure, runoff from the area south of A2 Pit, including bedrock / forest / wetland areas to the west, will drain along the south boundary of the A2 Pit (depending on the final pit fill configuration) to the diverted upper Reach 1. Prior to development, local topography suggests that runoff from this area would have reported to the same reach of Baker Creek, though no defined channels are visible in the available air photos.

A schematic of the planned post-closure flow paths relative to mine components at the Site is provided in Figure 5.5-13. Changes from existing conditions include removing covered ponds from the managed water system to areas with runoff directed to the environment (Baker Creek and Yellowknife Bay), reducing seepage to the underground mine, and adding a new WTP with discharge to Yellowknife Bay rather than Baker Pond. For the purposes of this figure, the pits have also been removed from the managed water system areas, based on the assumed scenario whereby fill is in pits.

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635000

6935000

6930000

Martin River

North Shot Lake

Shot Lake

Trapper Lake

Gar Lake

Yellowknife River

Baker Creek

Lower Martin Lake

Baker Pond

REACH 6

REACH 5

REACH 4

REACH 3

REACH 2

REACH 1

REACH 0

A

B

C

D

E

F

G

H

I

Handle Lake

Fox Lake

Long Lake

Yellowknife Bay

4

3

LEGEND

- REMEDIATED BAKER CREEK
- REACH BREAK
- WATERCOURSE
- WATERBODY
- MAJOR SPILL POINT SUB-WATERSHED
- CONTOUR (10 m INTERVAL)
- GIANT MINE PROJECT BOUNDARY
- HIGHWAY
- ROAD
- CITY OF YELLOWKNIFE LANDFILL

0 500 1,000

1:25,000 METRES

REFERENCE(S)

HYDROLOGY AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. CONTAINS PUBLIC SECTOR DATASETS MADE AVAILABLE UNDER THE CITY OF YELLOWKNIFE'S OPEN DATA LICENSE V.1
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

PROJECT

Giant Mine Remediation Project

YYYY-MM-DD	2019-01-23
DESIGNED	NS
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

TITLE

WATERSHEDS DRAINING TO BAKER CREEK POST-CLOSURE IN THE GIANT MINE AREA

REV. 0

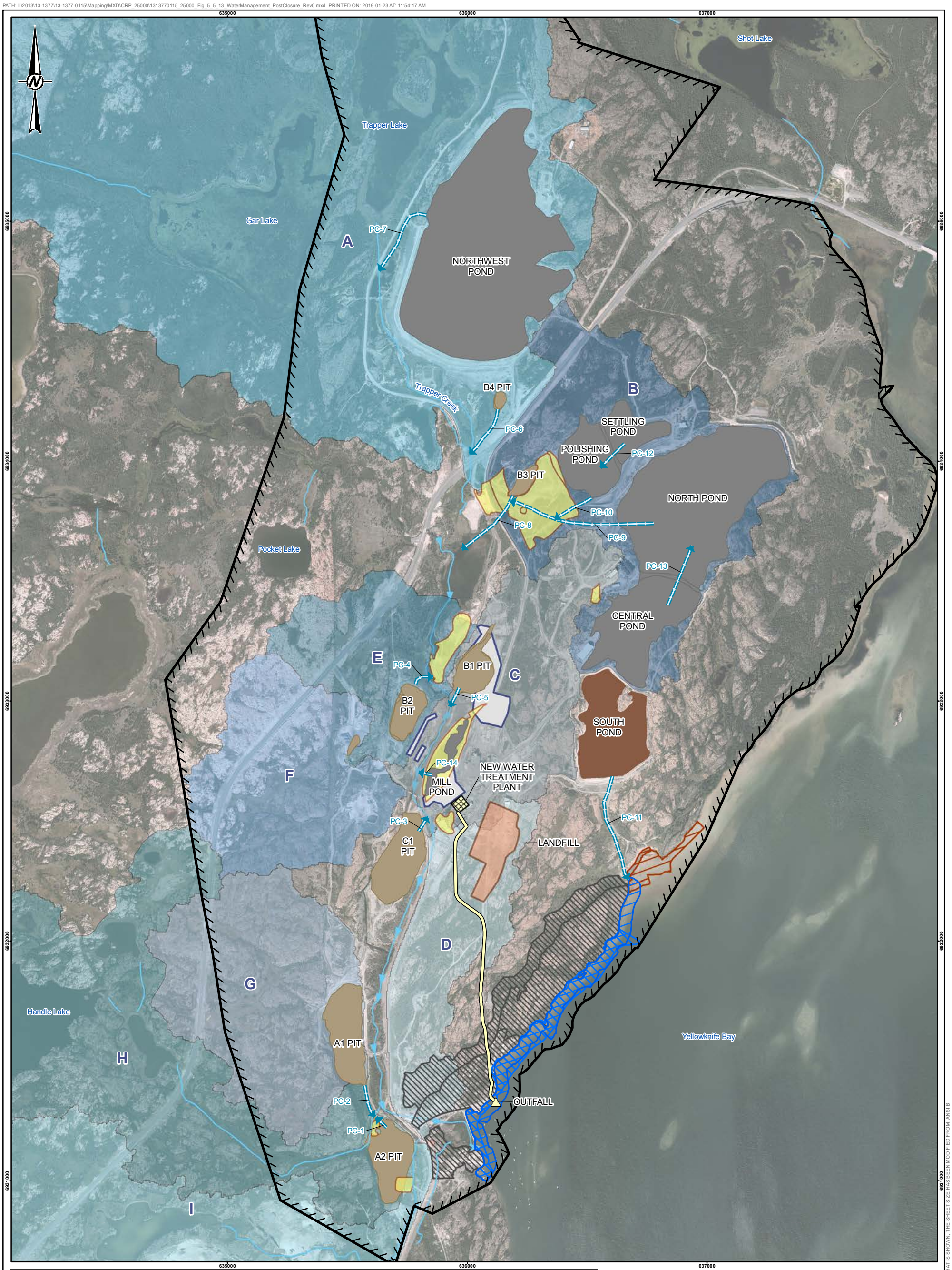
FIGURE 5.5-12

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

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LEGEND

- TREATED EFFLUENT OUTFALL
- GIANT MINE PROJECT BOUNDARY

SURFACE WATER FLOW CONVEYANCE

- DITCH / OUTLET CHANNEL / SPILLWAY
- WATER TREATMENT OUTFALL PIPE
- WATERCOURSE

MINE FACILITIES AT CLOSURE

- APPROXIMATE FORESHORE TAILINGS CAP
- APPROXIMATE SHORELINE CAP
- CAPPED WITH ENGINEERED COVER
- COVERED TAILINGS POND
- CLOSED PIT
- FREEZE PAD
- NON-HAZARDOUS WASTE LANDFILL
- RECLAIMED TAILINGS POND
- WATER TREATMENT PLANT
- REMEDIATED TO RESIDENTIAL SOIL QUALITY STANDARDS

MAJOR WATERSHEDS

A, B, C, D, E, F, G, H, I

0 250 500

1:15,000 METRES

NOTE(S)

PC = POST-CLOSURE

REFERENCE(S)

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YYYY-MM-DD	2019-01-23
DESIGNED	JL
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

POST-CLOSURE WATER MANAGEMENT SYSTEMS

REV. 0

FIGURE 5.5-13

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

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Quality

Post-closure surface drainage quality is expected to be improved, particularly in areas near:

- the mill and other areas with heavily contaminated soils, where soils will be excavated and disposed
- TCAs, which will be covered with a low permeability cover

Surface runoff from reclaimed areas will be monitored during closure and diverted to the underground and ultimately the WTP system until runoff water quality meets proposed runoff quality criteria (CIRNAC and GNWT 2019b), at which point runoff will be released to natural receiving watercourses.

As noted above, construction and operation of alternative technologies (e.g., wetlands) may be used in post-closure to achieve further improvements in runoff water quality; these are the subject of a Reclamation Research Plan (Appendix 5.5-B), with a summary of proposed tasks presented in Section 5.5.6.

5.5.7 Uncertainties

Engineering designs for the closure plan are currently at a conceptual level. As such, the basis for estimates and analyses include engineering judgement. Additional design works are planned to address key assumptions and reduce relevant uncertainties. The important uncertainties that affect Baker Creek and Surface Drainage are summarized below in Table 5.5-6, together with the engineering studies and other activities planned to address these uncertainties.

Table 5.5-6: Baker Creek and Surface Drainage Uncertainties

Uncertainty	Potential Impact of Uncertainty	Plan to Address Uncertainty
The rates of water flow in Baker Creek and corresponding Baker Creek water levels in the channel and flood plain, particularly for extreme runoff events (e.g., the PMF) are uncertain.	The results of the sensitivity analysis (i.e., varying discharges and channel roughnesses by ±20%) may not be conservative enough and fluctuations in water level in Baker Creek may be greater than expected.	Further uncertainty will be reduced by collecting flow and water level data during high flow events after construction of the Baker Creek closure channel.
Surface drainage rates (water quantity) are uncertain. Conservative runoff coefficients were used in the modelling.	The volume of water entering Baker Creek could be greater than expected.	These uncertainties will be addressed during detailed design by including a freeboard allocation in design of conveyance channels and storage features. The limited post-closure infrastructure at the Site will be sited to accommodate runoff from events with return periods greater than would normally be provided for municipal or industrial infrastructure.

Table 5.5-6: Baker Creek and Surface Drainage Uncertainties

Uncertainty	Potential Impact of Uncertainty	Plan to Address Uncertainty
The quality of surface drainage over contaminated areas that have been remediated and the quality of leachate water in areas that have been covered with mixed rock material are uncertain. It was assumed that surface water runoff from remediated areas will be suitable for discharge to Baker Creek (i.e., meet applicable runoff quality criteria) within three years.	Assumptions used in the model may not be conservative, resulting in active management and treatment of surface water for longer than the currently estimated three-year period	Surface runoff on-site will continue to be collected; SNP runoff stations will be established. Leachate analyses using cover materials (e.g., shake flask extractions from materials collected from site) will be completed prior to remediation activities. The feasibility study of passive treatment alternatives for surface runoff is underway, with the objective of reducing overall loadings of arsenic and other contaminants to Baker Creek (Reclamation and Research Plan described in Appendix 5.5-B).
The effect of blasting residuals from remediation activities and borrow extraction on surface runoff quality is uncertain.	Blasting may be a contributor of nitrogen-nutrient concentrations in surface drainage water.	An estimation of nutrient loads from blasting materials to surface runoff will be completed; the necessity of having water quality criteria for nitrogen will be assessed. A Borrow Materials and Explosives Management and Monitoring Plan will be developed.

PMF = probable maximum flood; SNP = Surveillance Network Program.

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Gouvernement des Territoires du Nord-Ouest

GIANT MINE REMEDIATION PROJECT

Closure and Reclamation Plan

January 2019

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CHAPTER 5
Permanent Closure and Reclamation

SECTION 5.6
Tailings Containment Areas

5.6 Tailings Containment Areas

5.6.1 Description

When the Giant Mine was operational, ore was milled and processed, and the resulting tailings were deposited within two TCAs: the Original TCA and the Northwest TCA. The Original TCA includes the North, Central, and South Ponds, as well as the Settling and Polishing ponds. Approximately 16 million tonnes (INAC and GNWT 2010) of tailings were deposited within these TCAs. Tailings were initially deposited into Yellowknife Bay, in an area referred to as the Foreshore Tailings Area. Deposition of the tailings into what became the TCAs started with tailings deposition into lakes and low elevation areas. Over time, storage requirements necessitated the construction of dams in these areas (total of 16 discrete dams by end of mining operation). Tailings deposition ceased in 1999 once milling at the Site ended. The tailings remain on site and are retained by a combination of earthfill dams and higher areas of surrounding topography (Figure 5.6-1). Currently, both of the TCAs are used in the Site's water management process for the storage of water (Section 5.6.2.2.1). Once the new WTP is online, the TCAs will be drained and covered.

Section 5.6 describes the activities planned for the closure and reclamation of the TCAs. These activities include:

- relocation of a portion of the tailings (current South Pond) to reduce the overall footprint of the TCAs
- disposal of the contaminated soils generated by other on-site closure activities into the TCAs (Section 5.4)
- grading and contouring of tailings and contaminated soils within the remaining TCAs to create a stable landform and promote surface water drainage off the TCAs
- stabilization of selected dams to meet applicable Canadian Dam Association (CDA) guidelines
- placement of an engineered cover over the tailings and contaminated soils
- excavation of spillways to drain surface water runoff from the covered TCAs
- extension of the existing cover at the Foreshore Tailings Area

Tailings not purposely deposited in the TCAs or the Foreshore Tailings Area, for example, tailings displaced on site due to a historical spill, are discussed in Section 5.4.

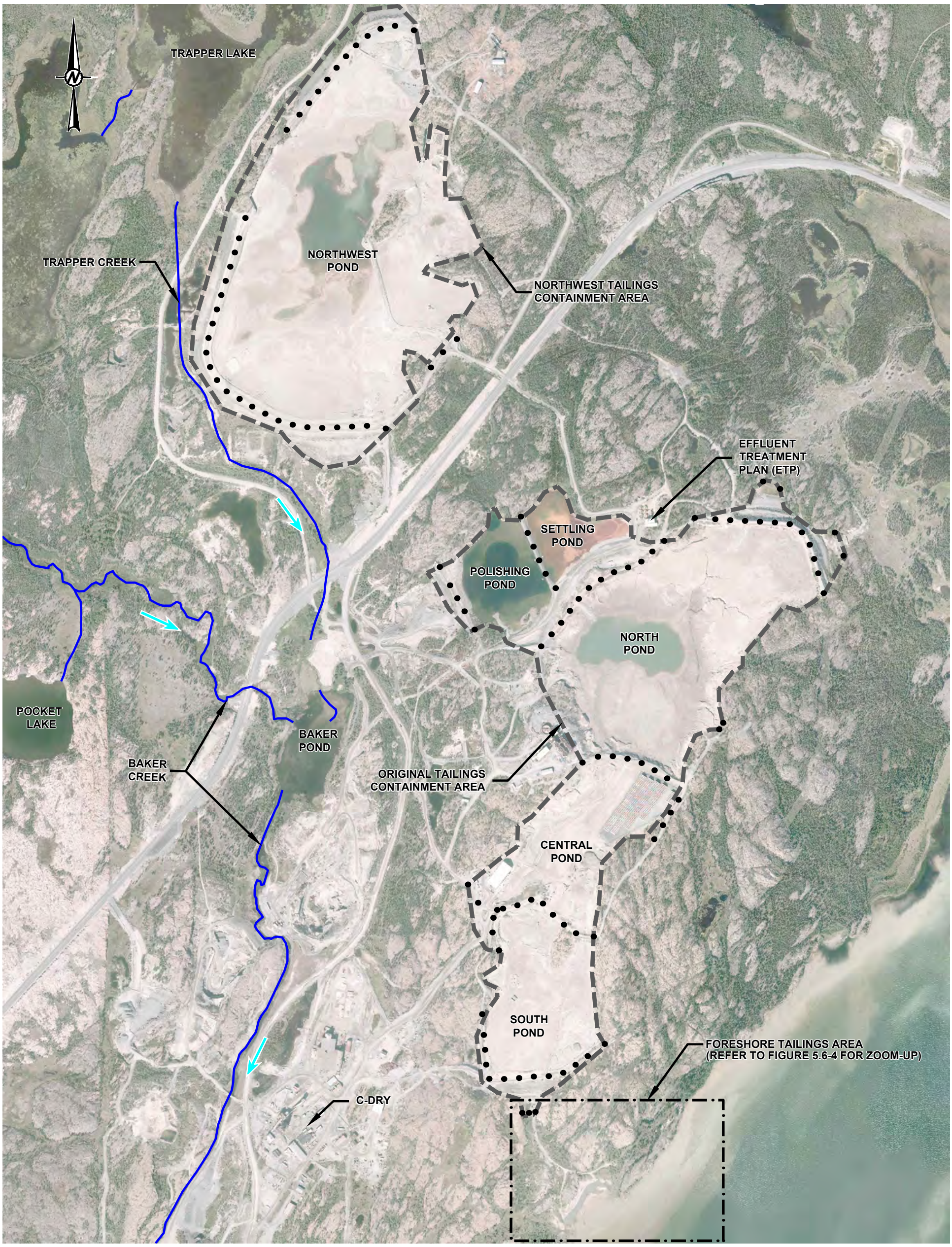
The CDA guidelines are referenced throughout this chapter. The CDA guidelines are recognized as one of the best available references for dam safety and are widely used across Canada and around the world. These guidelines are used by the MVLWB in the regulation of tailings dams.

5.6.1.1 Original Tailings Containment Area

As shown in Figure 5.6-1, the Original TCA is located east of Baker Creek and to the west of Yellowknife Bay. The footprint of the TCA is roughly 60 ha (Appendix 5.6-A) and is estimated to contain roughly 5 million m^3 of tailings (Appendix 5.6-B; SRK 2005b). Overall, the TCA is made up of five separate ponds that are divided by dams or dykes:

- North Pond
- Central Pond
- South Pond
- Settling Pond
- Polishing Pond

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LEGEND

- WATERCOURSE
- WATERCOURSE FLOW DIRECTION
- FOOTPRINT OF TAILINGS CONTAINMENT AREAS (APPROXIMATE)
- EARTHFILL DAMS (APPROXIMATE CREST ALIGNMENT)
- FORESHORE TAILINGS AREA

0 250 500
1:10,000 METRES

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TAILINGS CONTAINMENT AREA AND FORESHORE TAILINGS AREA LOCATION PLAN

REV. 0

FIGURE 5.6-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25 mm
0

The approximate surface area and volume of retained tailings is summarized for each of the Original TCA ponds in Table 5.6-1.

Table 5.6-1: Summary of Surface Area and Retained Tailings – Original Tailings Containment Area

TCA	Pond	Surface Area (ha)	Tailings or Sludge Retained (m^3)	Source
Original	North	29	2,200,000	Golder (2017e)
	Central	13	1,200,000	Golder (2017e)
	South	9	950,000	Golder (2017e)
	Settling	4	205,000	SRK (2005b)
	Polishing	5	234,000	SRK (2005b)
Total		60	4,789,000	

TCA = Tailings Containment Area.

At the perimeter of the Original TCA, there are several external dams. As shown in Figure 5.6-2, these are Dams 1 through 3 (Polishing and North ponds) and Dams 7 through 12 (South and Central ponds). These dams vary in height and length, but at 10 to 15 m high, Dams 1, 3, and 11 are the highest dams in the Original TCA (Golder 2005a).

Within the Original TCA perimeter, several dams and dykes divide the ponds (Figure 5.6-2):

- Dam 2 divides North Pond from the Settling and Polishing ponds.
- Dyke 6 divides North and Central ponds.
- Dams 4 and 5 divide the Central and South ponds.
- The splitter dyke divides the Settling and Polishing ponds.

Dyke 6 and the splitter dyke are not designed to retain water, as they are constructed of permeable rockfill and/or mine muck (Geocon 1983a). These dykes were constructed to retain solids and assist with clarification of water within the TCA.

5.6.1.2 Northwest Tailings Containment Area

As shown in Figure 5.6-1, the Northwest TCA is located north of Baker Pond and to the west of the relocated Ingraham Trail (Highway 4). The Northwest TCA has a surface area of roughly 44 ha (INAC and GNWT 2010) and is estimated to contain 5 million m^3 of tailings (SRK 2005b). The Northwest TCA was constructed in 1987 to increase the available storage capacity for the site (INAC and GNWT 2010).

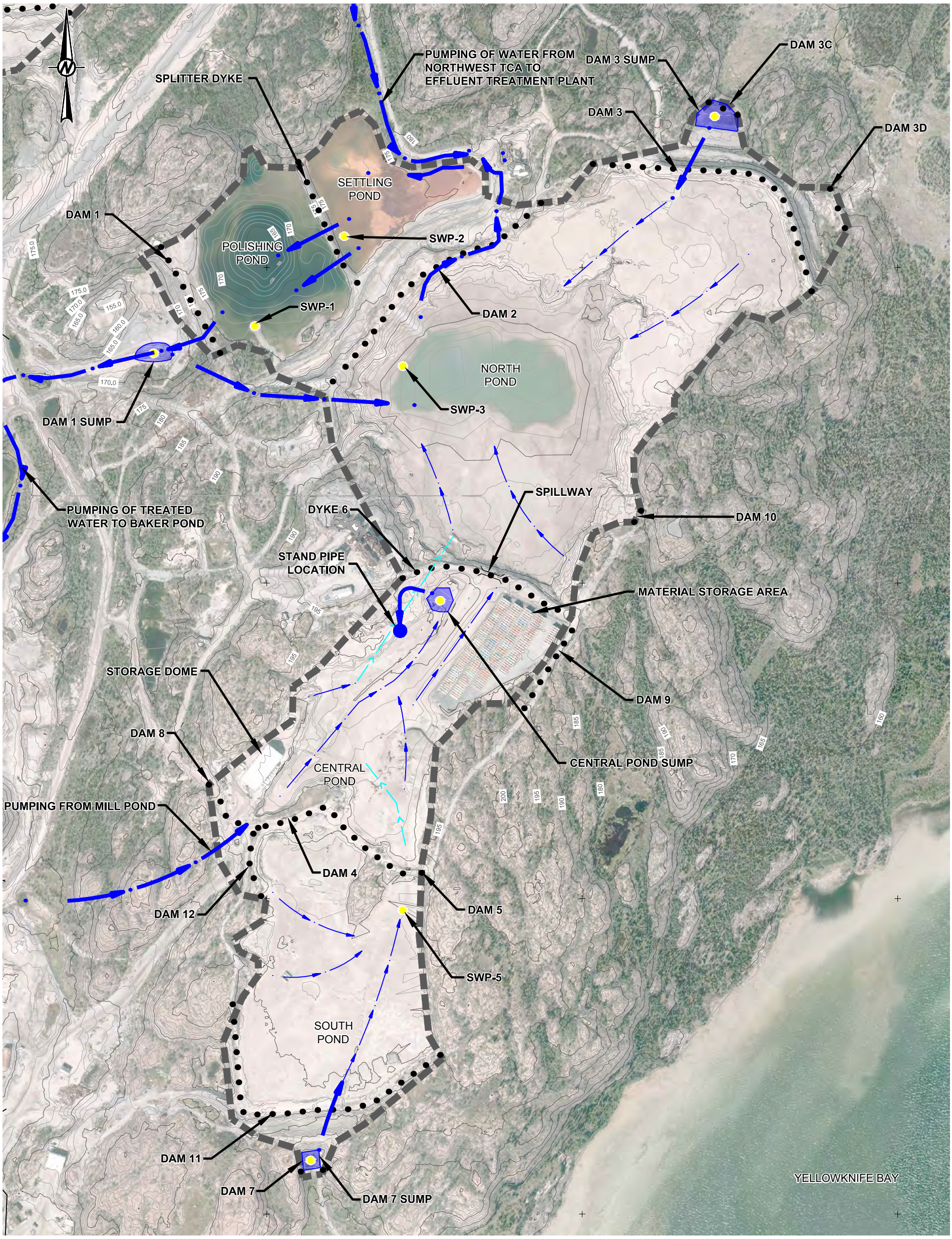
The Northwest TCA consists of perimeter dams and local topographic highs. The perimeter dams are constructed of earthfill and, as shown in Figure 5.6-3, they are generally located at the north and south extents of the Northwest TCA. Bedrock outcrops are located along a portion of the western perimeter and along almost the entire eastern perimeter. Dam 21, which is made up of four sub-sections designated 21A through 21D, is located along the southern perimeter of the TCA, while Dam 22 (made up of sub-sections 22A and 22B) is located along the north perimeter. All of the perimeter dams have maximum vertical heights of between 12 and 15 m (Golder 2005a).

5.6.1.3 Foreshore Tailings Area

As shown in Figure 5.6-1, the Foreshore Tailings Area is located on the shore of Yellowknife Bay, south of the Original TCA. Prior to the early 1950s, between 300,000 and 375,000 t of tailings were purposefully deposited in the area, with approximately 35% of the tailings located above water level in Yellowknife Bay (SRK 2004; INAC and GNWT 2010). Tailings deposition in the area was suspended during early operations and re-directed to the area upstream of the present-day Dam 1 (Golder 2001a).

In 2001, remedial works were carried out on the tailings located along the shoreline in the Foreshore Tailings Area. The extent of the cover placed (approximately 2,500 m^2) is shown in Figure 5.6-4. The cover consists of a coarse rock layer, underlain by gravel, and a non-woven geotextile. The objective of this work was to extend the physical barrier between the tailings and the waters of Yellowknife Bay in order to reduce the potential for further erosion and minimize further dispersion of tailings into Yellowknife Bay.

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LEGEND

- 195 — MAJOR EXISTING GROUND CONTOURS @ 5 m INTERVALS
- MINOR EXISTING GROUND CONTOURS @ 1 m INTERVALS
- FOOTPRINT OF TAILINGS CONTAINMENT AREAS (APPROXIMATE)
- EARTHFILL DAMS (APPROXIMATE CREST ALIGNMENT)
- WATER QUALITY MONITORING LOCATION
- GRAVITY FLOW VIA PIPELINE
- DIRECTION OF ACTIVE PUMPING
- DIRECTION OF SURFACE WATER FLOW
- SUMP LOCATION

0 100 200
1:6,000 METRES

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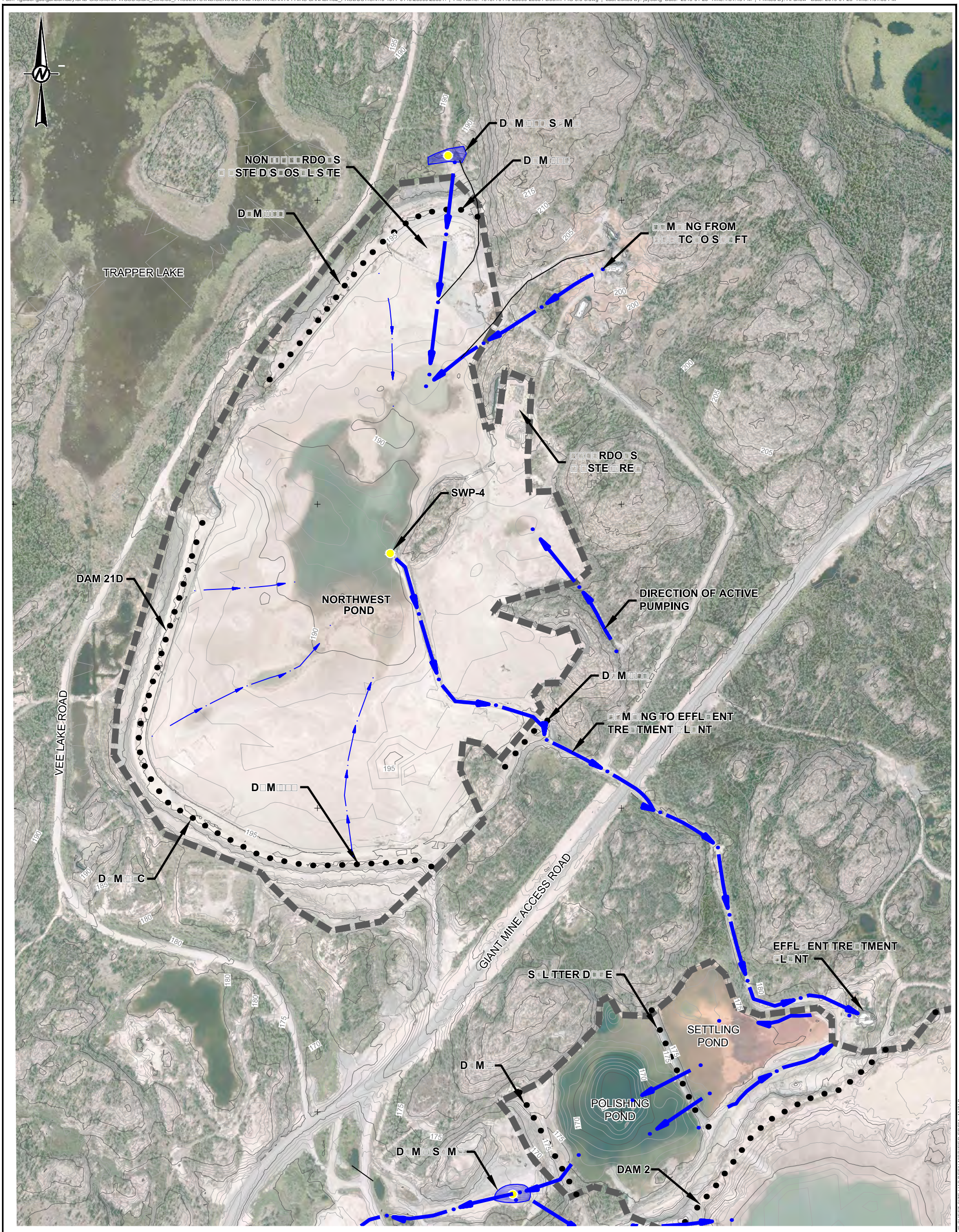
ORIGINAL TAILINGS CONTAINMENT AREA EXISTING CONDITIONS

REV. 0

FIGURE 5.6-2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
0 25 mm

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LEGEND

- 195 — MAJOR EXISTING GROUND CONTOURS @ 5 m INTERVALS
- MINOR EXISTING GROUND CONTOURS @ 1 m INTERVALS
- FOOTPRINT OF TAILINGS CONTAINMENT AREAS (APPROXIMATE)
- EARTHFILL DAMS (APPROXIMATE CREST ALIGNMENT)
- WATER QUALITY MONITORING LOCATION
- DIRECTION OF ACTIVE PUMPING
- DIRECTION OF SURFACE WATER FLOW
- SUMP

0 100 200
1:6,000 METRES

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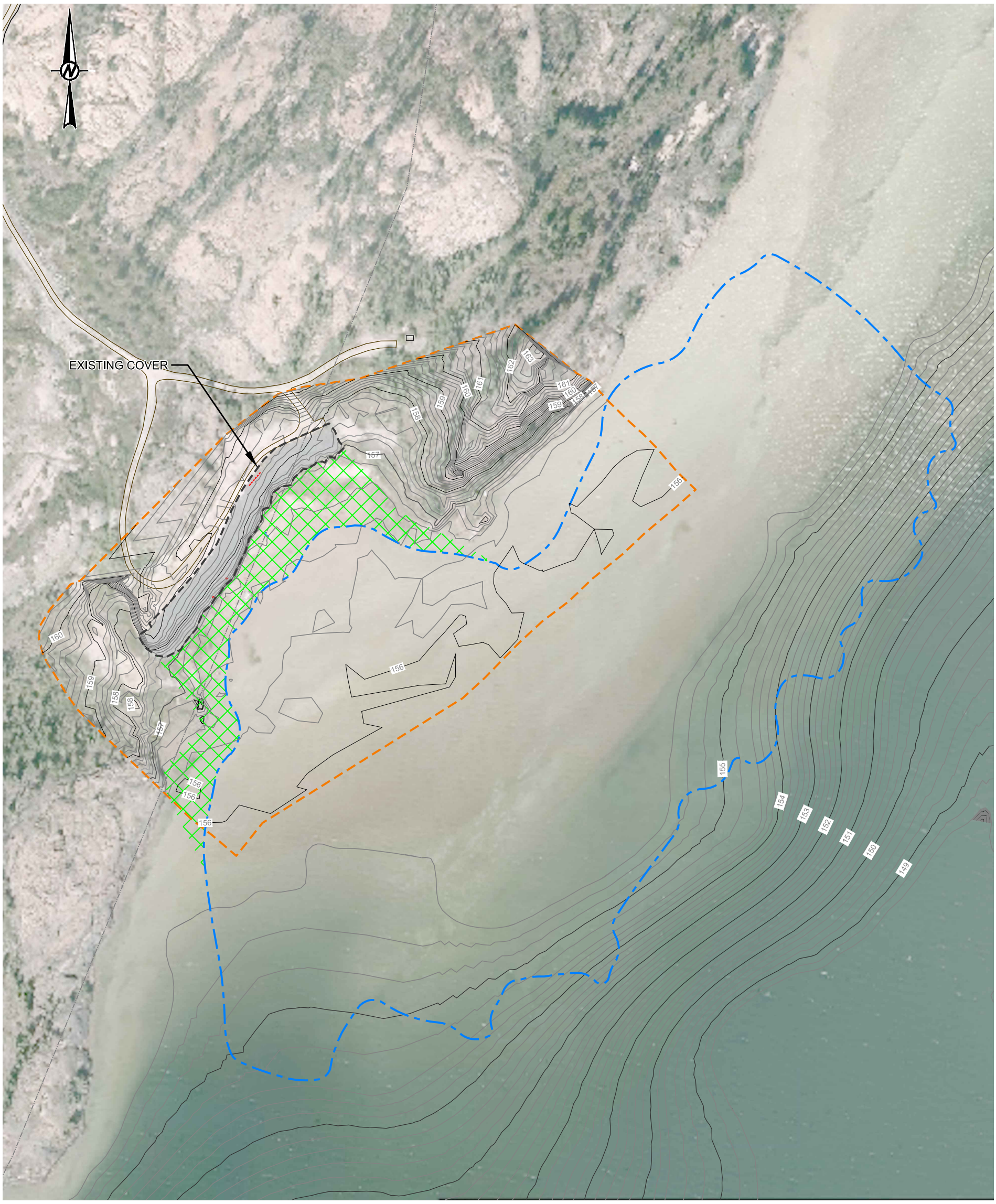
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NORTHWEST TAILINGS CONTAINMENT AREA EXISTING CONDITIONS

REV. 0
FIGURE 5.6-3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
0 25 mm



LEGEND

- 195 — MAJOR EXISTING GROUND CONTOURS @ 5 m INTERVALS
- MINOR EXISTING GROUND CONTOURS @ 1 m INTERVALS
- 2014 SURVEY BOUNDARY
- EXTENT OF EXISTING COVER (APPROXIMATE)
- EXTENT OF SUBMERGED TAILINGS (SEE REFERENCE 1)
- ROADS
- APPROXIMATE EXTENT OF EXPOSED TAILINGS (SEE NOTE 1)

0 50 100
1:2,000 METRES

NOTE

1. EXPOSED TAILINGS SHOWN IS BETWEEN TOE OF EXISTING COVER (157.0 m) AND THE 1 IN 2 YEAR OPEN WATER LOW (156.4 m). AREA IS APPROXIMATE.

REFERENCE

1. SRK CONSULTING. 2007. GIANT MINE REMEDIATION PLAN. FIGURE 3.6.1., "APPROXIMATE LIMIT OF TAILINGS AND ARSENIC IN LAKE SEDIMENTS".

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FORESHORE TAILINGS AREA - EXISTING CONDITIONS

REV. 0

FIGURE 5.6-4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm

0

5.6.2 Pre-disturbance and Existing Site Conditions – Original and Northwest Tailings Containment Areas

Prior to mining activities at the site, the rolling natural terrain included numerous low-lying areas with bogs, wetlands and lakes, as shown in Figure 5.6-5. Tailings containment areas were constructed in selected low-lying areas, as well as being discharged to the area now known as the foreshore tailings area. At closure, tailings areas will be relocated or contoured as required to establish final drainage patterns, and covered.

5.6.2.1 Pre-disturbance Conditions

The TCAs were constructed in lakes, bogs, wetlands, and low-lying areas. The construction of the TCAs altered local drainage patterns. The original drainage patterns directed most flow to Baker Creek or its tributaries, with the area that is now the South Pond area draining directly to Yellowknife Bay. Interpretation of historical aerial photography (SRK 2005a) supported by recent geotechnical drilling in the Original TCA area confirmed that the substrate below the TCA was variable and largely contained recent organics and fine-grained lacustrine silts and clays. The pre-development terrain largely contained lakes, bogs, and vegetation, with some bedrock outcrops. In Figure 5.6-5, the TCAs are superimposed onto an aerial photograph that shows the pre-disturbance conditions (SRK 2005a).

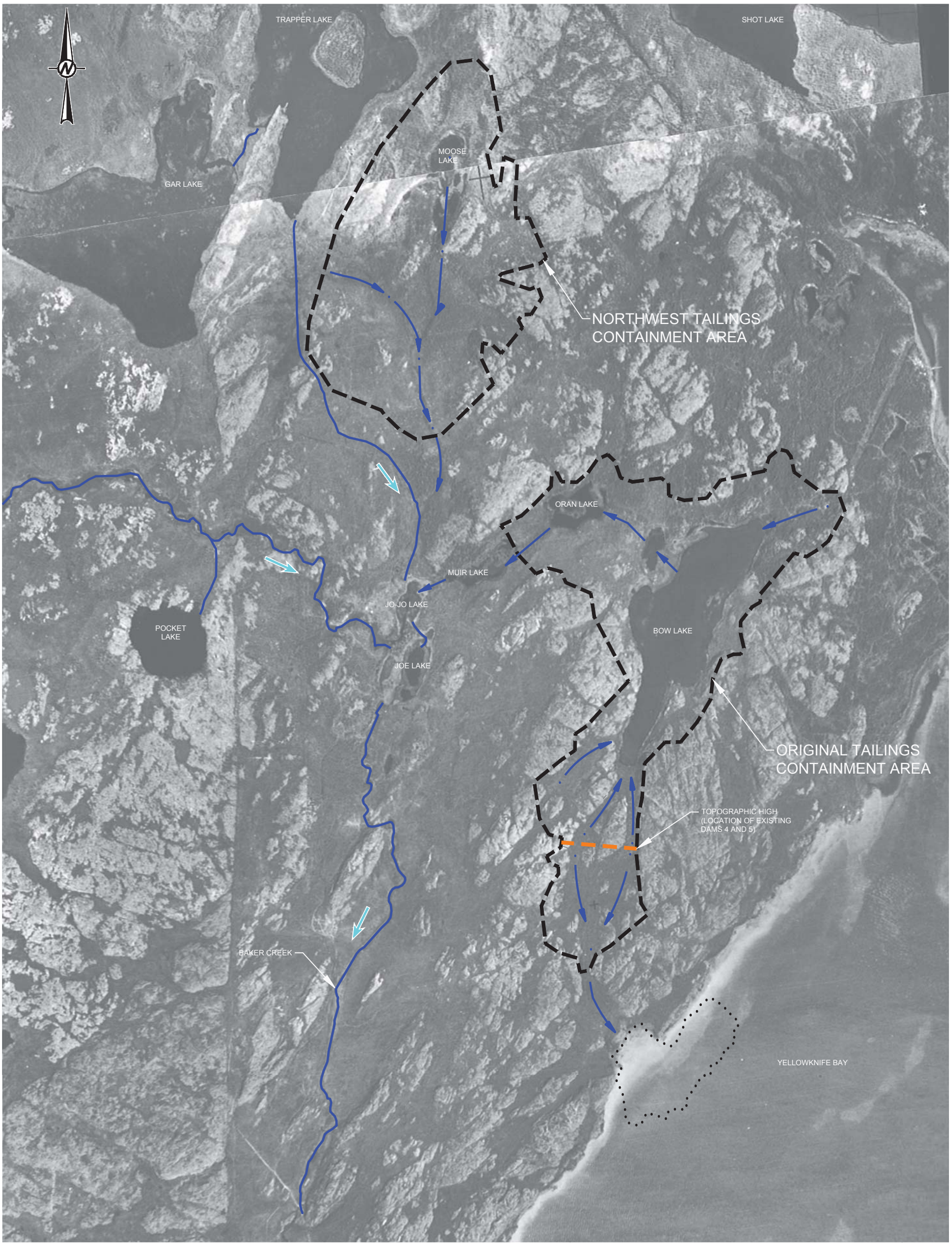
Prior to the placement of tailings and construction of the dams, the South Pond area drained to Yellowknife Bay, while all remaining Original TCAs drained into Baker Creek (Geocon 1983b), as shown in Figure 5.6-5. A topographic high between what is now the South and Central pond areas acted as a drainage or surface water flow divide.

At the south of the Original TCA, a topographic high exists (where Dams 4 and 5 are now located), where surface water runoff flowed north into the area now known as the Central and North ponds (Bow Lake), and eventually into what is now the area of the Settling and Polishing ponds (Oran Lake). Prior to Mine development, all of these areas drained into Baker Creek from a watercourse that flowed southwest, perpendicular to the alignment of Dam 1.

Within what is now the Northwest TCA, surface water drained south towards Jo-Jo Lake and then to Joe Lake. Joe Lake is now referred to as Baker Pond. To the west of the Northwest TCA, what is presently known as Trapper Creek appears to have flowed towards the pre-disturbance footprint area.

Geotechnical drilling of the North, Central, and South ponds in 2016 provided additional data on the pre-existing conditions under the TCAs. This stratigraphy typically consisted of organics, clay, and silt, overlying bedrock in order of increasing depth below bottom of tailings. In some locations, till was encountered, overlying the bedrock. The till was granular, consisting of a mixture of gravel, sand, and fine-sized particles. Some areas of what are now TCAs had bedrock with no soil cover, which was consistent with observations made from viewing the historical air photos.

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LEGEND

- WATERCOURSE
- WATERCOURSE FLOW DIRECTION
- DIRECTION OF SURFACE WATER FLOW (APPROXIMATE) (SEE NOTE 1)
- EXISTING FOOTPRINT OF TAILINGS CONTAINMENT AREAS (APPROXIMATE)
- EXISTING FOOTPRINT OF FORESHORE TAILINGS AREA (APPROXIMATE)

NOTE

1. DIRECTION INTERPRETED FROM PHOTOGRAPHY.

0 250 500

1:12,500 METRES

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TAILINGS CONTAINMENT AREAS AND FORESHORE TAILINGS AREA PRE-DISTURBANCE CONDITIONS

REV. 0

FIGURE 5.6-5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
0 25 mm

5.6.2.2 Existing Conditions

The existing conditions at the Original and Northwest TCAs are shown in Figures 5.6-2 and 5.6-3. As noted above, the TCAs contain tailings and water, with selected areas used for the storage of additional materials and mine waste. The tailings impoundments are bound by earthfill dams and local topographic highs. Seepage collection sumps downstream of selected dams form an integral part of the current TCAs and site water management system.

This section provides a description of the existing tailings topography and the resulting surface water runoff regime, including the current approach to water management for the TCAs and the use of the TCAs in support of water treatment. None of the TCAs currently incorporate emergency overflow spillways, as all water is treated prior to discharge into the receiving environment. This section also provides a discussion of the current state of the dams, including both perimeter and internal dams. The framework for this discussion of the current state of the dams is based on the current dam consequence classifications (Table 5.6-2), which have been assigned using the CDA (2013) guidelines. At the end of this section, a brief summary of the geotechnical and geochemical characterization of the tailings is also provided.

Surface Water Management

Surface water management is described below for each TCA, including operation of the associated seepage collection sumps and the use of selected TCAs in the current water treatment process.

Original TCA – North, Central, and South Ponds

Under current operating conditions, water within the North, Central, and South ponds flows in the direction of a depression in the North Pond. Within the South Pond, the tailings topography slopes to the northeast in the direction of a small pond of water, located south of Dam 5. From this small pond of water, roughly 20 m by 50 m depending on the time of year, water can flow into the Central Pond via a culvert, and then flows into Central Pond via a buried pipeline, as shown in Figure 5.6-2.

In the Central Pond, the defining feature is a swale excavated in the middle of the pond and sloped to the north. This swale collects water from the southwest and southeast corners of the pond and conveys it to an unnamed temporary sump located south of Dyke 6. The water collected in the sump is conveyed into the North Pond via gravity through a standpipe. Due to stability concerns with Dyke 6, pumping is used rather than a spillway to convey water to the North Pond (Golder 2017d). There is a smaller catchment within the Central Pond (around the material storage area) where lesser flows are conveyed over Dyke 6 into the North Pond by a ditch and spillway.

All water flowing to the North Pond gathers into a depression that contains water year-round. This depression is the dominant hydrological feature of the area and is a relic of a hydraulic tailings mining program that was conducted between 1988 and 1990 (Silke 2009). To the north and south of the depression are steep slopes consisting of consolidated tailings or mine muck. At the north side, there is a near vertical escarpment of tailings measuring 4 to 6 m in height. All surface water runoff north of this escarpment flows southward, towards the depression. At Dyke 6 on the south perimeter of the North Pond (the boundary with the Central Pond), there is a steep slope up to 10 m in height. The stability of both Dyke 6 and this steep tailings escarpment is marginal. Seepage through Dam 2 towards the Settling and Polishing ponds area is believed to occur. To protect the stability of Dam 2, the difference in water surface elevation between the North Pond and the Settling and

Polishing ponds is managed to limit the hydraulic gradient across the dam (Golder 1999). During care and maintenance, this has required ongoing monitoring and control of water levels on both sides of Dam 2.

There are currently two TCA water quality monitoring stations in the North, Central, and South ponds area:

- SWP-3—west shore of the North Pond TCA
- SWP-5—northeast shore of the South Pond TCA

Further details regarding the Site's water monitoring program are provided in the Water Management and Monitoring Plan (CIRNAC and GNWT 2019a).

Original TCA – Settling and Polishing Ponds

The Settling and Polishing ponds are currently used as part of the Site water treatment system. Following treatment in the ETP, water is discharged into the Settling Pond, where an arsenic precipitate is permitted to settle, forming a material referred to as a sludge. The sludge accumulates in the Settling Pond, where it overlies previously deposited tailings. To increase the storage capacity of the Settling Pond, sludge was excavated in 2015 below the typical operating water level. Excavated material was placed within its existing footprint (Golder 2016b).

Water from the Settling Pond is transferred to the Polishing Pond, either by gravity seepage through the splitter dyke or by pumping. The splitter dyke is a rockfill causeway that separates the Settling Pond from the Polishing Pond. The Polishing Pond provides further retention time for additional suspended solids removal. Water from the Polishing Pond is actively discharged to Baker Pond via a syphon once it meets surface water runoff criteria. Additional details on the water treatment process are found in Section 5.8.

The Polishing Pond surface area is covered with water year-round. The Settling Pond is generally free of water when not used in the water treatment process during the summer months, with the exception of an area of roughly 4,000 m^2 (roughly 10% of the pond's surface area) beside the splitter dyke.

Water levels in the ponds are actively monitored and controlled, with the maximum allowable water levels defined based on CDA (2013) guidelines for the assessment of minimum allowable freeboard. Maximum allowable elevations are reviewed annually based on updated survey data and the inspection of a qualified Professional Engineer. The sludge surface in the Settling Pond slopes to the southwest in the direction of the Polishing Pond, with an average slope of less than 1%. Based on bathymetry from 2002 (Golder 2002a), the tailings surface in the Polishing Pond slopes between 5% and 20%. As shown in Figure 5.6-2, the slope is shallowest at the perimeter of the pond (between 5% and 10%). The minimum elevation of sludge/solids in the pond is at approximately 165 m, 9 m below the pond's current maximum permissible water elevation of roughly 174 m.

There are currently two TCA water quality monitoring stations in the Settling and Polishing Pond area:

- **SWP-1**—Polishing Pond, west side of the splitter dyke between the Settling Pond and Polishing Pond; perimeter samples are also collected from 10 sites (SWP-1A to SWP-1J) around the perimeter of the Polishing Pond
- **SWP-2**—Settling Pond, east side of the splitter dyke between the Settling Pond and Polishing Pond

Original TCA – Perimeter Sumps

As shown in Figure 5.6-2, three perimeter sumps (SMPs) are used to manage seepage from the Original TCA:

- **SMP-1**—located south of the South (Dam 11) Pond, retained by Dam 7
- **SMP-3**—located on the north side of North Pond (Dam 3), retained by Dam 3C
- southwest of the Polishing Pond (Dam 1), collected in a depression east of B3 Pit (recently designated as SMP-4)

Seepage from the sumps at Dam 1 and Dam 3 (SMP-3) is pumped to the North Pond. Water from Dam 11 (SMP-1) is pumped to the South Pond.

During annual inspections between 2013 and 2017, no active seepage flow has been observed to collect in SMP-1 or SMP-3. Occasional seepage has been collected from the south abutment of Dam 1, with seepage observed during annual dam inspections in two recent years (2013 and 2015).

Northwest TCA

The Northwest TCA is currently used in the Site's water treatment process. During the fall and winter months, water from the underground is pumped into the Northwest Pond for storage. In summer (typically through July and August), water is pumped from the Northwest Pond to the existing ETP (Figure 5.6-3) for treatment.

The tailings surface of the Northwest TCA is sloped towards the centre of the TCA (Figure 5.6-3). Generally, the tailings slopes range from 0.5% to 5% on the beaches (portion above water). Below water, based on a combination of 1998 (Royal Oak Mines Inc. 1998) and 2002 (Golder 2002a) bathymetry, the tailings slopes range from 5% to 12%. Incident precipitation falling within the TCA flows towards the centre of the TCA and/or infiltrates into the tailings and then to the underground.

A single sump is located at the north of the TCA, downstream of Dam 22B (SMP-2). Water collected at the sump is pumped over the crest of Dam 22B, back into the Northwest Pond. Active seepage from Dam 22B has not been observed during recent annual inspections, including the five-year period from 2013 to 2017.

There is currently one TCA water quality monitoring station in the Northwest Pond area, SWP-4, located on the east shore in the Northwest TCA.

Non-tailings Waste Storage in Tailings Containment Areas

Four areas within the TCAs currently store waste materials that are not tailings (Figures 5.6-2 and 5.6-3):

- Central Pond
  - material storage area (temporary)
  - storage dome (temporary)
- Northwest Pond
  - hazardous waste storage area (temporary)
  - non-hazardous waste disposal site (permanent)

The material storage area, located in the northeast corner of the Central Pond, contains steel shipping containers which store arsenic-contaminated waste resulting from the demolition of the roaster in 2013. A laydown pad of granular material, covering an area of approximately 20,000 m^2, was placed on the tailings surface prior to placement of the shipping containers. A chain link fence encloses the entire area. Final disposal of these containers and their contents outside of the TCAs is described in Section 5.10.

The storage dome is a temporary steel and synthetic shelter used to store excavated tailings in support of paste production for underground backfilling and stabilization. Similar to the material storage area, this area includes a granular laydown pad. The superstructure over the pad area will be removed as part of final closure activities, following completion of the paste production activities.

The hazardous and non-hazardous waste storage areas are both located in the Northwest Pond and are described in Section 5.10. The non-hazardous waste is buried in the tailings south of Dam 22B. The non-hazardous materials generally consist of inert wastes such as demolition rubble and surface debris. The hazardous waste area, which is another temporary storage location, contains petroleum products, mill process materials, mercury, and amended paint material.

Management and final disposal of the non-tailings solid wastes currently stored in the tailings ponds is discussed in the Waste Management and Monitoring Plan (CIRNAC and GWNT 2019b).

Dam Stability

Dams that retain tailings at the Site vary in height, length, and CDA classification. The locations of the dams are shown in Figures 5.6-2 and 5.6-3, and a summary of the dams that form part of the TCAs is provided in Table 5.6-2. This table also includes a summary of the consequence of failure classification for each TCA dam under existing conditions, based on CDA (2013) guidelines. These classifications were assessed considering a hypothetical dam breach and the projected impact on life and environment.

Table 5.6-2: Summary Tailings Containment Area Perimeter Dam Classifications

TCA	Dam	Approximate Dimensions[a]		Classification[b]
		Maximum Height (m)	Length (m)	
Original	Dam 1	9	275	High
	Dam 2	12[c]	365	High
	Dam 3 (A & B)	15	460	Significant
	Dam 3C	2	45	Low
	Dam 3D	4	30	Low
	Dam 4 (A & B)	2	75	Low
	Dam 5	2	50	Low
	Dyke 6	9	245	Low
	Dam 7	3	15	Low
	Dam 8	3	75	Low
Original	Dam 9	2	75	Low
	Dam 10	4[d]	60	Low
	Dam 11	15	425	Significant
	Dam 12	5	60	Low
	Splitter dyke	4	200	Low

Table 5.6-2: Summary Tailings Containment Area Perimeter Dam Classifications

TCA	Dam	Approximate Dimensions[a]		Classification[b]
		Maximum Height (m)	Length (m)	
Northwest	Dam 21A	11	90	High
	Dam 21B	15	245	
	Dam 21C	15	275	
	Dam 21D	12	365	
	Dam 22A	12	245	
	Dam 22B	12	185	

(a) Source: Golder 2005a.
(b) Source: Golder 2015.
(c) Before majority of dam cross-section was removed in 1991.
(d) Before majority of dam cross-section removed.

TCA = Tailings Containment Area.

As shown in Table 5.6-2, under current operating conditions, all Northwest TCA dams are classified as High consequence. For the Original TCA, Dams 1 and 2, which both retain water, are also classified as High consequence. Dams 3 and 11, which retain consolidated tailings in the North and South ponds, respectively, are classified as significant consequence.

In the stability review (Golder 2015), numerical modelling was carried out on dams with a classification of High or greater. Based on the assumptions used in the models, the factors of safety for Dam 2 and Dam 21A did not satisfy CDA guidelines (CDA 2013) and would require improvements if they were to continue to function in the long term under current operating conditions.

As part of the ongoing care and maintenance of the Site, the dams at the site are inspected annually by a Professional Engineer. Recent observations from these inspections indicated minor sloughing of a downstream bench of Dam 21D. Although Dam 2 has shown signs of instability in the past, no indicators of slope movement have been observed during annual geotechnical inspections since at least 2001. Recent observations from these inspections have also indicated ongoing settlement of Dam 1. While the factor of safety calculations mentioned above (Golder 2015) were satisfactory, the calculated factor of safety is primarily related to horizontal movements and does not address the observed vertical settlements.

Geotechnical Characterization of Tailings

Geotechnical studies to characterize the tailings were carried out between 2000 and 2016. Geotechnical investigations within the North, Central, South, Settling, and Northwest ponds included both test pits and drilling (SRK 2007; Golder 2011, 2012b, 2017e).

Tailings were hydraulically deposited (slurry) within the TCAs from spigots located at the perimeter of the dams. Exact locations and elevations of the spigots changed frequently as deposition progressed. This deposition method typically results in segregation of tailings, with the coarsest particles settling out first, nearest to the spigot location (i.e., beach tailings), and the finer particles settling out farther from the spigot point. The finest tailings settle within the ponded water (i.e., pond tailings). The combined effect of frequent changes of spigot locations and the segregation of tailings is a variable distribution of grain sizes throughout the deposit.

The tailings in the TCAs are typically classified as a sandy silt to a silt with some sand, using the Unified Soil Classification System (Appendix 5.6-C). The particle size of the tailings solids typically ranges from a medium-grained sand (particle diameter of 2 mm or less) to clay-sized (particle diameter of 0.002 mm or less). Typically, the tailings are non-plastic and, therefore, the fine-grained particles (particle diameter of 0.075 mm or less) are considered a non-plastic silt. However, there are some instances of low plasticity silt behaviour (Appendix 5.6 C).

Due to the deposition method described above, the geotechnical characterization of the tailings can be broadly sub-grouped according to one of three zones: beach, transition, and pond tailings. Coarser tailings that were deposited near spigot locations (i.e., beach tailings) would mostly contain sand-sized particles and thus be described as a silty sand. Within the ponds (i.e., pond tailings), the tailings would primarily contain fine-grained particles and be described as silt with trace to some sand. Between the beach and pond tailings, a transition zone would contain a range of particle size distributions would have sand and silt mixtures in different proportions and range from descriptions of either beach or pond tailings, or some intermediate description (e.g., silt and sand).

A water table (phreatic surface) is present throughout the TCAs, and the stiffness of the tailings is related to the location of the tailings above or below that water table (Appendix 5.6C). In the South and Central Ponds, the water table is between 4 to 8 m below the tailings surface (Golder 2017e). Within the North Pond, the depth ranges from roughly 1 m in close proximity to the water, to 4 to 12 m in the northern perimeter in the vicinity of Dam 3 (Golder 2017e). Above the water table, the consistency of the tailings would be described as firm to stiff based on standard penetration testing blow counts (Appendix 5.6 C). In contrast, below the water table, the consistency of the tailings is soft to very soft.

The TCAs are located within a broader climate zone where discontinuous permafrost can be expected, as described in Chapter 2. However, drilling investigations in the North, Central, and South ponds in 2015 (Appendix 5.6-C) suggest that the distribution of frozen tailings within the deposit is limited. In 21 boreholes distributed through the three ponds, frozen soils were encountered in only two boreholes. The frozen soil that was encountered was located at 4.5 m below the top of tailings and was not continuous to the base of the profile.

Geochemical Characterization of Tailings

The primary basis for geochemical characterization of the tailings was from work conducted in 2001 (Golder 2001b), on samples from the North, Central, South, and Northwest ponds. Analysis of tailings samples included characterization of major and trace element chemistry, soluble constitutes, acid rock drainage (ARD) potential, and mineralogy. Additional characterization work was carried out since the 2001 study (Andrade et al. 2010; Fawcett et al. 2015; Walker et al. 2015; Appendix 5.6-C), and results were comparable to Golder (2001b).

Typical arsenic concentrations in the tailings are approximately 2,000 to 4,000 mg/kg, with a few samples in the 5,000 mg/kg range. Generally, only a small proportion of arsenic in the tailings is water-soluble, an average of 0.2% by weight. From short-term leaching tests conducted on 33 tailings samples, average dissolved arsenic in the leachate was 1.3 mg/L, with a range from 0.26 to 9.4 mg/L (Appendix 5.6-C). Mineralogy of the tailings typically consists of quartz and carbonate minerals, with a small proportion of sulphides, including arsenopyrite. Roaster products, or calcine, are also present in samples.

The 2016 geochemical investigations of the North, Central, and South ponds (Appendix 5.6-C) identified that in addition to arsenic, the tailings are enriched in antimony, cadmium, lead, and sulphur relative to natural crustal abundances. Analytical results showed that measured concentrations varied not only among ponds, but among boreholes located within the same pond.

5.6.3 Pre-disturbance and Existing Site Conditions – Foreshore Tailings Area

5.6.3.1 Pre-disturbance Conditions

Limited information exists on the pre-disturbance conditions at the Foreshore Tailings Area. The area is a small, cove-like area of Yellowknife Bay. Historical aerial photography, as shown in Figure 5.6-5, indicates that the topography in the area was flat in relation to bedrock outcrops located to the north and south, with a rocky and sandy shoreline. The natural topography where South Pond is currently located drained into Yellowknife Bay in this area. Based on the flat topography and drainage location, the beach pre-dating the Foreshore Tailings Area was likely to have consisted of fine-grained soils such as of silt, clay, sand, and mixtures thereof, although no records or investigations that confirm this are known to exist. Water and sediment quality would have been uncontaminated in pre-disturbance conditions. Sediment cores from this area show that the sediment underlying the present-day tailings has low arsenic concentrations (Chételat et al. 2017).

5.6.3.2 Existing Conditions

Physical Setting

Tailings are present in the beach area of the Foreshore Tailings Area and extend out radially from the shoreline into the bay. The tailings range in thickness from 0.5 and 1.7 m (Golder 2005b). There is an engineered cover present over tailings in the beach area which was installed in 2001 (Golder 2001a). The cover was placed to form a physical barrier between the tailings and the waters of Yellowknife Bay to reduce the potential for further erosion and minimize further dispersion of tailings into Yellowknife Bay.

The existing cover at the Foreshore Tailings Area measures roughly 150 m long and 15 m wide. As shown in Figure 5.6-4, the toe of the cover is at a nominal elevation of 157 m, with a maximum elevation of 159 m at the southern end of the area. From the crest, the cover slopes to the east in the direction of Yellowknife Bay at slopes ranging from 7% to 13%. In Figure 5.6-4, the horizontal extent of submerged tailings distributed in the Foreshore Tailings Area is shown and covers an area of roughly 8 ha.

The existing cover consists of the following materials, in order of increasing depth from surface:

- 0.6 m layer of rockfill
- 0.15 to 0.30 m layer of gravel
- non-woven geotextile

From the toe of the cover, the slope of the tailings extends into Yellowknife Bay at an average slope of 1% for up to 100 to 150 m. Beyond this distance directly to the east, bathymetry measurements indicate that the slope increases to 7%. Vegetation had begun to establish on the exposed tailings at the toe of the cover (Golder 2016a). Recent inspections (Golder 2017d) have shown the cover itself to be intact and stable.

Hydraulic Conditions

The water elevation in Yellowknife Bay has decreased since 2001 when the cover was placed. In 2015, a hydraulic assessment was carried out to estimate the average open water low (1-in-2-year return period) to be 156.4 masl (Golder 2016a), which is below the toe of the existing cover. The water elevation estimated for a 1-in-50-year open water low is now estimated to be 156.04 masl, almost 1 m below the toe of the existing cover.

Surface Water Management

Upstream of the Foreshore Tailings Area, as shown in Figure 5.6-2, is Dam 7, which was constructed to collect seepage if it occurred from the South Pond of the Original TCA. Between Dam 7 and the Foreshore Tailings Area is a surface water drainage channel that has a catchment area of roughly 11 ha (Golder 2001a). The channel is designed to intercept runoff upstream and divert the water around the Foreshore Tailings Area. The outlet of the channel is located at the south end of the Foreshore Tailings Area. The channel consists of a 3 m wide base with 4 horizontal to 1 vertical side slopes. Vegetation has established within portions of the channel, as designed (Golder 2001a), to minimize the flow of sediments from the area upstream of the Foreshore Tailings Area. Flow in this channel is ephemeral.

Geochemistry of Tailings and Impact on Environment

Historical records suggest that the geochemistry of the tailings in Foreshore Tailings Area is different from the tailings in the impoundments. A review of historical mine records indicates that during the era of tailings deposition at the Foreshore Tailings Area, not all of the tailings deposited in this area were subjected to cyanidation and roasting (Silke 2009). Tailings deposition at the Foreshore Tailings Area is believed to have terminated sometime in 1951. Up to at least 1948, processing was limited to gold extraction via amalgamation or the production of gold concentrate through a flotation circuit, resulting in tailings that were distinct from those produced later and disposed of in the TCAs. Not until sometime between 1949 and 1950 was processing via the roasting plant implemented (Silke 2009). It is not known how much, if any, of the tailings deposited in the Foreshore Tailings Area was subjected to the roasting and cyanidation process.

Since 2000, studies have been carried out to evaluate the geochemistry of the tailings located in the Foreshore Tailings Area and its impact on the environment (Golder 2002b, 2005b; SRK 2004), as well as studies throughout north Yellowknife Bay (Golder 2005b; Stantec 2014; Chételat et al. 2017). Assessment of sediment cores from the Foreshore Tailings Area have shown that the total arsenic concentration is greater than 1,000 mg/kg, similar to areas at the mouth of Baker Creek. Roughly 500 m to the north of the Foreshore Tailings Area, the total arsenic concentration in the sediment is below 500 mg/kg. All tailings are non-acid generating.

Arsenic contamination of Yellowknife Bay sediments in the Foreshore Tailings Area has negatively affected the benthic invertebrate community in this area of Yellowknife Bay. Foreshore Tailings reduce habitat for fish and benthics by covering native sediment; Chemical, biological and visual data suggest that tailings had been remobilized from the historical tailings deposits along the western side of Yellowknife Bay increasing the spatial extent from the original deposition. Total arsenic and other metals are released from the Foreshore Tailings area at a low rate (Golder 2002b). Despite this, the water column above the tailings meets total arsenic water quality guidelines for aquatic life (Golder 2005b; SRK 2004).

5.6.4 Closure Objectives and Criteria

Closure objectives were identified specifically for the closure and reclamation of the TCAs, as shown in Table 5.6-3.

Table 5.6-3: Tailings Containment Areas and Dams Closure Objectives and Criteria

Closure Objectives	Closure Activity	Closure Criteria	Monitoring/Maintenance and Inspection
T1. Arsenic loading from the tailings containment area to the environment is reduced	• Reduce overall footprint of tailings (see Objective T5). • Grade tailings to promote positive drainage of precipitation off the TCAs and avoid ponding. • Cover tailings in the TCAs with a low permeability geosynthetic cover to minimize the possibility that precipitation will come in contact with or seep through tailings. • Protect the geosynthetic material with a 1 m layer of fine and coarse material, promoting its long-term integrity. • Construct spillway channels to route surface water to receiving environment (see Objective BC3), once surface runoff quality criteria are met.	• **T1-1** Design engineering drawings are signed and sealed by a Qualified Professional and the specifications outlined therein are met, such that arsenic loading to the environment is reduced. • **T1-2** Runoff water quality from North Pond, Central Pond, and Northwest Pond meets or is lower than applicable surface runoff quality criteria as per the approved Water Management and Monitoring Plan. • **T1-3** Runoff water quality from former South Pond area meets or is lower than applicable surface runoff quality criteria for direct discharge to Yellowknife Bay. as per the approved Water Management and Monitoring Plan. • *Refer to SW1, meeting air quality standards*	*Active Remediation Phase:* • As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB. • Satisfactory final inspection by inspector. • Follow Tailings Management and Monitoring Plan once closure activities are complete. *Active Remediation, Adaptive Management and Post-Closure Phases:* • Water Management and Monitoring Plan, Operational Monitoring Plan - water quality monitoring of surface, groundwater and sumps. • Surveillance Network Program - water quality monitoring of surface, groundwater and sumps.
T2. Risk of tailings erosion and human contact with tailings in the foreshore area is reduced	• Design and place cover on tailings in the foreshore tailings area. • Administrative controls, refer Objective SW4.	• **T2-1** Design engineering drawings for the foreshore tailings cover are signed and sealed by a Qualified Professional and the specifications outlined therein are met. *Criteria in Development with further engineering work and development of the Fisheries Act Authorization* • **T2-2** Inspection confirms limited erosion within design allowance (criterion to be determined). • **T2-3** Cover depth is X m, and extent is X m preventing wave and ice scour (criterion to be determined).	*Active Remediation Phase:* • As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB. • Satisfactory final inspection by inspector. *Active Remediation, Adaptive Management and Post-Closure Phases:* • Operational Monitoring Plan • Periodic inspections/surveys of foreshore tailings area to verify that tailings remain covered.

T3. Dam stability is maintained	• Evaluate stability of dams in their closure configuration. Where necessary, undertake stabilization works such as buttressing or reconstruction to confirm that all permanent dams meet stability criteria.
	• Re-evaluate dam stability following construction to confirm compliance with CDA criteria.
		• **T3-1** Dams meet applicable CDA stability criteria.
		• **T3-2** Design engineering drawings for dam reinforcement works are signed and sealed by a Qualified Professional and the specifications outlined therein are met.
			Active Remediation Phase:
			• As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB.
			• Satisfactory final inspection by inspector.
			
			Active Remediation, Adaptive Management and Post-Closure Phases:
			• Tailings Management and Monitoring Plan and Dam monitoring including
			  • Monitoring of slopes (slope indicators), phreatic surface (piezometers) and settlement at select locations, as designated by the Engineer of Record.
			  • Annual dam inspections by qualified engineer.
			  • Dam Safety review in accordance with CDA Guidance.

T4. Avoid surface water ponding on Tailings Containment Areas	• Contour tailings and cover tailings to stable grades, the grade should promote drainage to avoid surface water ponding.	• **T4-1** Design engineering drawings are signed and sealed by a Qualified Professional and the specifications outlined therein are met.
		• **T4-2** Cover meets minimum 0.5% grade for site drainage.
			Active Remediation Phase:
			• As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB.
			• Satisfactory final inspection by inspector.
			
			Adaptive Management and Post-Closure Phase:
			• Tailings Management and Monitoring Plan.
			  • Visual inspection and periodic surveys of the TCA to verify that grades are maintained and that areas of significant ponding do not develop.
			  • Visual inspection of covers for evidence of erosion and exposure of geosynthetic barrier.

Table 5.6-3: Tailings Containment Areas and Dams Closure Objectives and Criteria

Closure Objectives	Closure Activity	Closure Criteria	Monitoring/Maintenance and Inspection
T5. Footprint of tailings is reduced	• Relocate South Pond to within the remaining TCAs to provide a reduction in the total area covered by tailings. • Relocate Jo-Jo tailings and Dam 3 tailings-impacted soils to remaining TCAs (see Objective CS1).	• **T5-1** The total tailings impoundment footprint is reduced by approximately 90,000 m^2.	*Active Remediation Phase:* • As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB. • Volume of material moved is recorded in Design and Construction Plans and as-built drawings. • Satisfactory final inspection by inspector.
T6. Access to tailings cover areas is discouraged	• Tailings covers are rough / coarse gradation / rock cover. • Boulders placed in access areas.	• **T6-1** Cover is constructed in accordance with design specification including a rough surface on TCA's and coarse gradation of material • **T6-2** Site inspections verify area access is limited; confirm no damage to the cover by ATV'or other vehicles • *Refer to SI3-2 - Security log records a reduction in number of trespasser sightings in restricted areas*	*Active Remediation Phase:* • As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB. • Satisfactory final inspection by inspector. *Active Remediation, Adaptive Management and Post-Closure Phases:* Tailings Management and Monitoring Plan • Visual inspection and periodic surveys of the TCA to verify that rough surface remains. Operational Monitoring Plan • Inspection and logs of site access.

TCA = Tailings Containment Area; EQC = effluent quality criteria; TBD = to be determined; MVLWB = Mackenzie Valley Land and Water Board; CDA = Canadian Dam Association

5.6.5 Consideration of Closure Options and Selection of Closure Activities

In preparation of the CRP, several option studies were undertaken to select the preferred closure activities for the TCAs. These studies form the basis for:

- the selection of the engineered cover (Appendix 5.6-D)
- the approach for reduction in the TCA footprint (Appendix 5.6-B)
- the selection of final disposal locations for contaminated soils and relocated tailings (Golder 2017a)

Selection of closure activities included the performance of technical studies and the presentation of results in a series of internal project workshops. In these workshops, objectives, criteria, alternatives, and study outcomes were discussed. Group consensus was reached upon the completion of the workshops, ultimately leading to the selection of the preferred option for the closure activities. The key drivers for the selection of a preferred option, were based on the outcomes from the Report of EA and the SDE process and further evaluated through various option studies (MVEIRB 2013; SRK 2016) (Figure 5.6-6).

Tailings – Key Drivers for Closure Decisions

Higher ↑ Priority ↓ Lower

Driver

Meet regulatory requirements:
- Measure 22
- Measure 24

Input from Surface Design Engagement & affected parties

Align with other remediation activities

Design Considerations

- Cover not compromised by vegetation growth
- Prevent cover from being compromised by all-terrain vehicle traffic
- Maintain appearance of abandoned mine to visually convey history to future generations. (i.e. non-vegetated cover, coarse and grey surface)
- Reduce the tailings footprint
- Release runoff from cover when criteria is met
- TCAs provide location to dispose of tailings and contaminated soils
- Remove ponding water
- Cover grading aligns with site-wide water management plan

Selected Options

Tailings cover
- Geosynthetic liner (non-contact runoff)
- Rock fill surface

Relocate South Pond tailings and Jo-Jo tailings and contaminated soils/sediment to Central and North TCAs

PROPONENT

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

Government of Northwest Territories | Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2018-12-19
DESIGNED	H. Machtans
PREPARED	D. Pahl
REVIEWED	J. Amphlett
APPROVED	J. Amphlett

PROJECT

Giant Mine Remediation Project

TITLE

KEY CONSIDERATIONS DRIVING THE SELECTION OF CLOSURE ACTIVITIES FOR THE TAILINGS CONTAINMENT AREAS

REV. 0

FIGURE 5.6-6

5.6.5.1 Engineered Cover Design

Earlier cover designs presented in the DAR incorporated a vegetated cover for the TCAs (INAC and GNWT 2010). In the EA process, concern was expressed about the needed depth of cover soils, erosion risks, and the possibility of uptake of metals by vegetation. Later feedback from the SDE processes was that some affected parties preferred a non-vegetated cover option. From the affected party perspective, particularly the YKDFN, non-vegetated covers would convey the appearance of an abandoned mine site to future generations. In addition, the non-vegetated cover option would address any residual concerns about the potential for metal uptake to vegetation. Based on this feedback, the cover design was re-evaluated through a formal trade-off study with a multiple accounts analysis (Appendix 5.6-D).

The trade-off study provides a documented basis and rationale for the selection of the engineered cover design to be used for the TCA. Technically feasible options were identified, incorporating feedback from the EA and SDE processes. The design engineering team conducted a formal options analysis, with independent third party technical review of the analysis. Design choices were finalized at an internal design expert workshop, accounting for integration with other materials management needs (borrow, contaminated soils, contaminated sediments, pit fill, and underground backfill).

A range of non-vegetated and vegetated cover options were considered in the trade-off study. Based on the affected party feedback from the SDE process, the vegetated options were screened out and only four of the technically viable non-vegetated cover options identified were advanced to the trade-off study phase. These options included:

- rockfill cover with geosynthetic barrier layer (selected as the preferred option)
- a monolithic rockfill layer
- rockfill cover underlain by compacted fine-grained soil
- rockfill cover underlain by an amended fine-grained soil

The trade-off study resulted in the selection of the rockfill cover with geosynthetic barrier layer as the preferred option. Implicit in the outcome is that this option was assessed to best satisfy the closure objectives for Tailings and additional design objectives as defined for the study. Key drivers that resulted in the selection of a geosynthetic-based cover were the superior ability of this approach to physically isolate the tailings and the confidence this provides that runoff water would be unaffected by contact with underlying tailings. Additional benefits of this option that were not key drivers behind the selection of this cover included the well-proven capacity of this approach to reduce infiltration to very low levels, and elimination of root penetration into the underlying tailings (addressing any real or perceived concerns with respect to metal uptake in vegetation).

The selection of a cover that will have a non-vegetated surface is a change from the cover concept originally presented in the DAR (INAC and GNWT 2010). The DAR concept was for a store-and-release cover with a surface layer of organic soil and vegetation. Such a cover, while a technically feasible option, is vulnerable to erosion that can negatively impact its performance, particularly from all-terrain vehicle (ATV) use. By selection of a non-vegetative cover that includes rockfill and a geosynthetic barrier layers, Measures 22 (as it related to tailings cover) and 24, which were established in the DAR commitments, have been effectively addressed.

- Measure 22 – The Developer will conduct a study to determine appropriate depth of the tailings cap and B1 pit cover, in consultation with Environment Canada and responsible regulators, to verify that the depth proposed will ensure the tailings cap and B1 pit cover are not compromised by vegetation growth. The Developer will provide a report of this study to the Mackenzie Valley Land and Water Board before it issues a water licence for the Project.
- Measure 24 – The Developer will physically prevent all-terrain vehicle access to the tailings cap and B1 pit cover to prevent the surface from being eroded or otherwise compromised. The Developer will monitor the effectiveness of this prevention, and will take any additional management measures as necessary to prevent all- terrain vehicle access.

Due to the change in the cover concept to a non-vegetative cover with a geosynthetic barrier, the possibility of the cover being compromised by vegetation growth is eliminated, and it is no longer relevant to prevent ATV access to the cover. The rockfill cover material will also provide a durable protection and not be vulnerable to erosion from the action of ATVs. In contrast, the originally designed vegetated cover would be subject to the damage of both soil and vegetation by ATV transit. Further, the rockfill surface is expected to be less attractive to ATV users as the rockfill surface limits the practical speed and maneuverability of the vehicle and may damage tires.

5.6.5.2 Tailings Relocation

During the SDE process, affected parties expressed preferences for options that reduced the footprint of the TCAs as part of the rehabilitation efforts. As such, an options study was initiated to evaluate the feasibility of tailings relocation at a conceptual level (Appendix 5.6-D).

Prior to the options study, a wide variety of relocation alternatives were evaluated. Many options were screened out either on a volume or constructability basis. For instance, it would not be possible to relocate all tailings into a single location (such as the Northwest Pond) without a complete reconfiguration of the site involving extensive dam construction. Also, options considered for filling pits with fine grained material, such as tailings of some types of contaminates soils, posed additional risks to the underground, and thus were eliminated from further consideration at most pits (Section 5.1).

Based on the screening, the potentially feasible relocation options that could result in a reduction of the tailings footprint were 1) relocation of only the South Pond into the Central and North pond footprints, and 2) relocation of both the Central and South ponds into the North Pond and A1 and C1 pits. As a point of comparison, the option of covering all TCAs in place, without consolidation of the tailings in a smaller footprint, was also considered.

Relocation of the South Pond was selected in the options evaluation. This option would reduce the tailings footprint by roughly 9 ha, and also would remove tailings from an area where pre-mining topography drained in the direction of Yellowknife Bay. Further reduction in the tailings footprint by relocating both the South and Central ponds was found to add considerable cost and project risk. Removal of the Central Pond would require the construction of a completely new dam at the current division between the Central and North ponds (current Dyke 6 location). Further, relocation of Central Pond would add long-term management requirements for both dam stability and water management. While removal of the South Pond would restore natural drainage towards Yellowknife Bay, removal of the Central Pond would take place on the other side of a flow divide, where water would naturally drain towards the North Pond. Active management of this drainage would be required over the

long term (potentially involving pumping), particularly as the drainage would be towards the toe of the new dam constructed to isolate the North Pond tailings. For geotechnical reasons, it would not be desirable to accumulate water at the toe of the dam.

Relocation of the South Pond provides an approach to reduce the tailings footprint on the site, addressing desires to reduce the tailings areas as expressed in the SDE process with an approach that is geotechnically feasible, with an added benefit of restoring a portion of site surface water drainage to pre-mining conditions. Increasing the footprint reduction by removing the Central Pond as well would introduce disproportionate costs (nearly double that of South Pond relocation and four times greater than covering all tailings in place) and technical challenges (including new long-term water management and dam monitoring needs) for limited additional footprint reduction. Covering all tailings in place without footprint reduction is technically attractive but would not meet the closure objective of footprint reduction.

5.6.5.3 Disposal of Relocated Tailings and Contaminated Soil

As part of the Site remediation, contaminated soils will be relocated to the TCAs for disposal, as discussed in Chapter 5.4. Disposal of these materials within the TCAs, in addition to the relocated tailings, will have several geotechnical implications, particularly storage capacity of the TCAs, dam stability, and the potential for differential settlement of the cover. These implications were considered in the assessment of disposal options.

With the quantity of materials estimated to be relocated to the TCAs as part of the GMRP, dam heights will not need to be increased. However, to accommodate these materials, some rehabilitation and stabilization will be required, as discussed in Section 5.6.6.2.

5.6.5.4 Foreshore Tailings Area

Several rehabilitation options for the Foreshore Tailings Area have been considered over the years (SRK 2004). These include stabilization options, either chemically or physically, or complete removal of the tailings. However, in consideration of the limited environmental impact of the tailings, the potential for environmental impacts as a result of removal, as well as the high cost of removal, the approach to date has been to minimize further erosion of the tailings through cover placement and continue to monitor.

Additional work is planned to develop the design of the final cover in this area. Suggestion 14 from the Report of EA noted that baseline conditions for existing fish habitat in Back Bay and development of a foreshore tailings cover design and foreshore tailings monitoring and mitigation plan be developed for review by the Department of Fisheries and Oceans pursuant to habitat provisions of the *Fisheries Act*." The fish habitat work and consultation with Department of Fisheries and Oceans is underway.

5.6.6 Engineering Work – Original and Northwest Tailing Containment Areas

Engineering works needed to complete the remedial activities for the TCAs will consist largely of earthworks, with additional engineering including the construction of a geosynthetic cover and installation of the instrumentation needed to support post-closure monitoring of the closed site.

Principal activities to complete closure works will include:

- tailings excavation and relocation (principally from the South Pond area)
- dam rehabilitation/stabilization

- former South Pond footprint and sump area rehabilitation
- placement of arsenic-impacted material, including tailings and contaminated soil, in the remaining TCA areas
- shaping of the remaining TCA areas to promote positive drainage
- cover placement
- borrow source development for fine and coarse material needed for cover construction
- spillway construction
- instrumentation installation
- final decommissioning of remaining retention structures

The design work for these activities has been completed to a conceptual level. Additional design work will be advanced prior to implementing the closure works. Scheduling of the works has numerous interactions with other closure activities at the site. Some of the principal constraints that are taken into account in the overall GMRP schedule are as follows:

- The Settling and Polishing ponds, and portions of the Northwest Pond involved in the current operation of the water treatment system, cannot be decommissioned, drained, and covered until the new WTP is operating and the old one decommissioned.
- Ponds will need to be fully dewatered to promote the formation of trafficable surfaces prior to constructing the final landform.
- Cover placement cannot be completed until all tailings material required for underground backfilling activities has been extracted from the TCAs.
- Cover placement cannot be completed until all materials that will be disposed of in the TCAs have been relocated to the TCAs. This will include material from the contaminated soils rehabilitation activities.
- Final decommissioning of water retention structures, and return of surface water to the environment, will not take place until after water quality of the surface water has been demonstrated to meet surface water runoff criteria.

5.6.6.1 Tailings Relocation

Relocation of the South Pond will require the excavation, dewatering, hauling, and disposal of roughly 1 million m^3 of tailings. The extent of the relocated tailings, and the configuration after the completion of relocation is shown in Figure 5.6-7. In addition to tailings, impacted natural soil below the tailings will also require rehabilitation. As part of this work, perimeter Dams 11 and 12 will be removed. Following removal of the tailings, arsenic-impacted natural soil, and the perimeter dams, and the South Pond area will also be remediated. To manage the potential residual effects, surface water runoff from the area will be managed by maintaining Dam 7 until final decommissioning (when surface water is safe for discharge to Yellowknife Bay), with pumping and treatment of any retained water if needed.

The work to relocate and reclaim the South Pond area is described in this section. For descriptions of how the materials excavated are to be disposed, refer to Section 5.6.6.4, where this is described for both relocated tailings and contaminated soils.

As materials relocated to the North and Central ponds (principally tailings and tailings-impacted natural soils) will form the foundation of the engineered cover, which will incorporate a geosynthetic barrier layer, the excavation, dewatering, and handling will need to be closely managed. Therefore, as much as is practicable, the relocation work will be carried out during the summer months over several years. Winter excavation of frozen material will also be possible, and may be preferred when excavating saturated material, but subsequent disposal will require additional management (Section 5.6.5.3).

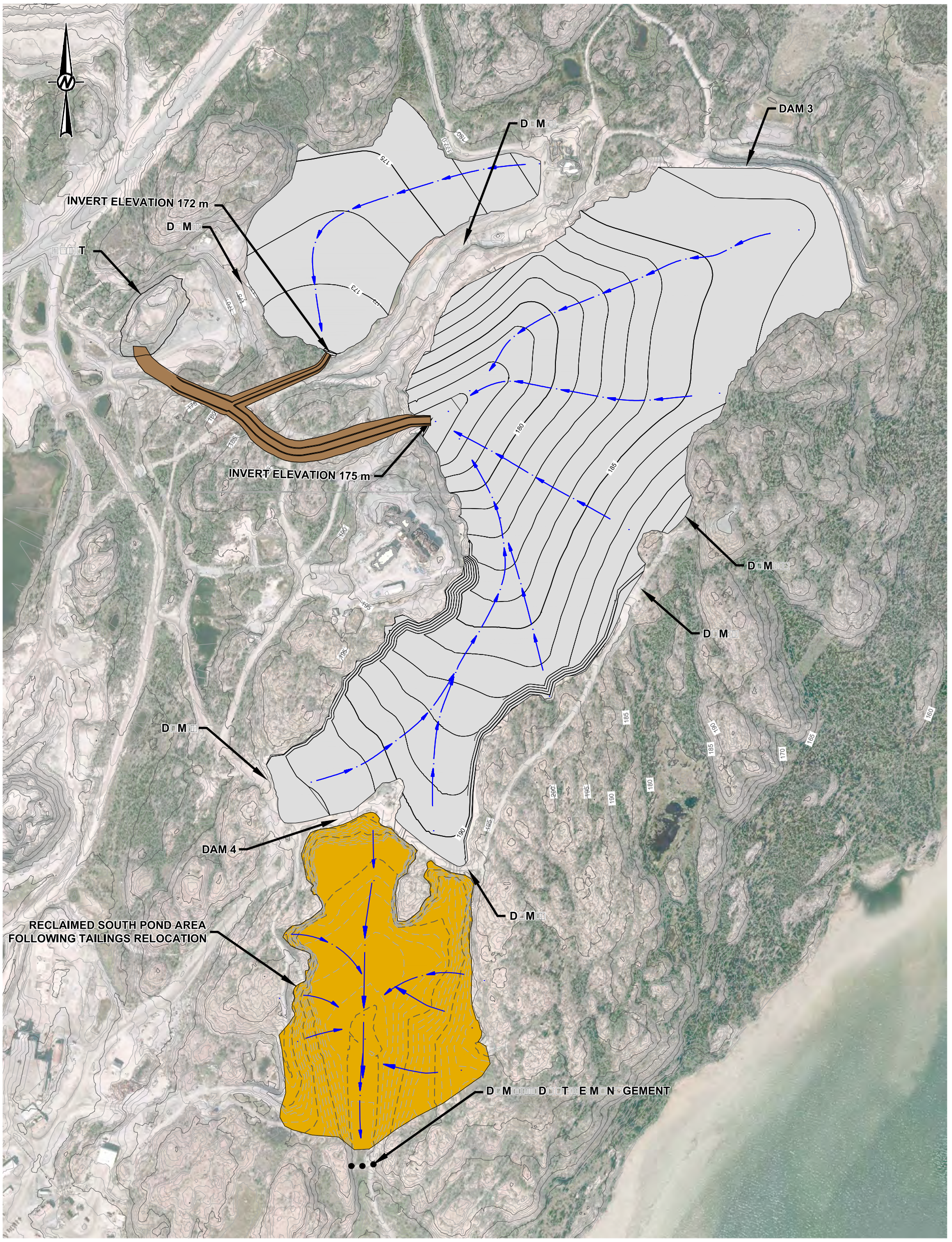
Excavation will be done by standard earthmoving equipment. While the exact staging process will be developed as part of the final design, the conceptual plan for staging is the excavation of tailings in lifts, with upper layers of tailings excavated progressively until the underlying bedrock or natural soil is reached. In the case of natural soils, it is expected that the tailings-impacted natural soils will be excavated, and handled as tailings, with unimpacted natural soil left in place. The maximum height of each lift would have to be limited so as to manage the stability of the exposed slopes.

Excavation of tailings above the water level or water table in the South Pond is expected to be relatively straightforward. Below the water table, conditions will be more challenging. Based on 2016 drilling investigation results in the South Pond, the water table is roughly 6 m below the top of tailings (Appendix 5.6-C). It is estimated that roughly half of the estimated tailings within the South Pond (about 500,000 m^2) would be located below the water table. Standard penetration testing results indicate that the strength of the tailings is lower below the water table than above. Therefore, below the water table, the excavations will have to be closely managed. Promoting drainage of the tailings will be required to manage the stability of the excavation as well as the water content of the excavated tailings to facilitate disposal.

Excavated materials will be placed in dedicated haul trucks and transported to the North and Central ponds for disposal. Transportation will require management of dust and handling of wet tailings. A Dust Management and Monitoring Plan (CIRNAC and GNWT 2019c), describes methods, which were previously developed and implemented for the excavation of tailings for use in underground stabilization work. These sections have been updated for closure works. Transportation of tailings material may include the use of covered trucks and/or manual wetting of the tailings surface in the truck. Potential for spillage of wet materials from the haul trucks is also possible, so detailed excavation planning may also require the use of lined trucks or, following the completion of the work, removal of the upper layer of road surfacing material (with disposal in the TCAs). Specific mitigations related to tailings excavation will be included in the applicable Design and Construction Plan submitted to the MVLWB. Refer to Section 5.9 for further discussion on how contaminated road surface materials are to be managed.

Following completion of the tailings excavation, rehabilitation of the excavated area will be undertaken, as described in Section 5.6.6.3.

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LEGEND

- 195 — MAJOR CONTOURS @ 5 m INTERVALS
- MINOR CONTOURS @ 1 m INTERVALS
- EARTHFILL DAMS (APPROXIMATE CREST ALIGNMENT)
- TOP OF COVER
- RECLAIMED SOUTH POND
- EXCAVATED SPILLWAY
- FLOW DIRECTION OF RUN-OFF

0 100 200
1:6,000 METRES

PROPONENT

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

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-02-01
DESIGNED	CARLO PENACERRAD
PREPARED	ALAN FARLOW
REVIEWED	HILARY MACHTANS
APPROVED	BJÖRN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

ORIGINAL TAILINGS CONTAINMENT AREA DRAINAGE MANAGEMENT

REV. 0

FIGURE 5.6-7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25 mm
0

5.6.6.2 Dam Stabilization and Recommissioning

As part of the closure activities, Dams 2, 4, 5, and 21A may require stabilization and recommissioning to satisfy closure goals and objectives, namely that the stability of the dams be maintained to CDA (2013) guidelines in post-closure. During active closure, Dam 1 will require remedial measures to address ongoing settlement.

- **Dam 1** will require remedial work to account for ongoing settlement of the dam and to allow effective operation of the Polishing and Settling ponds while the current ETP is still operating (Section 5.8).
- **Dam 2** is anticipated to require recommissioning to allow the dam to retain saturated tailings and contaminated soils.
- **Dams 4 and 5**—The removal of the South Pond tailings that abut these dams to the south, has been assumed that additional stabilization of these dams is necessary as part of closure works. This assumption is considered conservative, as historical photographs and drawings suggest that these dams were originally constructed to retain water (i.e., zoned earthfill) and that they did not rely upon the South Pond as a buttress.
- **Dam 21A** will need stabilization, as its stability does not satisfy minimum CDA guidelines (Golder 2015).

The specifics of the dam stabilization requirements and technical approaches for achieving them will be developed as part of detailed design. At a conceptual level, it has been conservatively assumed that buttressing will be used to achieve the required stability. Based on preliminary design assumptions, an estimated 50,000 m^3 of rockfill will be required for the dam stabilization (Appendix 5.6-B). These assumptions will need to be validated through future characterization, design work, and stability analysis.

Ongoing settlement of the crest of Dam 1 has resulted in reduced operational capacity of the Polishing and Settling ponds. Issues relating to Dam 1 are considered to be limited to within the Active Remediation and Adaptive Management Phase while the current ETP is in operation and while open access to the portal in B3 Pit is maintained. In post-closure, B3 Pit will be filled or recontoured and water will be removed from the Polishing and Settling Ponds and the areas covered. During the Active Remediation and Adaptive Management Phase, a raise to the crest of Dam 1 or other remedial measures may be required to maintain operational capacity within the Polishing and Settling ponds.

For recommissioning Dam 2, it is assumed that the upstream low permeability barrier needs to be rehabilitated. As portions of the dam were excavated as a source for materials following hydraulic mining of the North Pond, the quantity and quality of the remaining materials are unknown. Roughly 20,000 m^3 of fine- and coarse-grained borrow materials are estimated to be required (in addition to the 50,000 m^3 of rockfill indicated above) in support of recommissioning, but further assessments will be required to confirm assumptions.

Performance of the stabilization and recommissioning work will be carried out using standard earthmoving equipment. Geotechnical instrumentation will be installed to monitor dam performance.

5.6.6.3 Former South Pond and Sump Area Rehabilitation

Following completion of the tailings excavation, some fine-grained natural soils may be left within the former tailings footprint, where further investigations confirm that they have not been significantly impacted by the overlying tailings. Site investigations suggest that these soils were not impacted at depth by the overlying tailings (Appendix 5.6-C) and meet industrial land use criteria (GNWT ENR 2003). To the extent practical, these soils

will be left in place in the former South Pond basin. Erosion protection work may be needed on these materials to prevent excessive soil losses. This work may include placement of vegetation or rock covers. It is expected that the final approach will be developed adaptively as part of construction, depending on the characteristics and extents of the material remaining in the former footprint.

Revegetation efforts will be confined to areas of exposed fine-grained soils. Where bedrock outcrops remain, the fractures and discontinuities in the rock will likely retain residual arsenic contamination that will be difficult to fully remove by conventional excavation. As such, incident precipitation within the recovered area will likely contain dissolved arsenic for several years and require surface water management. Sump areas, including the sump upstream of Dam 7 (shown in Figure 5.6-7), will remain in operation until final closure to provide control of TCA area surface water discharges for monitoring purposes. As part of the initial relocation of South Pond tailings and tailings-impacted soils, impacted sediment in this sump will also be cleaned out, with material excavated and transported to the remaining TCAs for final disposal.

5.6.6.4 Placement of Tailings and Contaminated Soils

Tailings and contaminated soils relocated to the TCAs will become the foundation for the engineered cover. To achieve the desired final drainage characteristics of the TCA, and minimize differential settlement of the cover, design and management of the material placement in the TCAs will be required.

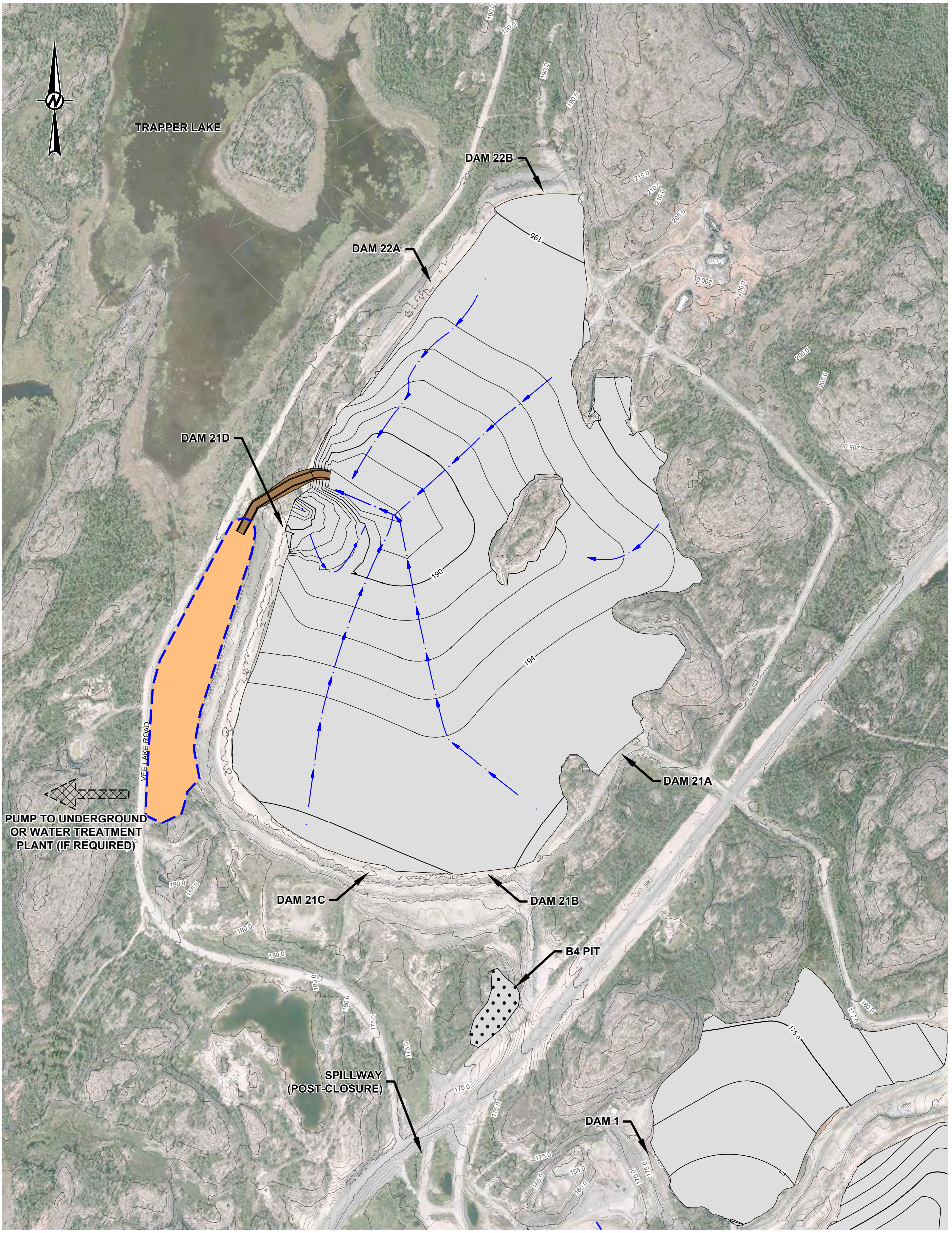
Detailed material handling and placement sequencing plans have not been developed. However, conceptual strategies are described below:

- **Foundation preparation**—Existing tailings in the TCAs in the ponds will be prepared as required prior to the placement of relocated materials. At a minimum, wet or inundated areas will need to be dewatered (through a combination of evaporation and pumping water to mine pool/treatment) and allowed to dry. Some areas may require ripping or proof rolling prior to placement of relocated material.
- **Placement of frozen material**—Frozen materials placed at high water contents will need to thaw, dewater, and consolidate. Some double handling of material, such as spreading, ripping, or mixing, may be required to achieve the range of water content that will allow the targeted degree of compaction to be achieved. Once frozen materials are excavated, an intermediate or temporary storage area (possibly within the TCA) may be required for thawing and dewatering prior to final disposal within the TCAs.
- **Scheduling**—The time between placement of relocated materials and construction of the engineered cover will be beneficial. This will allow time for consolidation of the foundation tailings and the relocated materials.
- **Monitoring**—Measurement of the degree of settlement after the relocated materials are placed, but prior to placement of cover, will be required to confirm or refine settlement predictions, and to support design adjustment if needed.

5.6.6.5 Tailings Containment Area Shaping for Positive Drainage

The placement of relocated materials will be coordinated and managed, with additional shaping undertaken to achieve the designed elevations and grades, similar to the conceptual grading plan shown in Figures 5.6-7 and 5.6-8 for the top of tailings / relocated materials.

Shaping and grading of the final TCA surface will provide a final topography that will convey water towards the spillways. This work will be carried out by conventional earthmoving equipment where possible, with low-pressure / wide pad equipment used if softer ground conditions make it necessary.



LEGEND

- 195 — MAJOR CONTOURS @ 5 m INTERVALS
- MINOR CONTOURS @ 1 m INTERVALS
- TOP OF COVER
- TEMPORARY WATER MANAGEMENT AREA (ADAPTIVE MANAGEMENT)
- EXCAVATED SPILLWAY
- FLOW DIRECTION OF RUN-OFF
- PITS BACKFILLED AND COVERED
- ACTIVE WATER MANAGEMENT (PUMPING AND/OR TREATMENT)

0 100 200
1:6,000 METRES

PROPONENT

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

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-25
DESIGNED	CP
PREPARED	JY
REVIEWED	HILARY MACHTANS
APPROVED	BJÖRN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

NORTHWEST TAILINGS CONTAINMENT AREA ADAPTIVE MANAGEMENT

REV. 0

FIGURE 5.6-8

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
0 25 mm

5.6.6.6 Cover Placement

The typical cover profile is shown in Figure 5.6-9. The top of the tailings facility will be shaped and prepared as described in Section 5.6.5.1. This surface will serve as the foundation for the geosynthetic cover material, with the geosynthetic generally in contact with the underlying tailings or fine-grained soils. Where material such as waste rock is present at the foundation surface, it will be covered with a minimum 0.15 m thick fine-grained layer (tailings or contaminated soil) to minimize damage to the geosynthetic.

A summary of the materials estimated to be required to construct the TCA covers is presented in Table 5.6-4. The required volumes of rockfill and fine-grained material will be clean material (not contaminated) sourced from on-site borrow sources. Preliminary studies indicated that on-site sources will provide sufficient borrow material for closure needs, as documented in Section 5.7.

Table 5.6-4: Estimated Tailings Containment Area Cover Material Quantities

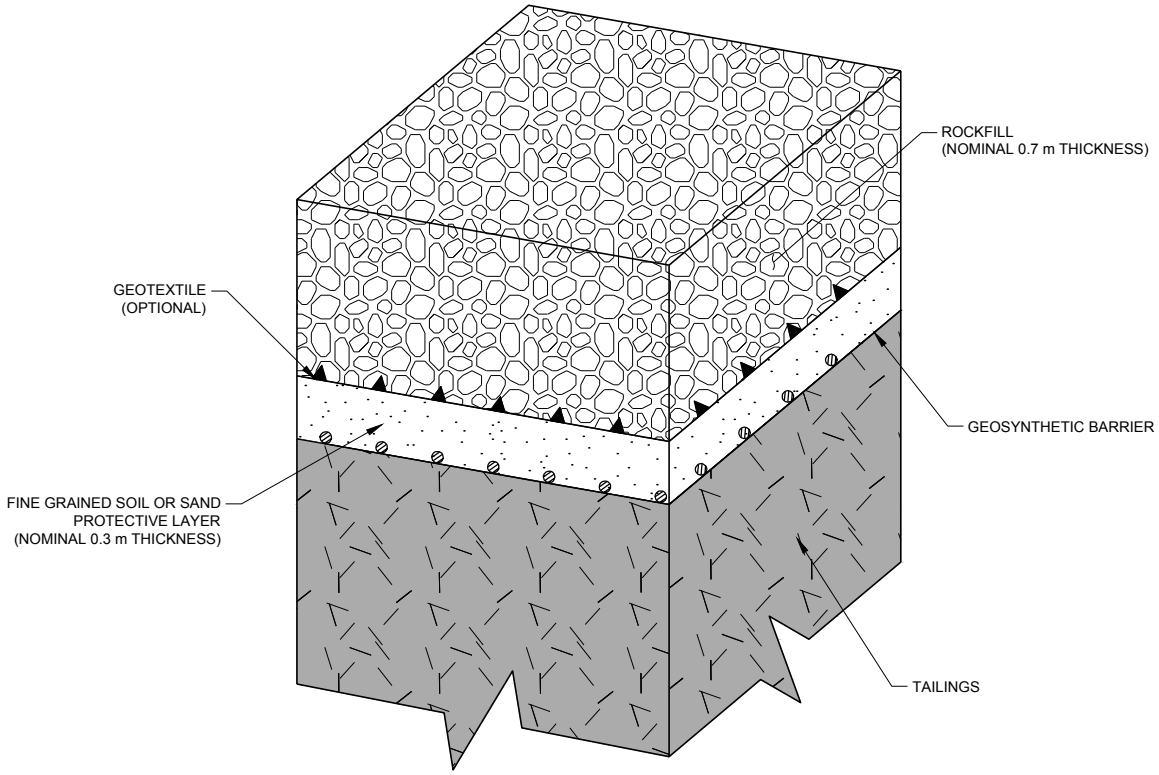
Pond	Rockfill (m^3)	Fine Grained (m^3)	Non-woven Geotextile (m^2)	Geosynthetic (m^2)
North and Central	290,000	124,000	414,000	414,000
Settling and Polishing	64,000	27,000	91,000	91,000
Northwest	303,000	130,000	433,000	433,000
Total	657,000	281,000	938,000	938,000

Note: For geotextile and geosynthetic no allowance for overlap of panels included.

Geosynthetic will be placed on the contoured surface. Any geosynthetic placement will require the use of industry standard quality assurance / quality control (QA/QC) procedures for the supply, storage, and placement of the liner. The specific placement procedures will depend on the type of geosynthetic that is selected in final design. While the liner will be placed in accordance with industry standard procedures, some defects may arise during placement, or in the longer term due to stresses from differential settlement. While not desirable, such defects are not expected to seriously impede the design function of the synthetic, which is to isolate surface runoff from the underlying tailings. In a similar way, while aging of the geosynthetic over the 100-year design life may result in some degradation, this is also not expected impede design function. Research suggests that properly protected geosynthetics are highly resisting to degradation over time (Müller et al. 2007; Hsuan et al. 2008; Holl 2002).

A 0.3 m thick protective layer of fine-grained soils will be placed over the geosynthetic barrier layer. Quality assurance and quality control will be needed for the soil placed in this layer, so that no oversized material is placed to present a puncture risk. The bedding layer will not have to have a specific hydraulic conductivity target; therefore, the material specification will likely allow silts, clays, and fine- to medium-grained sand, or combinations thereof.

Final specifications for the rockfill layer are to be developed, but it is expected that the material will consist of cobble- and gravel-sized particles (300 mm or less) that will not be a significant generator of ARD, metal leaching, or arsenic leaching. Work is required to sample and test materials from proposed borrow areas to evaluate the ARD potential.



LEGEND

- ROCKFILL
- FINE GRAINED SOIL OR SAND PROTECTIVE LAYER
- TAILINGS
- NON-WOVEN GEOTEXTILE
- GEOSYNTHETIC BARRIER

PROPONENT

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

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-25
DESIGNED	CP
PREPARED	JY
REVIEWED	HILARY MACHTANS
APPROVED	BJÖRN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

ENGINEERED COVER PROFILE TAILINGS CONTAINMENT AREAS

REV. 0

FIGURE 5.6-9

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

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5.6.6.7 Spillway Construction

Spillways will be used to convey surface water runoff from the TCAs. In the short term, water from the spillways will be retained and directed to the underground until proven that runoff quality meets discharge runoff criteria prior to release to the environment. In post-closure, the design intent is that spillways will be connected to the receiving environment to discharge surface water that meets all surface runoff criteria directly to the environment.

As shown in Figures 5.6-7 and 5.6-8, the spillways from the TCAs will be excavated through bedrock outcrops at the perimeter of the TCAs. Excavations will be carried out using conventional drilling and blasting. Maximum side slope excavations will be sloped at 0.5 horizontal to 1 vertical.

Spillways will be sized to accommodate the peak flows resulting from the estimated 24-hour duration PMP climate event for the site (see Section 5.5 for more details). Flows and spillway characteristics are summarized in Table 5.6-5.

Table 5.6-5: Estimated Tailings Containment Area Spillway Dimensions

Spillway	Peak Flow (PMP) (m^3/s)	Channel Minimum Base Width (m)	Channel Minimum Depth (m)	Minimum Longitudinal Slope (%)	Excavation Quantity (m^3)
Northwest Pond	28	10	1.2	2	35,000
North Pond	25	10	1.2	2	200,000
Polishing Pond	15	5	1.5	2	50,000

PMP = probable maximum precipitation

The PMP has been used for the spillway design under the rationale that the spillways will need to function for the foreseeable future in post-closure. A shorter return period has been used for the temporary water storage areas downstream of the spillways. These areas are expected to operate for a few years and would be sized considering a precipitation event with an appropriate return period, such as 1 in 10 years. Once it has been demonstrated that water quality is suitable for discharge to the environment, these areas will be decommissioned.

Further engineering assessments will be required to determine if areas downstream of the spillways will require additional engineering to address erosion protection to accommodate the estimated peak flows and management of surface water runoff from adjacent areas. One example is the Water Management Area at the outlet of the Northwest Pond spillway, as shown in Figure 5.6-8, located between the downstream toe of Dam 21D and Vee Lake Road. Erosion protection of the downstream toe of Dam 21D will be needed to maintain dam integrity and safeguard the dam from flow from a PMP event.

5.6.6.8 Instrumentation Installation for Monitoring

Instrumentation will be used to monitor the performance of the TCA engineered cover and select perimeter dams. Monitoring of these instruments will be carried out and the resulting data used to evaluate whether the cover and dams are performing as intended. Instruments anticipated to be used are as follows:

- engineered cover
- **soil moisture sensors**—monitor moisture in TCA materials and confirm cover performance
- **survey monuments**—measure displacement and differential movements of the cover over time
- **thermistor strings**—measure the thermal conditions within the cover, tailings, and contaminated soils to evaluate the development and variations in frozen conditions within the TCA following closure
- dams
- **vibrating wire piezometers**—pressure measurements from the vibrating wire piezometers will be used to infer the phreatic conditions within the dam and how that would affect the estimated factors of safety
- **inclinometers**—monitor displacements over time
    - **survey monuments**—monitor displacements over time, particularly useful in detecting zones of displacement in vertical space

The number and location of the monitoring points, as well as the details of the sensors and data loggers used and monitoring protocols, will be developed as part of detailed design.

5.6.6.9 Final Decommissioning of Remaining Structures

As indicated previously, Dam 7 and a water retention structure / weir downstream of the Northwest Pond will be used to control the discharge of water from the TCAs on a temporary basis after the covers have been constructed. Once it has been demonstrated that the surface runoff discharged through the spillway meets relevant applicable environmental criteria, these retaining structures will be decommissioned, permitting a restoration of off-site discharge from these areas.

Detailed design for the decommissioning of the retaining structures will be developed at the end of their operation. The decommissioning of Dam 7 will be an earthworks activity, with the dam either completely removed or a notch cut through the dam of sufficient width that the dam will not retain water. The water-retention structure / weir downstream of the Northwest Pond will be completely removed. In the former retaining structure locations, works will be undertaken to verify that they will not be a source of ongoing erosion in the future. This may consist of the placement of riprap or other erosion control measures.

5.6.7 Engineering Work – Foreshore Tailings Area

Further conceptual and detailed design for the extension of the Foreshore Tailings Area cover is required. A preliminary design has been developed considering scour control. However, considering the proximity of the Foreshore Tailings Area to the townsite, additional work will be needed so the design results in a cover that also limits the potential for human contact and meets the proposed closure objective for the Foreshore Tailings Area. This updated design will require consideration of projected water levels in the lake, wading depths, and

maintenance of appropriate isolation of the tailings. As part of detailed design, assessment of additional variables such as wave transformations (i.e., shoaling, diffractions, or refraction), water currents, and regulatory considerations will also be required. Preliminary design work for this area considers extending the cover such that it would provide coverage of the tailings that would be mobilized for up to a 1-in-500-year wave event. This was a combination of a 1-in-50-year low water level (elevation of 156.04 masl) and 1-in-10-year southeast wind in Yellowknife Bay. This design will be further refined considering design objectives.

5.6.8 Final Site Conditions – Original and Northwest Tailings Containment Areas

The final site conditions will be driven by four main closure activities:

- South Pond tailings relocated to North and Central ponds (area once occupied by the South Pond will be remediated).
- Where required, perimeter dams (Dams 2 and 21A) will be stabilized to meet CDA guidelines (CDA 2013).
- Engineered cover will be placed on tailings in the North, Central, Settling, Polishing, and Northwest ponds.
- Spillways will be excavated through bedrock outcrops to drain surface water runoff from engineered cover.

The final site conditions for the Original and Northwest TCAs include management of surface water runoff from the TCAs engineered cover to the spillways (Figures 5.6-7 and 5.6-8) and eventually into Baker Creek without active management, once runoff quality meets surface runoff criteria.

Prior to attaining post-closure conditions, there will be a period of adaptive management for the TCAs, with a site configuration as shown in Figure 5.6-10. During this period, surface runoff from the closed areas will be controlled and monitored for quality; this is expected to occur during the Active Remediation and Adaptive Management Phase (Chapter 1). This runoff will be directed to treatment until such time as it has been demonstrated to meet runoff criteria. Once that quality has been demonstrated, closure activities will be completed to allow free drainage off site, as shown in Figure 5.6-11. The TCAs will require post-closure monitoring (Section 5.12).

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TRAPPER LAKE

INVERT ELEVATION 187 m

NORTHWEST COVER

PUMP TO UNDERGROUND OR WATER TREATMENT PLANT (IF REQUIRED)

CONTROL STRUCTURE/ WEIR

B4 PIT

EFFLUENT TREATMENT PLANT (DEMOLISHED)

B3 PIT

FLOW TO UNDERGROUND

NORTH AND CENTRAL COVER

POCKET LAKE

BAKER POND

B1 PIT

B2 PIT

RECLAIMED SOUTH POND AREA FOLLOWING TAILINGS RELOCATION

BAKER CREEK

FLOW TO UNDERGROUND

C1 PIT

NEW WATER TREATMENT PLANT (APPROXIMATE LOCATION)

DAM 7

C-DRY

LEGEND

- TOP OF COVER
- RECLAIMED SOUTH POND
- CLOSED PITS
- EXISTING FOOTPRINT OF FORESHORE TAILINGS AREA (APPROXIMATE)
- EXCAVATED SPILLWAY
- TEMPORARY WATER CONTROL STRUCTURE/WEIR
- FLOW DIRECTION OF RUN-OFF
- TEMPORARY WATER MANAGEMENT AREA
- WATERCOURSE
- WATERCOURSE FLOW DIRECTION
- ACTIVE WATER MANAGEMENT

0 250 500

1:10,000 METRES

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-25
DESIGNED	CP
PREPARED	AD
REVIEWED	HILARY MACHTANS
APPROVED	BJÖRN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

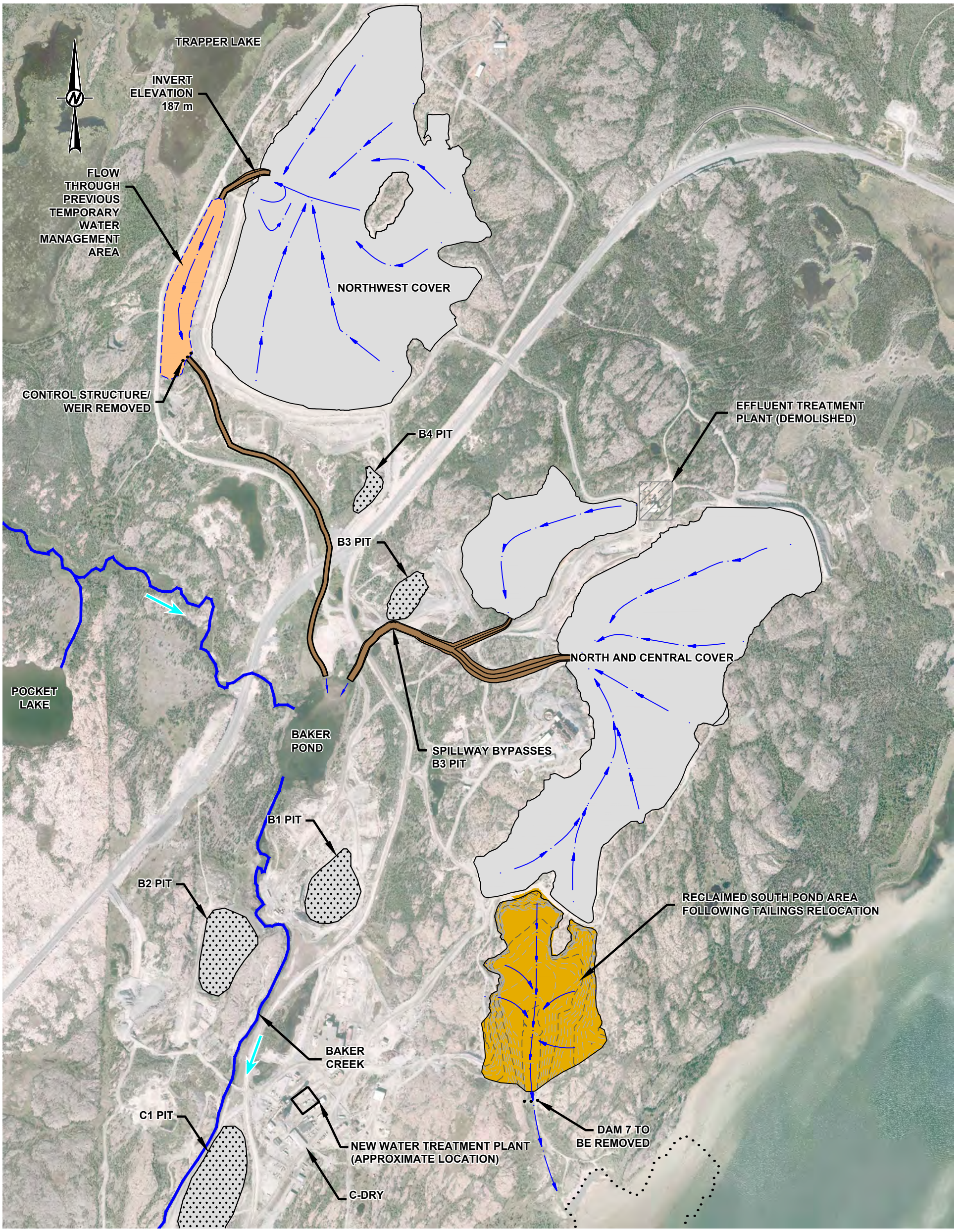
TAILINGS CONTAINMENT AREA SURFACE WATER MANAGEMENT - ADAPTIVE MANAGEMENT

REV. 0

FIGURE 5.6-10

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
0 25 mm

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LEGEND

- EXISTING FOOTPRINT OF FORESHORE TAILINGS AREA (APPROXIMATE)
- CLOSED PITS
- EXCAVATED SPILLWAY
- TOP OF COVER
- RECLAIMED SOUTH POND
- WATERCOURSE
- FLOW DIRECTION OF RUN-OFF
- WATERCOURSE FLOW DIRECTION

0 250 500
1:10,000 METRES

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-25
DESIGNED	CP
PREPARED	JY
REVIEWED	HILARY MACHTANS
APPROVED	BJÖRN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

TAILINGS CONTAINMENT AREA SURFACE WATER MANAGEMENT - POST CLOSURE

REV. 0

FIGURE 5.6-11

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25 mm
0

5.6.8.1 South Pond Relocation

Following removal of South Pond tailings, the pre-existing natural soil and bedrock within the South Pond area will be exposed. This pre-existing topography is shown in Figure 5.6-7 based on 1967 survey data that have been digitized (Geocon 1983b). After tailings relocation, it is anticipated that the topography will be restored to an approximation of pre-mining conditions and surface water flow will be restored to the original flow direction. Depending on the characteristics of the exposed natural soil, erosion control measures may be implemented such as revegetation or rock armoring of exposed fine-grained material.

Based on the pre-existing topography, all surface water runoff in the former South Pond area will flow south towards Yellowknife Bay once Dam 11 is removed. In active remediation and adaptive management phases, Dam 7 will be used to retain and temporarily manage the surface water runoff. If the water quality exceeds runoff discharge quality criteria, it will be pumped to the water treatment plant (WTP). Once the surface water runoff from the recovered area is shown to meet surface water runoff criteria, Dam 7 will be removed. Surface water runoff from the recovered area will then flow in the direction of Yellowknife Bay via gravity.

Following the relocation of South Pond tailings, the soil quality of the remaining natural soil will be assessed to determine if further remediation is required. Natural soil or residual tailings left behind after relocation with arsenic concentrations exceeding the GNWT industrial land use criterion will either have to be covered or relocated. In the current conceptual design, a proportion of the estimated natural soil in the South Pond is assumed to be removed and relocated to within one of the TCAs and placed under an engineered cover.

5.6.8.2 Dam Stabilization and Recommissioning

Dam stabilization will form part of the closure activities, including work on dams with existing stability concerns or dams that may be affected by closure activities. As mentioned in Section 5.6.2.2, Dams 2 and 21A may require stabilization based on the most current analyses. This stabilization will likely take the form of toe berms constructed with rockfill along the toe length of the dams.

Removal of the South Pond will change the condition of the associated dams at its perimeter. In post-closure, Dams 4 and 5 will remain in place, while Dam 11 will be removed as part of closure activities. As a result of this change, the anticipated stability of Dams 4 and 5 during the removal of the South Pond and for the long term will require evaluation. For the conceptual design, it has been assumed that stabilization of these dams using a rockfill toe berm will be sufficient.

Dams not mentioned in this section have been assessed to not require stabilization as they satisfy stability criteria (CDA 2013) or their consequence of failure classification is low.

5.6.8.3 Disposal of Arsenic-Impacted Materials into Tailings Containment Areas

As part of the site-wide rehabilitation activities for the Site, an estimated 2.1 million m^3 of arsenic-impacted soil and tailings materials will require disposal. As shown in Table 5.6-6, a total of 1.3 million m^3 will be relocated to the TCAs (Golder 2017a). The remaining 0.8 million m^3 will be disposed of within A1 Pit and/or frozen in B1 Pit.

Table 5.6-6: Disposal of Arsenic-Impacted Materials to Tailings Containment Areas

TCA	Pond	Volume of Arsenic-Impacted Material (rounded to nearest 100,000 m^3)				
		South Pond		Contaminated Soil		Total
		Fine Grained (tailings)	Dam Fill (coarse grained[a])	Fine Grained	Coarse Grained	
Original	North	600,000[b]	100,000	200,000[c]	0	900,000
	Central					
	Settling	0	0	0	100,000	100,000
	Polishing					
Northwest	Northwest	0	0	200,000	100,000	300,000
Total	*Subtotal*	*700,000*		*400,000*	*200,000*	1,300,000
	Grand Total	**1,300,000**				

(a) Proportion of dam fill assumed to be contaminated.

(b) Does not include the 400,000 m^3 of tailings estimated to be required for underground stabilization.

(c) Arsenic-impacted materials disposed of in the TCAs will also include tailings from the remediation of Jo-Jo Lake. The estimated volume of tailings from this activity is 33,000 m^3.

TCA = Tailings Containment Area; n/a = not applicable

5.6.8.4 Engineered Cover

The design for the cover of the TCAs is proposed as a non-vegetated cover that incorporates a geosynthetic barrier layer (such as high-density polyethylene or a bituminous geosynthetic) which will be placed on all tailings within the TCAs. As shown in a sketch in Figure 5.6-9, the cover will consist of:

- 0.7 m thick layer of rockfill
- a layer of non-woven geotextile
- 0.3 m thick layer of fine-grained soil
- a single geosynthetic barrier layer

The geosynthetic barrier layer will be designed such that surface runoff from the TCAs does not contact the underlying tailings. The cover will also significantly reduce infiltration of precipitation into the underground mine. The principal motivation for using a geosynthetic barrier layer is to promote the generation of surface water runoff from the TCAs that will meet surface water runoff criteria for release to the environment.

The fine-grained soil serves as a bedding layer to protect the underlying geosynthetic from puncture or damage caused by the overlying rockfill. The rockfill cover will provide a robust physical barrier, isolate the tailings, prevent erosion, and minimize vegetation growth. Furthermore, the coarse angular surface of the rockfill will be uninviting to wildlife and humans, in keeping with desires expressed by some affected parties through the SDE process (SRK 2016) and to meet requirements of Measure 24. Boulders may also be placed at strategic access points to discourage use of the covered areas.

The geosynthetic barrier layer will be placed in direct contact with the underlying tailings or contaminated soils. As fine-grained materials, these are expected to be appropriate for direct contact with the geosynthetic barrier layer, with some exceptions. As shown in Figures 5.6-7 and 5.6-8, some areas will not have tailings at the surface:

- the material storage, area located in the Central Pond
- the storage dome, located in the Central Pond
- the non-hazardous waste landfill, located in the Northwest Pond

In these areas, prior to placement of the geosynthetic barrier layer, a bedding layer will be required. This may be relocated tailings or other fine-grained waste material. New borrow for the bedding layer is not anticipated.

As shown in Figures 5.6-7 and 5.6-8, the slope of the cover varies between the TCAs, as well as within each respective pond. Target slopes shown have been informed by the expected settlements of the cover following placement. In general, the least settlement is anticipated where the tailings present stiff or dense conditions and the thickness of tailings is less. These areas are typically found in beaches, particularly near the outer perimeter of the TCAs. Greater settlement is anticipated in or near ponding areas, where finer tailings would have been deposited. These tailings consist mostly of fine-grained material with soft consistency.

The final slopes vary within the ponds from a maximum of 3.4% to 5% on the north part of the North TCA, to a minimum of 1%. In selected areas, geometry and volume constraints have resulted in slopes flatter than 1%, with slopes of 0.5% in the beach area of the Northwest Pond. In addition to the slopes shown in Figures 5.6-7 and 5.6-8, blue arrows indicate the general direction of surface water flow.

Vegetation is not part of the cover design, and in the first years following placement of the cover vegetation growth is expected to be minimal. However, experience in the Yellowknife area has shown that even rocky soils will eventually revegetate naturally if active measures to remove vegetation growth are not undertaken. Further consultation with affected parties will be undertaken to determine if ongoing vegetation control will be undertaken, or limited natural vegetation growth permitted and incorporated into the Tailings Management and Monitoring Plan.

Additional details on the layout of the North and Central ponds, Polishing and Settling ponds, and Northwest Pond are provided below.

Original TCA – North and Central Ponds

As shown in Figure 5.6-7, the covered surface topography of the North and Central ponds will direct surface water runoff to a spillway located at the west side of the North Pond. The spillway is located at the south abutment of Dam 2, in an area with visible bedrock outcrops.

Within the North Pond, surface water flows west and southwest. From a maximum cover elevation (rockfill), located along the northeast perimeter, the cover slopes at a grade of at least 1%. Within the vicinity of the spillway, the slope steepens to around 2.5% to 3.5%, with a maximum of 5% near the spillway.

To achieve the topography shown in Figure 5.6-7, fill placement is required in the North and Central ponds. Additionally, some excavation of the existing tailings in the Central Pond is required to achieve design slopes.

Original TCA – Polishing and Settling Ponds

As shown in Figure 5.6-7, the surface of the Polishing and Settling pond cover slopes from the northeast perimeter of the Settling Pond to the southwest, in the direction of the spillway. The spillway is located at the southern edge of the Polishing Pond.

Within the Settling Pond, the top of cover is sloped at roughly 1.0% in the direction of the Polishing Pond. Within the Polishing Pond, surface water is directed to the spillway at a typical slope of 1.0%.

To achieve the topography shown in Figure 5.6-7, fill placement is required in the Polishing and Settling ponds. Fill placement may be as thick as 8 m in the Polishing Pond and will be generally less than 3 m in the Settling Pond.

Northwest TCA

As shown in Figure 5.6-8, the north, east, and south perimeters drain to middle of the TCA where Northwest pond is currently located, from where surface water runoff is directed to the spillway located at the western perimeter.

To achieve the topography shown in the figure, fill placement into the TCA is required.

5.6.8.5 Surface Water Discharge

Spillways will be constructed to allow for the safe discharge of surface water runoff from the TCAs. The spillways will be constructed during active remediation and operated during the adaptive management phase and through long-term operation and maintenance.

During active remediation and potentially for part of the adaptive management phase, closure spillways will route surface water runoff from the surface of the engineered cover to a location outside of the TCAs for temporary management as shown in Figure 5.6-10. During this time, the runoff will be collected and monitored. Once monitoring results show consistent achievement of runoff quality criteria, spillway discharge will flow directly to the environment as shown in Figure 5.6-11, with final discharge to either Baker or Trapper Creek. Long term monitoring of runoff water quality will continue through adaptive management and into the post-closure phase.

Original TCA – North, Central, Settling, and Polishing Ponds

The Central and North ponds will drain via the North Pond spillway, which will be excavated into a bedrock outcrop at the south abutment of Dam 2. For the Settling and Polishing ponds, a spillway will be excavated in the southeast corner of the Polishing Pond. Located in the vicinity of present day B3 Pit, the North Pond and Polishing Pond spillways will join to create a single spillway outlet.

During the active remediation, the Polishing Pond and North Pond spillways will be temporarily routed to B3 Pit for discharge to the underground minewater pool. In post-closure, B3 Pit will be backfilled or recontoured and no longer used to store surface water runoff from the TCAs. As shown in Figure 5.6-11, the spillway will be routed to bypass B3 Pit, so water can be discharged directly to Baker Pond.

Original TCA – South Pond

As part of the South Pond relocation, Dam 11 will be removed. During active remediation, surface water runoff will flow to the south and be retained by the existing Dam 7. The surface of the reclaimed South Pond will be graded to promote surface water flow. Some placement of erosion protection will be required in areas of exposed fine grained soil.

Once surface water runoff from the former South Pond area meets runoff criteria, Dam 7 will be removed and surface water runoff directed through existing channels towards Yellowknife Bay. Some placement of erosion protection may be required in areas of exposed fine grained soils.

Northwest TCA

Within the Northwest Pond, the spillway inlet will be excavated into a bedrock outcrop located at the western perimeter. The outlet of the spillway will drain into a topographic low that is located downstream of Dam 21D. Protection of the downstream toe of Dam 21D from erosion through the placement of riprap or other erosion controls may be needed and will be addressed as part of the final spillway design.

In active remediation, surface water runoff from the Northwest Pond spillway will be managed in the area downstream of Dam 21D, which is located along Trapper Creek and is upstream from the narrow bedrock channel. Currently, Trapper Creek flows to the south and through a narrow channel that was excavated through bedrock during the construction of Dam 21D. At a conceptual level, this has been assumed to be an adjustable weir structure that would be installed to control and monitor surface water runoff from the Northwest TCA, as shown in Figure 5.6-10.

Once surface water runoff quality meets runoff criteria, the weir structure would be removed and the spillway extended to discharge into Baker Pond. Routing of the spillway will follow the alignment of Trapper Creek. Placement of erosion protection along the extended spillway, as well as within the decommissioned temporary water treatment area, will be required. Installation of culverts will be required where the spillway intersects the Ingraham Trail (Highway 4). The conceptual alignment for this discharge is shown in Figure 5.6-11.

5.6.9 Final Site Conditions – Foreshore Tailings Area

After the completion of final closure activities, the existing Foreshore Tailings Area cover will be modified, and is expected to provide additional coverage of submerged tailings out into Yellowknife Bay, in accordance with design objectives. The final extent and configuration of this cover will be defined in detailed design to ensure the design meets closure objectives. This concept may be modified as design is advanced.

5.6.10 Uncertainties

Engineering designs for the closure plan are currently at a conceptual level. As such, the basis for estimates and analyses include engineering judgement. Additional design works are planned to address key assumptions and reduce relevant uncertainties. The important uncertainties that affect tailings are summarized below in Table 5.6-7, together with the engineering studies and other activities planned to address these uncertainties.

Table 5.6-7: Tailings Containment Area Uncertainties

Uncertainty	Potential Impact of Uncertainty	Plan to Address Uncertainty
The as-built stability characteristics of several dams are uncertain. Stabilization works are currently planned for selected dams based on observed performance and conservative assumptions.	Assumptions may be incorrect, resulting in either more or less effort to stabilize dams than currently anticipated.	These assumptions will be evaluated in future engineering studies to adjust the planned stabilization works.
Surface water runoff discharge from the TCAs is expected to meet applicable water quality criteria for off-site discharge; it is assumed it will take three years for runoff from the TCA covers to reach the water quality criteria, which is assumed to be a background arsenic concentration in Baker Creek (see the *Effluent Quality Criteria Report* [CIRNAC and GNWT 2019d] for full details).	Active management and treatment of water may be needed for longer than the currently estimated three-year period.	Design studies to better predict runoff water quality will be carried out, including geochemical characterization of borrow materials and estimation of nutrient loads from blasting materials. Water will be treated until runoff meets applicable criteria.
The extent of future differential settlement of tailings is uncertain. With the drying of the tailings in the TCAs and placement of additional material within them, consolidation of the tailings can be expected.	Differential settlement can result in localized areas of poor drainage, and may place stress on the geosynthetic cover materials.	Differential settling will be addressed through further characterization of tailings, predictive modelling, test plots and through monitoring of the tailings elevations and adapting material placement based on observations. Due to the deposition method used for the tailings and the complex distribution of variable grain sizes, prediction of the settling across the TCAs is impractical.
For the cover of the Tailings Foreshore Area there are uncertainties regarding the future water elevation in Yellowknife Bay. While analyses have been carried out to select a plausible open water low elevation, conditions could result in a reduction in the Yellowknife Bay water elevations beyond what is available in the historical data.	Greater than projected reductions in the water level could result in the extent of subaqueous coverage being less than projected.	Future site monitoring will be required to verify that the constructed cover and hydraulic conditions in Yellowknife Bay align. If water levels drop more than anticipated, the cover can be extended further out into the bay.

TCA = Tailings Containment Area.

SECTION 5.7
Borrow Material

5.7 Borrow Material

5.7.1 Description

Borrow material describes soil and/or rock that is excavated from one area of the mine and used for works occurring at a different area. Borrow material is excavated from a borrow source and will be required for use in closure and reclamation activities. This includes activities described elsewhere in this CRP, such as:

- backfilling pits (Section 5.3)
- covering TCAs (Section 5.6)
- covering areas where contaminated soils or tailings have been removed, or where contaminated soils have been left in situ (Section 5.4)
- constructing bases for drill pads for the freeze program (Section 5.2)
- constructing and covering the landfill (Section 5.10)
- rehabilitating Baker Creek and Baker Pond (Section 5.5)

The CRP assumes borrow materials will be sourced from within the project boundary. Off-site sources of borrow could also be considered. An initial concept for the development of borrow sources has been developed, taking into account the current understanding of project needs (as summarized in Section 5.7.2.2), volumes of usable material that will be generated from other closure and reclamation activities at the site (such as spillway construction), and areas available for development of new borrow sources within the project boundary. Candidate borrow source locations have been identified through previous work (Golder 2004, 2017). This work provided an initial confirmation that sufficient borrow is available on site.

Selection of borrow sources will prioritize areas targeted for other works which will produce closure by products, such as excavation of tailings spillway and previously developed areas, such as the Brock Pit quarry site which has been used in the past to support borrow needs for the GMRP.

At the Site, borrow material can be obtained from the following sources:

- quarries developed for providing rockfill and similar materials
- borrow areas developed for fine-grained soils
- by-products of other closure and reclamation activities (e.g., excavation of spillways)
- spoils generated from past construction activities

5.7.2 Borrow Material Development

A preliminary plan for the development of the borrow material was prepared. As part of this, the required types of borrow materials have been identified, along with the quantities required under the CRP. To characterize the corresponding borrow development, a preliminary identification of the planned borrow sources has been prepared, based on available information. This includes the conservative assumption that open pits will be completely filled. Partial backfilling of some pits will reduce the amount of borrow material required. As the characterization of both the requirements and the material availability will undergo further refinement through the

detailed design process, contingency or alternative sources are also identified. Assumptions were also made with respect to the borrow source locations that have been identified. Further work is needed to refine the planned borrow areas, as defined in this section. This is expected to include further evaluation of visual impacts, engagement with interested parties, geochemical characterization, and accommodating the results of the archeological work.

5.7.2.1 Borrow Material Classification

Works at the Site will require different classes of soil material. Based on the intended use, borrow materials have been grouped in two broad categories:

- Fine-grained materials—This term is used to apply to materials where the majority of the material has a particle size of fine sand or smaller (<0.425 mm). Examples include silt, clay, fine sand, and combinations thereof in varying proportions. Naturally occurring fine-grained borrow sources may contain medium sand and fine gravels in some proportion. Fine-grained materials are considered to have a low permeability, and will be obtained primarily from borrow pits, with additional material possibly generated from reclamation and closure activities around the Site.
- Coarse-grained materials—This term is used for materials where the majority of the material has a gravel particle size of 5 mm or larger. Examples include sandy gravel, gravel, crushed rockfill, and run-of-quarry rockfill. Naturally occurring coarse-grained borrow sources may contain sand-sized particles and trace (<5% by mass) fine-grained particles. Coarse-grained materials are considered to be of high permeability and will be obtained from on-site quarries. Additional material may be generated from other closure and reclamation activities around the Site, such as spillway construction, creek channel rehabilitation, high wall recontouring, and dam removal.

5.7.2.2 Borrow Material Requirements

As indicated, borrow material will be required for the completion of the closure and reclamation activities documented in the CRP. The demand for borrow material is summarized in Table 5.7-1, based on the current project description. These values represent the best current understanding of the project requirements, but it is recognized that values may be modified prior to construction as a result of design refinement. Volumes in the table have been rounded to the nearest 10,000 m^3. Additional small amounts of borrow may be required for incidental project needs around support infrastructure. Borrow volumes for coarse-grained materials have increased over what was planned in the DAR (approximately 660,000 m^3) due to changes in the project description including possible pit fill placement and rockfill needs for the tailings covers. Fine-grained borrow requirements are less than those estimated in the DAR, due to changes in the cover design for the tailings.

The current estimates of borrow volume requirements are considered to represent an upper limit on all volume estimates. In particular the current estimates were developed based on a scenario considering that borrow would be used to fill all pits level with the pit spill point. In practice, the total fill volume placed in most pits is likely to be less than this once pit fill design is completed.

Some of the reclamation and closure activities will be carried out using arsenic-impacted materials. For example, underground backfilling work will be conducted using arsenic-impacted tailings. These arsenic-impacted materials are not considered borrow, and borrow material requirements do not include tasks that will be completed with arsenic-impacted materials.

Table 5.7-1: Project Requirements for Borrow Material

Closure and Reclamation Project	Coarse-Grained Demand (m^3)	Fine-Grained Demand (m^3)
Baker Creek realignment	90,000	20,000
Pond Cover – North/Central Pond	290,000	120,000
Pond Cover – Settling/Polishing Pond	60,000	30,000
Pond Cover – Northwest Pond	300,000	130,000
Dams (remedial activities)	50,000	10,000
Closing openings to surface	30,000	0
Foreshore Tailings Area	20,000	0
Contaminated soils (covers/backfill)	850,000	260,000
Freeze pads & associated access roads	140,000	0
Landfill	340,000	0
Water treatment plant	30,000	0
Utilities	50,000	0
Foundation backfill for demolished buildings	7,500	0
Pit backfill – A1 Pit	110,000	10,000
Pit backfill – A2 Pit	480,000	10,000
Pit backfill – B1 Pit	180,000	10,000
Pit backfill – B2 Pit	200,000	10,000
Pit backfill – B3 Pit	50,000	0[(a)]
Pit backfill – C1 Pit	320,000	10,000
Total	**3,580,000**	**620,000**

(a) The estimated quantity is less than rounding limitation used.

5.7.2.3 Planned Borrow Sources

The borrow materials required for the completion of closure and reclamation projects will be obtained both from dedicated borrow sources and as by-products of excavations conducted for Mine site closure activities. The latter would include excavations done for the construction of spillways, Baker Creek realignment, high wall reduction or slope recontouring, dam removal, and relocating the south pond.

Site closure activities will generate enough borrow for roughly 72% of the currently forecasted borrow needs, while the remainder will be obtained from dedicated borrow sources, as summarized in Table 5.7-2. In developing the preliminary borrow source estimates, preference has been given to using material generated as a by-product from the site closure activities, as a means to minimize disturbance around the Site.

The borrow sources by-products of closure activities and dedicated borrow areas. The borrow areas identified in this CRP have been selected based on information presented in Golder's borrow source identification report (Appendix 5.7A). In that report, borrow sources were classified as either "defined" or "potential" based on the degree of characterization available. For either classification, further ground truthing to confirm material availability and characteristics will be required prior to development.

Fine-grained soils at ground surface in the borrow areas may have been impacted by historical arsenic deposition. As a conservative assumption, it has been considered that a 0.3 m thick layer of arsenic-impacted material exists on the surface of fine-grained deposits and will need to be removed before the borrow source can

be developed. A preliminary estimate of the quantity of arsenic-impacted fine-grained material created by this stripping is approximately 40,000 m^3, distributed as follows:

- 20,000 m^3 from the clearing east of Pocket Lake (Clearing Area)
- 10,000 m^3 from the borrow area designated NW1
- 10,000 m^3 from hill south of Brock Pit (the Hill)

Disposal of this arsenic-impacted fine grained material will be within the TCAs prior to cover placement. The quantity of material is minimal compared to the overall storage capacity.

Table 5.7-2: Planned Borrow Sources

Borrow Source		Coarse-Grained Supply (m^3)	Fine-Grained Supply (m^3)
Closure project by-products	Pit high wall recontouring (5H:1V) A1 Pit	1,000,000	0
	Pit high wall recontouring (5H:1V) A2 Pit	300,000	0
	Dam removal	80,000	20,000
	Baker Creek realignment	180,000	190,000
	South Pond relocation	0	240,000
	North Pond spillway area (c)	1,020,000	0
	Subtotal	*2,580,000*	*450,000*
Borrow areas	NWP 1	100,000	0
	NWP 2	220,000	0
	NWP 3	260,000	0
	Brock Pit quarry	190,000	0
	Baker Creek Pond quarry	110,000(a)	0
	Channels and ditches	130,000	0
	Clearing east of Pocket Lake (Clearing Area)	0	20,000(a)
	ICG Area (east of closed propane tank storage yard)	0	30,000(b)
	NW1	0	30,000(a)
	Hill south of Brock Pit (the Hill)	0	90,000(a)
	Subtotal	*1,010,000*	*170,000*
	Total	**3,590,000**	**620,000**
	Contribution from closure Activities	**72%**	**73%**
	Contribution from Borrow areas	**28%**	**27%**

(a) Additional supply available, if needed (Table 5.7-3).
(b) Estimated arsenic stripping is 5,000 m^3. All other arsenic stripping values noted in Table 5.7-3.
(c) Volume includes widening and recontouring spillway beyond the minimum required for flow conveyance, to provide additional borrow material.

The development areas shown in Figure 5.7-1 have been selected from the possible borrow sources based on a pairing of CRP needs with specific closure and reclamation activities that would generate borrow materials, or potentially feasible nearby borrow areas. In developing the CRP, the priority was using all material from various mine projects prior to initiating the development of borrow areas. Borrow areas closest to needs for material were prioritized to minimize haul distances and road crossings. Additionally, the visual impact from borrow area development was taken into consideration by minimizing the number of locations which are required to obtain the quantity of borrow material needed.

Path: \\golder.gds\gal\Burnaby\CAD-GIS\Client\PWGSC\Giant_Mine\99_PROJECTS\GIANT MINE CLOSURE AND RECLAMATION PLAN - EXTERNAL\02_PRODUCTION\DWG\ | File Name: FIG-5.7-1-Borrow Sources to Support Closure and Reclamation.dwg | Last Edited By: afarlow Date: 2019-02-01 Time:4:44:03 PM | Printed By: AFarlow Date: 2019-02-01 Time:4:57:58 PM



PLAN
SCALE 1:12,500

NOTE(S)

1. COORDINATES SHOWN ARE IN METRES GMRP GRID.
2. ACRONYM DEFINITIONS:
   - CGV: COARSE GRAINED VOLUME
   - FGV: FINE GRAINED VOLUME
   - NWP - NORTHWEST POND

REFERENCE(S)

1. PWGSC, AERIAL PHOTOGRAPH, IMAGE FILE: GIANTMINE_GRP.SID, DATED NOVEMBER 24TH 2009.
2. AECOM CANADA LTD. LEASE BOUNDARY, CAD FILE: GIANT MINE - LEASE BOUNDARY.dwg, RECEIVED ON OCT 12 2016.

LEGEND

- PROJECT BOUNDARY
- FINE-GRAINED BORROW SOURCE SITES
- COARSE-GRAINED BORROW SOURCE SITES
- TEXT — PROJECT AREAS
- TEXT — BORROW AREAS

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

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REVIEWED	HILARY MACHTANS
APPROVED	BJÖRN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

BORROW SOURCES TO BE DEVELOPED TO SUPPORT CLOSURE AND RECLAMATION ACTIVITIES

REV. 0

FIGURE 5.7.1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
0 25 mm

5.7.2.4 Alternative Borrow Sources

The plan for borrow areas outlined in Section 5.7.2.3 will be refined as designs advance. The quantities required for completion of closure works can be expected to be refined with the advancement of plans design, as will the quantities produced by mine projects. Further, the current definition of borrow sources is based on limited field characterization. Additional studies will be carried out to refine current estimates of available materials in the selected areas and to confirm the suitability of material for use in the closure design.

Additional borrow areas that may be feasible for development have been identified at a preliminary level. If some of the currently planned borrow areas should prove unsuitable, or evolving project requirements should increase the demand for borrow material, alternative borrow sources may need to be developed. One such alternative could be achieved by recontouring the pit high walls to a shallower slope than 5H:1V. Note that some alternative areas may involve longer haul distances or greater visual impact.

Preliminary estimates of the volumes in areas that could potentially be developed to supplement the existing material balance are presented in Table 5.7-3, and Figure 5.7-2 shows the location of the alternative borrow sources. The assumed quantity of arsenic-impacted material to be stripped from each area is also summarized in the table. If only a portion of the area is developed, less arsenic-impacted material would need to be stripped.

Table 5.7-3: Contingency Fine- and Coarse-Grained Borrow Sources

Borrow Area	Estimated Fine-Grained Supply (m^3)	Estimated Coarse-Grained Supply (m^3)	Estimated Arsenic Fine-Grained Stripping (m^3)
Narrow Valley – Back Bay (BB)[(a)]	39,000	0	15,000
North of A1 Pit (A1) [(a)]	106,000	0	15,000
Hill south of Brock Pit (The Hill) [(a)]	50,000	0	5,000
North of Brock Pit (Brock Pit) [(a)]	25,000	0	9,000
North of B2 Pit (B2) [(a)]	4,000	0	10,000
Clearing east of Pocket Lake (Clearing Area) [(a)]	230,000	0	16,000
Northeast of C1 Pit (C1) [(a)]	4,000	0	2,000
NW1[(a)]	30,000	0	4,000
SP1[(a)]	3,000	0	2,000
Roads[(b)]	12,000	0	0
Potential Source Area 1[(b)]	5,000	0	0
Potential Source Area 2[(b)]	5,000	0	0
Baker Creek Pond quarry[(a)]	0	10,000	-
Potential Source Area 3[(b)]	0	113,000	-
Potential Source Area 4[(b)]	0	54,000	-
Potential Source Area 5[(b)]	0	426,000	-
Totals	**513,000**	**613,000**	**78,000**

(a) Areas considered a "defined" borrow source in Appendix 5.7A are those that have been specifically characterized as borrow sources through limited on-site investigations (such as site walk-overs).
(b) Areas considered a "potential" borrow source in Appendix 5.7A are those that that have been identified through the review of available background information as potentially viable, but would require further study or design to quantify.

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NOTE(S)

1. COORDINATES SHOWN ARE IN METRES GMRP GRID.
2. ACRONYM DEFINITIONS:
   - CGV: COARSE GRAINED VOLUME
   - FGV: FINE GRAINED VOLUME
   - NWP - NORTHWEST POND

REFERENCE(S)

1. PWGSC, AERIAL PHOTOGRAPH, IMAGE FILE: GIANTMINE_GRP.SID, DATED NOVEMBER 24TH 2009.
2. AECOM CANADA LTD. LEASE BOUNDARY, CAD FILE: GIANT MINE - LEASE BOUNDARY.dwg, RECEIVED ON OCT 12 2016.

LEGEND

- PROJECT BOUNDARY
- FINE-GRAINED BORROW SOURCE SITES
- COARSE-GRAINED BORROW SOURCE SITES

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-25
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PREPARED	AF
REVIEWED	HILARY MACHTANS
APPROVED	BJÖRN WEEKS

PROJECT

Giant Mine Remediation Project

TITLE

ALTERNATIVE BORROW SOURCES

REV. 0

FIGURE Fig 5.7-2

5.7.3 Pre-disturbance and Existing Site Conditions

The borrow sources are distributed throughout the Site (Figure 5.7-1). In general, these sources are found in locations that have not been significantly modified by past mining activities, including rock outcrops and lower lying areas of fine-grained soils.

5.7.3.1 Pre-disturbance Conditions

A full description of pre-disturbance conditions that are largely applicable to the borrow source locations is provided in Section 2.2. Pre-disturbance conditions in the borrow source locations reflect the overall Mine site context. The overall Mine site context consists of undulating topography and extensive areas of exposed bedrock on the higher ground, and soil deposits in low-lying areas. Typically for the region, bedrock outcrops cover approximately 75% of the area, while fine-grained soils and organics are also present in localized deposits in low-lying areas between bedrock outcrops (INAC and GNWT 2010). Along the axis of many valleys in the Yellowknife area, sand and gravel deposits rest directly on bedrock and are overlain by thick sequences of silt and clay (INAC and GNWT 2010).

5.7.3.2 Existing Site Conditions

There are multiple historical locations around the Site where borrow materials were exploited in support of Mine operations, including the building of tailings dams, roads, and laydown areas.

Resources on the site currently that can be developed as borrow sources include fine-grained soils and rock. Most fine-grained soil deposits at the Site are shallow (<10 m in depth) and consist of silty-clay, clay, or fine- to medium-grained sand, while most coarse materials will be sourced from bedrock outcrops.

Previous reports and recent assessments of borrow sources (INAC and GNWT 2010; Golder 2012, Appendix 5.7A) have characterized existing site conditions with respect to borrow sources. Twenty-nine locations were identified as possible sources of fine-grained or coarse-grained material (Appendix 5.7A). Most of the identified borrow sources have access roads or are located near existing access roads. The total volume of the material sources has not yet been fully detailed, either in terms of depth or areal extent. The current estimates of existing resources will be refined as further design works and characterization progress, including field investigation planned to confirm potential volumes.

5.7.4 Closure Objectives and Criteria

Borrow areas need to be developed to provide material that will support closure activities for the Site. The borrow areas will themselves need to be closed and reclaimed, in keeping with the site-wide closure and reclamation objectives. Many of the site-wide objectives also apply to the borrow areas and are not repeated here. Objectives and criteria specifically applicable to the borrow areas are summarized in Table 5.7-4.

Table 5.7-4: Borrow Pits and Quarries Closure Objectives and Criteria

Closure Objectives	Closure Activity	Closure Criteria	Monitoring/Maintenance and Inspection

Q1. New disturbance due to borrow/quarry areas is minimized, to the extent practicable	• Preferentially use materials from Closure project by-products. Design each borrow area in accordance with clearly defined project needs, factoring in material volumes generated by other site activities and using opportunities to minimize project borrow needs
	  • recontouring slopes for safety reasons,
	  • spillway for Northwest Pond
	• Use stockpiles of fine- and coarse-grained material for site closure activities such that new borrow volumes are reduced.
		• **Q1-1** Borrow development is completed as defined in the approved Borrow Materials and Explosives Management and Monitoring Plan:
		  • Borrow areas are limited to areas identified in design. Preferentially use materials from Closure project by-products.
		  • Design to consider aesthetic impact (visibility to public) of borrow areas.
		  • Excavations are limited to the extent practical; without compromising the material properties, topography, and final borrow reclamation plan.
		  • Archaeological or heritage sites encountered are documented and avoided.
			Active Remediation Phase:
			• As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB.
			• Satisfactory final inspection by Land Use inspector.
			• Borrow and Explosive Management and Monitoring Plan including QAQC checks on borrow limits during construction.

Q2. Borrow and quarry materials/areas are not a source of environmental contamination and do not pose a safety risk	• Conduct investigations of potential quarry areas to confirm that materials are geochemically suitable. • Meet site water management program objectives and manage residuals from blasting. • Excavate to rock at fine grained borrow sources, to the extent practical to meet project objectives. • Revegetate areas of exposed fine-grained soils that remain after the exploitation of borrow areas to reduce potential for erosion (refer to SW5) • Manage blasting, excavation, site access, and coordinate traffic from haul trucks for worker and public safety. • Complete areas with final slopes that do not present hazards significantly greater than the surrounding natural environment.	• **Q2-1** Use geochemically suitable borrow sources as defined in the Borrow Materials and Explosives Management and Monitoring Plan. • **Q2-2** NWT Quarrying Regulations and Pits and Quarries Northern Land Use Guidelines are met. *Criteria in Development with engineering works* • **Q2-3** Slope grades in remediated borrow areas are completed such that final slopes do not present hazards significantly greater than the surrounding natural environment. • **Q2-4** Water quality and sediment load of surface runoff from borrow areas meets applicable surface runoff quality criteria from approved Water Management and Monitoring Plan.	*Active Remediation Phase:* • Air Quality Monitoring Plan – dust monitoring. • Erosion and Sediment Management and Monitoring Plan. • Water Management and Monitoring Plan -Water quality monitoring. • Borrow Materials and Explosives Management and Monitoring Plan. • Dust Management and Monitoring Plan. *Active Remediation, Adaptive Management and Post-Closure Phases:* • Satisfactory final inspection by Qualified Professional. • Water Management and Monitoring Plan -Water quality monitoring.
Q3: New borrow and quarry areas are reclaimed at the end of their production	• Revegetate with native vegetation, areas of exposed fine-grained soils that remain after the exploitation of borrow areas, where risk of erosion exists • Grade/contour to match existing landform.	• *Refer to Q2-2 NWT Quarrying Regulations and Pits and Quarries Northern Land Use Guidelines for reclamation are met.* • *Refer to Objective SW 5* - Establishment of native vegetation on fine-grained soils. *Criteria in Development with engineering works* • **Q3-1** Slope grades in remediated borrow areas are completed such that final slopes will be equivalent to current natural conditions of the surrounding environment.	*Active Remediation Phase:* • Erosion and Sediment Management and Monitoring Plan - monitoring for erosion in fine-grained borrow areas. Borrow Materials and Explosives Management and Monitoring Plan • As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB. *Active Remediation, Adaptive Management and Post-Closure Phases:* • Satisfactory final inspection by Qualified Professional.

MVLWB = Mackenzie Valley Land and Water Board; CIRNAC = Crown-Indigenous Relations and Northern Affairs Canada; NWT = Northwest Territories

5.7.5 Consideration of Closure Options and Selection of Closure Activities

Development of borrow areas form part of the necessary works to support closure activities for multiple mine components that were selected based on regulatory and affected party input as well as the requirements of the MVEIRB (Figure 5.7-3). As such, alternatives to the development of quarry areas were not explicitly considered. Currently planned locations for the borrow sources have been developed to a conceptual level. These locations are subject to further refinement and confirmation through the detailed design process. This will include work to characterize the potential borrow sources and evaluate their final design configuration, taking into account the closure objectives to minimize disturbance and not have a source of environmental contamination from borrow areas and materials. As such, borrow materials that are generated as byproducts of other site remediation activities will be used as a priority, with new borrow developments only undertaken when the quantities provided by site remediation projects are exceeded.

The GMRP has selected to obtain borrow materials from on-site sources in order to minimize haul distances and the risks associated with off-site traffic.

The necessary activities related to the development of borrow areas are described in Section 5.7.6.

Borrow – Key Drivers for Closure Decisions

Higher ↑ Priority ↓ Lower

Drivers	Design Considerations	Selected Options
Align with other remediation activities	➢ **Borrow material required for chosen closure activities:** ➢ **Filling of open pits** ➢ **TCA cover construction** ➢ **Freeze pad construction** ➢ **Landfill construction** ➢ **Berms, diversion for flood protection of pits, infrastructure** ➢ **Clean backfill for Baker Creek and contaminated soils, for sediment covers, Foreshore Tailings Area cover, contaminated soils covers**	• **Borrow will be used for required closure activities** • **Maximize use of borrow from site activities to minimize new borrow needs**
Technical Feasibility	➢ **Use of tailings to fill pits not chosen as technically not feasible for long-term stability and poses health and safety risks** ➢ **Clean borrow then required to form bulk of pit fill**	Note: Specific locations to be evaluated, incorporating additional consultation

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2018-12-19
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REVIEWED	J. Amphlett
APPROVED	J. Amphlett

PROJECT

Giant Mine Remediation Project

TITLE

KEY CONSIDERATIONS DRIVING THE SELECTION OF CLOSURE ACTIVITIES FOR BORROW MATERIAL

REV. 0

FIGURE 5.7-3

5.7.6 Engineering Work

The engineering work related to the identification and development of borrow sources will be developed under CIRNAC (INAC 2009) guidelines and will typically include the following:

- subsurface investigations and engagement to identify and quantify suitable borrow material (including identification of frozen conditions)
- evaluation of existing hydrologic and hydrogeologic conditions to confirm the suitability of the planned development
- geochemical characterization of potential borrow material underway (confirmation of suitability). It is assumed that no PAG material will be used as borrow, nor will PAG material be left exposed in borrow areas after completion. If investigation identifies PAG material, alternative non-PAG sources will be selected for use
- evaluation of other relevant Mine site conditions, including access, archaeological, visual impacts, existing land use, and habitat
- identification of access to borrow areas, with access development where necessary
- developing a borrow area development plan, per CIRNAC (INAC 2009), that includes
- description of mitigation measures, taking into consideration site context; mitigation measures to include consideration potential impacts such as habitat loss and dust generation during development
- description of site conditions, including delineation of resource
- Mine site design and development
    - operations description, including extraction techniques, explosives management, monitoring plans, and spill contingency plans
    - reclamation plan

Selection of borrow development strategies will involve further engagement with affected parties, both for the evaluation and selection of preferred borrow areas and for identifying opportunities for economic benefits of borrow development to local residents.

Strategies to avoid adversely affecting undiscovered heritage resources through the development of borrow sources and properly documenting those encountered include:

- review of available archaeological reports for the area (see Chapter 1)
- preconstruction surveys with systematic documentation and mapping of any heritage sites
- developing protocols for the management and reporting of new archaeological finds
- instructing all employees to not knowingly remove, disturb, or displace any archaeological specimen or site prior to proper investigation and documentation

- putting all activity in the area on hold in the event that an archaeological site or specimen is encountered or disturbed by any remediation activity, until such time that the appropriate authorities have been contacted for further direction and it has been provided
- identify locations of archeological / heritage resources and develop a strategy for investigation and documentation
- educating all employees involved in surface disturbance activities on any protocols regarding Cultural/Heritage Resources
- documentation and storage of salvaged materials in accordance with local regulations, guidance from the Prince of Wales Northern Heritage Centre and the YKDFN and NSMA.

The activities associated with the reclamation of borrow areas are presented in Table 5.7-5.

Table 5.7-5: Engineering Work Associated with Borrow Source Reclamation

Activities	Engineering Work Requirements
Site cleanup	• Machinery, fuel containers, garbage, and blasting materials will be safely removed.
Landscape reconstruction	• To the extent practicable, sources will be developed with consideration of the final desired contours for the completed area. • Some limited scaling of exposed faces and removal of overhangs may be required to achieve safe and stable final land form.
Fill material from borrow source for reclamation activities	• Quantification of required volumes, classification of material, contamination screening, methods of extraction, material hauling, and placement will be carried out.
Drainage and erosion control	• Exploited areas will be designed to be free-draining to the extent practicable and borrow pit lakes will not be created. • Erosion control will be primarily through vegetation of exposed fine-grained sediments. • Temporary or permanent ditches, berms, or swales may be required for drainage control. If required, design and construction will consider need to control erosion and sediment transport. • Additional temporary erosion control measures will be undertaken as needed.
Revegetation	• Seeding areas of exposed fine-grained soils with native species, and/or placement of trees/shrubs that were conserved prior to exploitation.

5.7.7 Final Site Conditions

The planned closure and reclamation activities make the development of new borrow sources necessary. Figure 5.7-1 shows the areal extent of the currently planned borrow sources. However, the final extent of the planned borrow sources will be confirmed through further design and trade-off evaluations. After the borrow areas have been developed, the CIRNAC guidelines for the Northwest Territories and Nunavut (INAC 2009) will be applied to their reclamation and closure. It is anticipated that a Borrow Materials and Explosives Management and Monitoring Plan will be submitted to the regulatory authorities and outline specifics about monitoring, management and mitigation.

Borrow locations have been selected to limit the extent of land disturbance, considering available information. The current plan will need to be further refined as the design advances and further characterization of the borrow sites is carried out, including evaluation of both material suitability and landscape design alternatives for the final

borrow locations. This evaluation will also factor in archeological considerations; updated archaeological work and traditional land use information from 2018 will inform this. Specific heritage mitigations will be built into the Borrow Materials and Explosives Management Plan (see below).

Borrow areas will remain as excavated areas following the completion of borrow and reclamation activities. The post-reclamation landscape of the borrow areas will be shaped to generate a topography that blends visually into the surrounding terrain (to the degree practicable), promotes runoff (working within the context of the site wide Water Management and Monitoring Plan), and minimizes risks to wildlife and humans. Where the development of borrow areas results in areas of exposed fine-grained materials that are susceptible to erosion, revegetation will be undertaken to stabilize the exposed areas. Where bedrock is left exposed by borrow activities, no further stabilization against erosion is proposed. The reclamation activities for borrow locations will include both new sources developed and historical locations.

5.7.8 Uncertainties

Engineering designs for the closure plan are currently at a conceptual level. As such, the basis for estimates and analyses include engineering judgement. Additional design works are planned to address key assumptions and reduce relevant uncertainties. The important uncertainties that affect borrow material are summarized below in Table 5.7-6, together with the engineering studies and other activities planned to address these uncertainties.

Table 5.7-6: Borrow Material Uncertainties

Uncertainty	Potential Impact of Uncertainty	Plan to Address Uncertainty
As the majority of the closure designs are at the conceptual level, there remains uncertainty as to the exact amount of borrow source material that will need to be developed.	This may affect the number and extent of borrow sources needed to complete site closure works.	Current borrow requirement estimates represent the upper range of the total amount of borrow that will be required. The borrow source plans and material balance will be periodically updated as engineering design progresses.
Borrow sources have been characterized based on limited field investigations and on interpretation of qualitative data such as air photos.	The actual amount of soils available in the identified borrow locations may be different (greater or lesser) than currently predicted.	Additional field investigation will be required to confirm interpretations on quantity of borrow.
The geology/geochemical characteristic of potential coarse borrow material has not yet been characterized in detail.	The chemical nature of coarse-grained borrow sources may be different than currently predicted.	Geological screening (and geochemical testing) will be carried out to select for coarse-grained material that will not generate unacceptable environmental impacts (e.g., contaminated runoff water quality) after blasting and excavation.
Characterization of the extent of roaster emission impacts on the fine-grained borrow sources is also limited.	The chemical nature of fine-grained borrow may be different than currently predicted.	The depth of roaster impacts on fine-grained soils will also be evaluated.

SECTION 5.8
Water Treatment Plant and Outfall Systems

5.8 Water Treatment Plant and Outfall Systems

5.8.1 Description

Throughout active remediation, adaptive management, and post-closure phases, it will be necessary to continue to pump and treat contaminated water at the Site. The CRP includes the interim operation of the existing ETP and then the construction of a new WTP during active remediation and continued management during adaptive management and into the post-closure phase. The ETP and WTP systems will be used to maintain mine pool levels and treat contaminated site water. Treatment is required as the mine pool includes contaminants, such as arsenic and antimony, which make it unacceptable for direct discharge to the environment.

5.8.1.1 Transitional Use and Closure of the Existing Effluent Treatment Plant

The existing ETP treats water seasonally, with contaminated minewater pumped to surface storage ponds year-round for subsequent summer treatment. As noted in Chapter 2, the ETP treats water to meet the MDMER (Government of Canada 2002, with updates) and comply with former Water Licence N1L2-0043 effluent quality criteria (EQC). The current treatment process consists of coagulation, pH adjustment, and settling in two large earth ponds. The treated effluent is then discharged to Baker Creek during summer (Figure 5.5-3).

The existing ETP will operate for approximately six years during mine closure. Minor improvements, if necessary, may be made to the ETP to confirm compliance with MDMER amendments; however, major changes to the existing ETP are not possible. Therefore, a new WTP will be constructed once remediation in the Core Industrial Area has begun and, contaminated soils have been removed (Section 5.4), and other site preparations are complete.

Following construction and successful commissioning of the new WTP and outfall, the existing ETP, surface storage ponds, and associated infrastructure will be decommissioned.

5.8.1.2 The New Water Treatment Plant and Outfall

It is estimated that the new WTP will be commissioned by 2026. The new WTP will operate year-round, treating influent to achieve the Measures and GMRP objectives. Effluent will be discharged via a new conveyance pipe and outfall into Yellowknife Bay via a nearshore outfall system near the existing Baker Creek mouth.

Pumping of the underground will continue to control the mine pool level to maintain access to the underground and to allow the underground to continue to act as a groundwater sink. Controlling the mine pool elevation will also keep arsenic trioxide storage areas dry during and immediately after the freeze program in the mine.

The new WTP will treat contaminated water from the mine pool. The completion of the freeze is expected to reduce the groundwater infiltration in the arsenic trioxide storage areas. Further, it is expected that the quality of the surface water runoff from the Site, which is currently treated, will improve and be suitable for direct discharge. Over the longer term, while it is expected that water from the underground may improve, it will continue to need treatment. Given this, a new WTP will remain in operation as required.

5.8.2 Pre-existing and Existing Site Conditions

5.8.2.1 Pre-existing Conditions

The water quality of Baker Creek and Yellowknife Bay prior to mining is not known. Based on the water quality of Yellowknife River, which is uncontaminated (Chapter 2), it is expected that the water was low in metals, ions and, subject to disinfection, was safe for drinking by humans and wildlife.

5.8.2.2 Existing Conditions

Since 1981, contaminated minewater has been treated on site in the existing ETP. The existing ETP surface system schematic is captured in Figure 5.5-3 and is described below.

Pumping System

Minewater will be pumped from the underground to surface by two deep well pumps at the Akaitcho interim deep well pumping station. These pumps are being installed and maintained from surface to intercept the mine pool below the 750L, and the mine pool is maintained to just below the 750L within a 0.75 m range. The mine pool includes highly contaminated water from the arsenic chambers, which is collected by pipes installed down C Shaft and B-ramp (referred to as the “high test line”). The high test line is maintained along a portion of the 750L track drive near the B-ramp system and the 7-20 scoop shop. The high test line pipes exit on the 750L at Akaitcho and drain to the adjacent mine pool where it will be managed by the Akaitcho interim deep well pumping station. The fate of the high test line at permanent closure is to be determined through future design work, with the assumption that the freeze program will manage the water from high test area post-closure (i.e., this water becomes frozen and no longer requires treatment). For additional details on the pumping redundancy system and the high test line, refer to Section 4.4 and the Water Management and Monitoring Plan (CIRNAC and GNWT 2019b).

Contaminated Water Storage

Water pumped from the underground at Akaitcho interim deep well pumping station is discharged via overland piping to the Northwest Pond. Collected site surface water is pumped to the South and Central ponds, then moves to the North Pond via a pipeline, and finally into the Northwest Pond. The Northwest Pond is the primary storage pond for Site water, and up to 650,000 m^3 of the pond is used for storage prior to treatment and release. Detailed site surface water movements are captured in the Water Management and Monitoring Plan (CIRNAC and GNWT 2019b).

Existing Effluent Treatment Plant

The existing ETP operates usually from June through September treating water per the MDMER limits (Government of Canada 2002, with updates) and discharge limits known as EQC included in the previous expired Type A Water Licence N1L2-0043 (Table 5.8-1). The existing ETP processes an average of 4,500 to 7,000 m^3/d depending on the volume of water stored at the surface in the Northwest Pond. These treatment rates are required as the plant is only operated during the summer months.

The existing ETP consists of two treatment trains operating in a duty-standby configuration, each train consists of three agitated reactor tanks in series. Influent flow from the Northwest Pond is split to enter either treatment train. The tank elevations are stepped so that gravity flow carries the water from one tank to the next. Water treatment consists of reagent chemical addition as follows:

- The supply line to Train B is fitted with an in-line static mixer where ferric sulphate is added. Flow then continues to the first reactor in Train B. Ferric sulphate can also be injected into the supply line to Train A; this line is not fitted with an in-line static mixer.
- Lime slurry is added to the first batch reactor of either train. The pH of the water leaving the first reactor tank is controlled to between 8.4 and 8.6. When the pH drops to 8.4, a pneumatic controlled pinch valve is opened and lime slurry is fed into the reactor tank until the pH reaches 8.6, at which time the pinch valve is closed.
- An anionic polymer is added to the effluent from the third batch reactor of either train.

Treated water is then released from the existing ETP to the Settling Pond and then the Polishing Pond for final treatment as follows:

- The effluent, containing water and precipitates, from the third reactor tank is decanted through a short pipeline to the north end of the Settling Pond where quiescent conditions allow the precipitates to settle out. Several metals present in the water precipitate and settle (e.g., the process precipitates the arsenic as ferric arsenate).
- The Settling Pond is separated from the downstream Polishing Pond by a permeable rockfill dyke (splitter dyke), which retains precipitates within the Settling Pond. Water from the Settling Pond flows through the dyke and/or is pumped over the dyke to the Polishing Pond.
- In the event of treatment problems, the capacity of the Polishing Pond provides an opportunity to contain water that does not meet the discharge limits and, if necessary, to pump the water back to the ETP for retreatment until acceptable limits are achieved. To achieve this, pumping of the water from the Northwest Pond would be halted and the Polishing Pond would be fed back to the ETP in a closed loop and retreated until the water was acceptable to discharge.

Effluent Discharge to Baker Creek

If the quality of water within the Polishing Pond (the Polishing Pond is contained to the north by Dam 1) is acceptable, the effluent is transferred via a syphon pipeline from the south shore of the Polishing Pond to the east shore of Baker Pond. The point of discharge is approximately mid-point in Baker Pond (Figure 5.5-3).

Table 5.8-1: Influent and Effluent Quality for the Effluent Treatment Plant

Parameters	Units	ETP Influent (2011–2018) SNP 43-21			ETP Effluent (2011–2018) SNP 43-1[a]			Applicable Effluent Limit		
		Median[a]	Average[a]	95th Percentile[a]	Median[a]	Average[a]	95th Percentile[a]	Maximum Monthly Mean	Maximum Composite Sample	Maximum Grab Sample
Field Parameters										
Field pH	-	7.6	7.6	8.0	8.3	8.1	8.5	6.5 to 9.5[b]		
Field specific conductivity	µS/cm	2,576	2,631	3,336	3,054	3,023	3,476	-	-	-
Field temperature	°C	8.7	9.4	13	17	15	22	-	-	-
Field dissolved oxygen	mg/L	11	10	11	9.4	9.7	13	-	-	-
Conventional Parameters										
pH	-	7.9	7.9	8.2	8.0	7.9	8.1	-	-	-
Specific conductivity	µS/cm	2,830	2,805	3,340	3,020	3,019	3,478	-	-	-
Hardness, as $CaCO_3$	mg/L	1,250	1,230	1,403	1,370	1,371	1,535	-	-	-
Total alkalinity, as $CaCO_3$	mg/L	174	174	187	77	77	89	-	-	-
Total dissolved solids, measured	mg/L	2,200	2,180	2,597	2,450	2,474	2,885	-	-	-
Total suspended solids	mg/L	1.6	3.1	9.0	1.2	1.4	3.4	15[b,c]	22.5[b]	30[b,c]
Total organic carbon	mg/L	7.3	7.3	8.1	5.7	5.7	6.6	-	-	-
Dissolved organic carbon	mg/L	7.0	7.0	7.7	5.6	5.5	6.1	-	-	-
Major Ions										
Bicarbonate, as $CaCO_3$	mg/L	174	174	185	80	79	90	-	-	-
Bromide	mg/L	5.6	5.5	7.3	5.5	5.5	6.9	-	-	-
Calcium	mg/L	351	346	402	399	401	458	-	-	-
Carbonate, as $CaCO_3$	mg/L	0.5	0.7	0.87	0.5	0.43	0.5	-	-	-
Chloride	mg/L	465	445	563	431	450	562	-	-	-
Fluoride	mg/L	0.2	0.2	0.2	0.2	0.2	0.2	-	-	-
Magnesium	mg/L	91	90	101	92	88	103	-	-	-
Potassium	mg/L	12	12	14	12	12	13	-	-	-
Sodium	mg/L	174	173	223	173	175	214	-	-	-
Sulphate	mg/L	885	863	943	1,115	1,111	1,220	-	-	-
Nutrients										
Nitrate	mg-N/L	2.0	2.3	3.9	1.6	1.8	3.7	-	-	-
Nitrite	mg-N/L	0.095	0.11	0.19	0.015	0.02	0.05	-	-	-
Total ammonia	mg-N/L	1.1	1.2	2.3	0.015	0.021	0.071	12[c]	-	-
Total phosphorus	mg-P/L	0.15	0.22	0.54	0.15	0.13	0.15	-	-	-
Dissolved phosphorus	mg-P/L	0.15	0.23	0.55	0.15	0.10	0.15	-	-	-
Total Metals and Metalloids										
Aluminum	mg/L	0.019	0.074	0.29	0.0082	0.0093	0.018	-	-	-
Antimony	mg/L	0.7	0.79	1.4	0.39	0.38	0.46	-	-	-
Arsenic	mg/L	28	32	64	0.3	0.29	0.35	0.5[b,c]	0.75[b]	1[b,c]
Barium	mg/L	0.044	0.043	0.054	0.016	0.016	0.019	-	-	-
Beryllium	mg/L	0.0025	0.0024	0.0025	0.00002	0.00003	0.00005	-	-	-
Bismuth	mg/L	0.00013	0.00018	0.0005	0.00005	0.000065	0.0001	-	-	-

Table 5.8-1: Influent and Effluent Quality for the Effluent Treatment Plant

Parameters	Units	ETP Influent (2011–2018) SNP 43-21			ETP Effluent (2011–2018) SNP 43-1[a]			Applicable Effluent Limit		
		Median[a]	Average[a]	95th Percentile[a]	Median[a]	Average[a]	95th Percentile[a]	Maximum Monthly Mean	Maximum Composite Sample	Maximum Grab Sample
Boron	mg/L	0.36	0.36	0.43	0.34	0.34	0.37	-	-	-
Cadmium	mg/L	0.00026	0.0003	0.00062	0.000026	0.000031	0.000065	-	-	-
Cesium	mg/L	0.00054	0.00059	0.00096	0.00025	0.00025	0.00033	-	-	-
Chromium	mg/L	0.005	0.0048	0.005	0.00025	0.00028	0.00067	-	-	-
Cobalt	mg/L	0.05	0.049	0.081	0.005	0.0056	0.01	-	-	-
Copper	mg/L	0.0046	0.0052	0.009	0.012	0.012	0.017	0.3[b,c]	0.45[b]	0.6[b,c]
Iron	mg/L	0.21	0.29	0.68	0.05	0.046	0.091	-	-	-
Lead	mg/L	0.00087	0.0011	0.0031	0.00005	0.00009	0.00024	0.2[b,c]	0.3[b]	0.4[b,c]
Lithium	mg/L	0.035	0.036	0.05	0.032	0.031	0.039	-	-	-
Manganese	mg/L	0.57	0.55	0.76	0.012	0.015	0.037	-	-	-
Mercury	mg/L	0.000005	0.000004	0.000005	0.0000025	0.0000027	0.000005	-	-	-
Molybdenum	mg/L	0.021	0.021	0.024	0.022	0.022	0.025	-	-	-
Nickel	mg/L	0.041	0.041	0.073	0.032	0.033	0.045	0.5[b,c]	0.75[b]	1[b,c]
Rubidium	mg/L	0.0087	0.0088	0.011	0.01	0.01	0.012	-	-	-
Selenium	mg/L	0.00025	0.0003	0.0005	0.00076	0.0008	0.001	-	-	-
Silver	mg/L	0.005	0.0048	0.005	0.00005	0.00005	0.00008	-	-	-
Strontium	mg/L	4.2	4.2	5.2	3.6	3.6	4.8	-	-	-
Thallium	mg/L	0.1	0.1	0.1	0.000034	0.000037	0.00005	-	-	-
Tin	mg/L	0.015	0.015	0.015	0.0001	0.000086	0.0001	-	-	-
Titanium	mg/L	0.01	0.012	0.027	0.005	0.009	0.022	-	-	-
Uranium	mg/L	0.0073	0.0074	0.009	0.0039	0.0039	0.0048	-	-	-
Vanadium	mg/L	0.015	0.015	0.015	0.0011	0.0012	0.0026	-	-	-
Zinc	mg/L	0.056	0.062	0.13	0.006	0.0062	0.0095	0.5[b,c]	0.75[b]	1[b,c]
Other										
Radium-226	Bq/L	-	-	-	0.005	0.006	0.012	0.37[b]	0.74[b]	1.11[b]
Cyanide	mg/L	0.013	0.014	0.024	0.003	0.003	0.006	1.0[b]	1.5[b]	2.0[b]
Oil and grease	mg/L	0.5	0.6	1.0	0.5	0.5	0.5	-	-	5.0[c]

a) Data reported as less than the detection limit were adjusted to half the detection limit when calculating statistics.
b) Metal Mining and Effluent Regulations (Government of Canada 2002, with updates).
c) Effluent quality criteria from the former Type A Water Licence N1L2-0043, Part D, Item 9.
ETP = effluent treatment plant; SNP = Surveillance Network Program; µS/cm = microsiemens per centimetre; mg-N/L = milligrams nitrogen per litre; mg-P/L = milligrams phosphorus per litre; Bq/L = bequerels per litre; $CaCO_3$ = calcium carbonate; "-" = no data or no guideline.

5.8.3 Closure Objectives and Criteria

As outlined in Chapter 1, an overall goal of the GMRP is to minimize the release of contaminants from the Site to the surrounding environment. To help achieve this, closure objectives relating to water treatment and the effluent outfall have been developed.

The closure objectives for water treatment and outfall systems incorporate the applicable EA Measures (MVEIRB 2013; INAC 2014; Section 5.8.4.1). In particular, Measures 14 and 15 set water quality objectives for the WTP to reduce arsenic in the treated effluent to 10 µg/L. In addition to treating arsenic to 10 µg/L, effluent from the WTP will be required to be non-acutely toxic, meet MDMER limits, or more protective EQC for parameters of potential concern (POPCs). The proposed EQC (Table 5.8-10) were developed such that water quality objectives will be met in Yellowknife Bay at the edge of the mixing zone defined by the MVEIRB (Measures 12 and 13). Further information is provided in Section 5.8.4 and the EQC report (CIRNAC and GNWT 2019a). The closure objectives and criteria for WTP and Outfall are captured in Table 5.8-2.

For clarity, EQC are end-of-pipe limits and water quality objectives are in-lake targets (receiving environment). The term “water quality objectives” refers to a collective list of water quality objectives that are applicable for use in Yellowknife Bay, including site-specific water quality objectives developed for the Site, generic aquatic life water quality guidelines (CCME 1999 [with updates to 2018]), published water quality guidelines from other jurisdictions (BCMOE 2017), and Canadian drinking water quality guidelines (Health Canada 2017). Selected water quality objectives are provided in the EQC report (CIRNAC and GNWT 2019a). Further information on the mixing zone in Yellowknife Bay is provided in Sections 5.8.4 and 5.8.5.

Table 5.8-2: Water Treatment Plant Closure Objectives and Criteria

Closure Objectives	Closure Activity	Closure Criteria	Monitoring/Maintenance and Inspection
WTP1. Treated minewater to Yellowknife Bay is discharged at a designated near-shore outfall. The outfall location is selected such that site-specific water quality objectives are met in the receiving environment	• Commission and operate the new WTP to treat minewater and discharge treated water year-round at the near shore outfall pipe. • Construct engineering controls at the outfall pipe location to prevent sediment scour and remobilization. • Decommission, demolish, and dispose of existing ETP, associated surface/settling ponds (see Section 5.6), and related infrastructure (see Sections 5.9).	• **WTP1-1** Treated water discharge to Baker Creek ceases and effluent is discharged to Yellowknife Bay • **WTP1-2** Site-specific water quality objectives are met in Yellowknife Bay, in the vicinity of the outlet of Baker Creek (edge of the mixing zone). • **WTP1-3 –** Install outfall at minimum water depth of 6m • *Refer Objective SI1* for removal of ETP. • *Refer to Objective WTP2 for details on meeting effluent quality criteria at the end of pipe*	*Active Remediation Phase:* • As-built engineering drawings signed and sealed by Qualified Professional and submitted to MVLWB. • Aquatic Effects Monitoring Program – sediment monitoring • Surveillance Network Program – Water quality monitoring at edge of mixing zone. *Adaptive Management and Post-Closure Phase:* • Surveillance Network Program – Water quality monitoring at edge of mixing zone.

WTP2. Water treatment plant discharge meets approved effluent quality criteria, derived such that site-specific water quality objectives are met in the receiving environment	• Commission and operate the new WTP to treat minewater using a treatment train with ion exchange
	• Operate the WTP to meet the effluent quality criteria / design specifications (see EQC Report for details)
		• **WTP2-1** Treated effluent is not acutely toxic, i.e., no acute lethality to *Daphnia* or rainbow trout from exposure to WTP discharge
		• **WTP2-2** Average arsenic concentrations in WTP discharge are at or below 10 µg/L.
		• **WTP2-3** Approved effluent quality criteria for parameters of potential concern, as prescribed by the Water Licence, are met.
		• **WTP2-4** Site-specific water quality objectives are met in Yellowknife Bay, in the vicinity of the outlet of Baker Creek (edge of the mixing zone)
		• **WTP2-5** Outfall does not scour or re-suspend arsenic from sediments during operation.
			Active Remediation, Adaptive Management and Post-Closure Phases:
			• Operational Monitoring Plan
			  • Quality control program for the treated water
			• Surveillance Network Program at end-of-pipe and edge of mixing zone
			  • Water and sediment quality
			  • Toxicity
			• Aquatic Effect Monitoring Program – water quality monitoring related to site specific water quality objectives and effluent plume

WTP3. Water treatment plant waste is disposed of in a controlled manner, so it is not, and will not become, a source of contamination to the environment	• Dispose spent ion exchange media, sludge, and other process residuals in the on-site landfill in a separate engineered cell (see Objectives L1 and L2). • Test materials to go into the on-site landfill according to the Toxicity characteristic leaching procedure (TCLP)	• **WTP3-1** Spent ion exchange media, sludge, and other process residuals comply with the non-hazardous classification of spent media per the EPA's SW-846 Test Method 1311: Toxicity Characteristic Leaching Procedure prior to disposal in landfill cell, meeting total arsenic of 2.5 mg/L prior to landfill disposal • *Refer to Objectives L1 and L2* related to runoff from landfill	*Active Remediation, Adaptive Management and Post-Closure Phases:* • Operational Monitoring Plan - Spent ion exchange media, sludge, and other process residuals testing • See objectives L1 and L2, Surveillance Network Program Surface and groundwater quality sampling

WTP = water treatment plant; ETP = effluent treatment plant; MVLWB = Mackenzie Valley Land and Water Board; EQC = effluent quality criteria; L = level; EPA = United States Environmental Protection Agency

5.8.4 Consideration of Closure Options and Selection of Closure Activities

This section summarizes key decisions made to date, and development of options to select specific closure activities for the new WTP and outfall. A number of options were reviewed to select the new WTP process and associated systems. Project assessments considered the following aspects:

- background to the water treatment design, including required influent treatment schedule, mine pool equalization storage, and the location of the WTP and associated systems
- incoming water quality and quantity, and outgoing water quality to meet the EQC
- available treatment methods for the WTP to meet the EQC
- location of the outfall and ability to meet water quality objectives in the receiving environment

5.8.4.1 Project Measures and Objectives at Closure

As noted in Chapter 1, the new WTP and outfall will be designed to meet, or contribute to the achievement of, numerous Report of EA measures (MVEIRB 2013; INAC 2014). The measures are repeated here because of their importance in guiding the development of the new WTP and outfall:

- Measure 14 - The Developer will add an ion exchange [referred to as adsorption with media in this document] process to its proposed water treatment process to produce water treatment plant effluent that at least meets Health Canada drinking water standards (containing no more than 10 µg/L of arsenic), to be released using a nearshore outfall immediately offshore of the Giant Mine site instead of through the proposed diffuser.
- Measure 15 - The Developer and regulators will design and manage the Project so that, with respect to arsenic and any other contaminants of potential concern [POPCs]:

  1) Water quality at the outfall will meet the Health Canada Guidelines for Canadian Drinking Water Quality.

  2) The following water quality objectives in the receiving environment are met:

  a. Water quality changes due to effluent discharge will not reduce benthic invertebrate and plankton abundance or diversity beyond 200 m of the outfall.

  b. Water quality changes due to effluent discharge will not harm fish health, abundance or diversity.

  c. Water quality changes due to effluent discharge will not adversely affect areas used as drinking water sources.

  d. There is no increase in arsenic levels in Yellowknife Bay water at 200 m from the outfall.

  e. There is no increase in arsenic levels in Yellowknife Bay sediments at 500 m from the outfall.

- Measure 16 - Before construction, the Developer will model re-suspension of arsenic from sediments and resulting bioavailability in the vicinity of the outfall. If the modelling results indicate that the outfall may re-suspend arsenic from sediments, the Developer will modify the outfall design until operation does not cause re-suspension of arsenic from sediment.

- Measure 17 - Before operating the outfall, the Developer will design and implement a comprehensive aquatic effects monitoring program that is sufficient to determine if the water quality objectives listed in Measure 15 are being met. This program will:

  1) At a minimum, be able to identify any accumulation of arsenic over time in the water, sediment, or fish in the receiving environment.

  2) Include appropriate monitoring locations near Ndilǫ, in Back Bay and in Yellowknife Bay, with a focus on areas in the vicinity of the outfall and areas used by people.

  3) Include the establishment of a baseline for aquatic effects in Back Bay before beginning project construction and installation of the outfall.

  4) Be developed according to AANDC Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories, June 2009, with corresponding action levels and management response framework.

The key drivers behind the selection of closure activities for water treatment and outfall systems are shown in Figure 5.8-1. The detail on the drivers is discussed in the following sections.

Water Treatment – Key Drivers for Closure Decisions

Higher ↑ Priority ↓ Lower

Drivers

Meet regulatory requirements:
- Measures 14, 15, 16 & 17
- MDMER
- Board Requirements

Input from Surface Design Engagement process & affected parties

Align with other remediation activities

Design Considerations

- Arsenic in effluent treated to 10µg/L
- Effluent to be non-acutely toxic, meet MDMER and EQC
- Protect aquatic life (meet SSWQOs)
- Minimize arsenic resuspension at outfall
- Outfall location preference of affected parties (ice conditions, preference for location near Baker Creek since already impacted)
- Water Modelling (Quality and Quantity)
- All activities that effect the Quality and Quantity of water is linked including Underground, TCAs, pits, contaminated soils, borrow, landfill, freeze, Surface water management, Baker Creek.

Selected Options

Decommission existing ETP

New WTP to be constructed with:
- additional step for Arsenic removal
- Continuous, year-round operation
- Minewater sourced near C-shaft

Single-pipe nearshore Outfall to be constructed in Yellowknife Bay near outlet of Baker Creek

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2018-12-19
DESIGNED	H. Machtans
PREPARED	D. Pahl
REVIEWED	J. Amphlett
APPROVED	J. Amphlett

PROJECT

Giant Mine Remediation Project

TITLE

KEY CONSIDERATIONS DRIVING THE SELECTION OF CLOSURE ACTIVITIES FOR WATER TREATMENT AND OUTFALL SYSTEMS

REV. 0

FIGURE 5.8-1

5.8.4.2 Background

Closure of the Existing Effluent Treatment Plant

The existing ETP system must be decommissioned as it cannot be retrofitted to meet GMRP water quality objectives, specifically the requirements of Measure 14 (Section 5.8.3). Furthermore, surface storage of contaminated water is not considered a suitable option for Mine remediation, and as the ETP treats seasonally using surface temporary water storage, it cannot be retained.

New Water Treatment Plant

The DAR (INAC and GNWT 2010) indicated that all contaminated water was to be directed to the underground, a new WTP would be constructed, all treatment by-products would be managed on site, and treated water would be discharged to Yellowknife Bay. The need to avoid using surface storage for contaminated minewater drove the decision towards storing water underground. Concerns about large fluctuations in the mine pool level led to the selection of year-round treatment. Year-round treatment precludes the use of Baker Creek and necessitates discharge to Yellowknife Bay.

- **Selection of a continuous water treatment process**—Surface storage of contaminated water is not considered a suitable option for Site remediation. Contaminated water will be directed underground for equalization storage in the mine pool (Section 5.8.5.2). While the mine pool will be used to attenuate spring freshets, the treatment process must operate on a year-round basis to prevent significant fluctuations in the mine pool water level, which could lead to ground instabilities and release further contaminants. The objective of using temporary water equalization storage underground within the mine is to manage the flow to the WTP, such that the annual volume requiring treatment will be processed at a reasonably consistent rate each month.
- **Selection of outfall location**—Baker Creek does not flow on a year-round basis. Any discharge to the creek can only occur when the creek is flowing. Otherwise icing and other water management issues may occur, risking flooding of the arsenic chambers. Therefore, discharge from the new WTP will be directed to Yellowknife Bay to allow the new WTP to operate on a year-round basis; this is in line with the requirements of Measure 14 (Section 5.8.1.2).
- **Selection of WTP location**—The location of the new WTP, and associated deep well pump system, was selected to be the C Shaft area. This area was selected as it centralizes the long-term site infrastructure elements.

5.8.4.3 Water Treatment Plant Design Process

The options for the WTP design were assessed through an iterative process involving the definition and calculation of the EQC and assessment of the quality and quantity of the influent during the various anticipated phases for operation (including current, active remediation, adaptive management and post-closure operating conditions). It also included assessment of various processes within the WTP system to meet the EQC, and testing to confirm the EQC and water quality objectives are achieved. Further details on this are provided in Section 5.8.5, which describes the design basis for the WTP.

Water Treatment Options to Achieve the Effluent Quality Criteria

To meet the project EQC, specifically the treatment of arsenic to no more than 10 µg/L of arsenic, as well as other POPCs, consideration was given to a number of treatment options. Three potential treatment processes were further explored to reduce arsenic concentrations (AECOM 2013a) as follows:

- **Option 1 – Clarification and Evaporation (zero discharge)**

  Option 1 would require influent from the mine to be pre-treated with clarification and then evaporated; as all the water would be evaporated, there would be no discharge to the environment. Water would evaporate into the atmosphere first, and then the solids from the clarification and evaporation processes would be collected and disposed of in the on-site Landfill. Evaporation equipment would require significant amounts of energy. For the assessment, a diesel boiler was assumed for calculation of the energy requirements. This creates a significant operating cost. Environmental effects from emissions from the energy generation (including greenhouse gas emissions) would be significant. This option, summarized in Table 5.8-3, was not selected.

Table 5.8-3: Summary of Clarification and Evaporation (zero discharge) Treatment Option

Potential Primary Treatment Process Trains	Residual Management Consideration	Treatment Objective	Result
Influent pumping, chemical addition (oxidation, coagulation, pH adjustment), clarification (HDS), granular media and evaporation.	Solids that accumulate on the evaporator, and dewatered solids from the clarification process, would be collected and hauled to the landfill.	0 µg/L	Not selected. The key benefit of this option is no discharge. However, a substantial amount of energy is needed to evaporate the volume of water, with a resulting high operating cost, environmental impact, and sludge / dried particulates for landfill disposal.

HDS = high density sludge; µg/L = micrograms per litre.

- **Option 2 – Treatment Process Train with Reverse Osmosis**

  This option uses a treatment train, as presented in the DAR (INAC and GNWT 2010), with reverse osmosis for final polishing of the influent to achieve an arsenic level of 5 µg/L in the treated water. This option would produce a brine waste stream, assumed to be 30% of the total treated water flow that needs to be managed. The options considered for the disposal of the brine waste product are a deep discharge within the mine, evaporation, or potentially re-cycle to the head of the treatment process. Life cycle costs for the alternative brine management approaches differ significantly. It is expected that a deep discharge within the mine of the reverse osmosis brine waste is not a sustainable long-term approach and is therefore not recommended. Evaporation equipment for brine management would require energy (assumed sourced from the hydro-grid or from a diesel generator for reliability), creating a significant operating cost and significant environmental impact due to emissions from the energy generation (including greenhouse gas emission), and the need for ongoing disposal of residuals from the brine evaporation. This option, summarized in Table 5.8-4, was not selected.

Table 5.8-4: Summary of Treatment Process Train with Reverse Osmosis Option

Potential Primary Treatment Process Trains	Residual Management Considerations	Treatment Objective	Result
Influent pumping, chemical addition (oxidation, coagulation, pH adjustment), clarification (HDS), granular media, adsorptive media, reverse osmosis, pH adjustment, treated water pumping.	Brine disposal from reverse osmosis options including discharge to the bottom of the mine and evaporation.	5 µg/L	Not selected. This option will be able to consistently achieve high quality treated water. However, the disposal of the brine from the reverse osmosis process is complex and costly.

HDS = high density sludge; µg/L = micrograms per litre.

- **Option 3 – Treatment Process Train with Ion Exchange (adsorption)**

  This option uses a treatment train, as presented in the DAR (INAC and GNWT 2010), with ion exchange for final treatment of the water to achieve an arsenic level of 10 µg/L in the treated water. This option is summarized in Table 5.8-5, and was the option selected for the Site.

Table 5.8-5: Summary of Treatment Process Train with Ion Exchange

Potential Primary Treatment Process Trains	Residual Management Considerations	Treatment Objective	Result
Influent pumping, chemical addition (oxidation, coagulation, pH adjustment), clarification (HDS), granular media (biofilter), adsorptive media, pH adjustment, treated water pumping.	There will be more filter backwash to manage on site and the disposal of the exhausted adsorption media.	10 µg/L	Selected. This option offers a treatment process capable of achieving the treatment objectives.

HDS = high density sludge; µg/L = micrograms per litre.

Assessment of Selected Option

Option 3 – Treatment Process Train with Ion Exchange (adsorption) was assessed and refined in the supporting documents listed below. The selected option is described in Section 5.8.5.

- *Giant Mine Water Disposal – Information Request Response, Further Technical Information for Arsenic Removal* (AECOM 2013b) recommended relevant testing be completed to confirm the operating parameters and the efficiency of adsorptive media at the Site.
- *The Giant Mine Remediation Project Pilot Plant Options Analysis* (AECOM 2018) assessed pilot plant options for using adsorption with media to treat the water to achieve 10 µg/L for arsenic. The report also discussed the need to identify available treatment systems that are effective in reducing arsenic and other POPCs (including antimony) to the concentrations expected as EQC. It explained that assessment of a

treatment system for procurement, commissioning, operation, and maintenance issues, including the identification of advantages and disadvantages of each option, is required. The report closed by indicating that screening studies to assess likely preferred technologies are recommended.

Further screening and testing is currently underway to finalize recommendations for the adsorptive media to be considered in the new WTP. To date this work program has included off-site testing to evaluate various media products provided by participating vendors using benchtop laboratory testing, the results from the testing were used to evaluate products and selected the media suppliers were invited to participate in the on-site testing. Details of on-site testing are described in Section 5.8.5.

5.8.4.4 Outfall Design Process

The outfall design was selected based on a number of inputs, primarily affected party engagement, outfall location, cooling requirements of the discharged effluent, and the achievement of water quality objectives. The sub-sections below discuss each of these aspects and summarize the assessment of each option using defined evaluation criteria and an option risk matrix.

Information on the options assessment, including the location and type of outfall, has been reviewed in a number of previous studies. Key reports were:

- *Preliminary Design Report for the Giant Mine Water Treatment Plant* (Appendix 5.8A)
- *Giant Mine Remediation – New Effluent Treatment Plant Outfall Location Options Analysis* (Appendix 5.8B)

5.8.4.3.1 Outfall Affected Party Consultation

Affected party engagement was referenced in the options assessment process for the outfall location and other outfall considerations. Engagement with various affected parties included four meetings and follow-up discussions with the respective affected party groups (AECOM 2017a), further detailed as follows:

- Consultation Meeting No. 1: Giant Mine Working Group Presentation (afternoon); GMAC (evening); 13 September 2016, Yellowknife, NWT
- Consultation Meeting No. 2: YKDFN and GMAC presentation (all day); 10 November 2016, Yellowknife, NWT
- Consultation Meeting No. 3: Giant Mine Working Group Presentation; 8 December 2016, teleconference
- Consultation Meeting No. 4: GMRP Public Forum; 1 March 2017, Yellowknife, NWT

The general plan for the consultation sessions was as follows: introduce the purpose of the outfall and review preliminary design criteria and site constraints, obtain feedback from affected parties (for preferred locations, additional site constraints, constructability issues, and environmental concerns), provide ongoing and transparent feedback of the outfall evaluation criteria scoring and rankings, and present the recommended outfall option to project-affected parties.

Meeting minutes were prepared for the affected party consultations and are included in the outfall location options analysis (AECOM 2017a). Preferred aspects for the outfall design and location from the affected party consultation sessions included a desire for components of the GMRP be centralized in one location, minimizing further disturbance from the Site (especially for arsenic-contaminated areas), selecting an outfall location with

deeper shoreline depths to minimize the development of thin ice, minimizing environmental impacts (including fish migration and habitat), as well as creating a highly visible and safe outfall area for lake users.

5.8.4.3.2 Outfall Location Options

Four proposed outfall locations were selected based on affected party input (Section 5.8.4.3.1), previous design reports, and the EA measures (MVEIRB 2013), specifically Measure 14 (Section 5.8.1.2), as well as considering existing site constraints such as the Foreshore Tailings Area and water depth.

The four locations were Location A – vicinity of Baker Creek, Location B – south of Foreshore Tailings Area, Location C – north of Foreshore Tailings Area, and Location D – mouth of Yellowknife River. Advantages and disadvantages for each of the four locations is provided in Table 5.8-6.

Table 5.8-6: Summary of Outfall Options Assessment

Options	Advantages	Disadvantages
Location A In the vicinity of Baker Creek outfall	• Proposed conveyance pipe alignment follows existing site road right-of-way or old water supply main alignment • Existing disturbance area nearby access road (former Highway 4); active cooling building at site of old water pump house, if needed • Easy access from site access road for inspections and maintenance • Active cooling infrastructure located near Bluefish power line • Minimal footprint and short in-lake outfall • Minimal impact on existing land use and future land use • Location preferred by Yellowknives Dene First Nation	• Longer conveyance pipe length than Locations B & C (approximately 1,500 m) • Construction activities may have impact on lake users • Proximity to area frequently used by others (boat launch, marina)
Location B Nearshore discharge south of Foreshore Tailings Area	• Closest option to the proposed WTP • Shortest alignment for treated water conveyance piping • Minimal impact on existing land use • Outside of City of Yellowknife lease boundary	• Additional rock blasting and/or grading required for active cooling infrastructure pad • Power line would need to be extended to proposed location • Conceptual conveyance pipe alignment travels through alternative borrow source • Construction of new site access road for inspections and maintenance • Longer in-lake outfall than Location A
Location C Nearshore discharge north of Foreshore Tailings Ares	• Second closest option to the proposed WTP • Minimal impact on existing land use • Outside of City of Yellowknife lease boundary	• Additional rock blasting or grading required for active cooling infrastructure pad • Power line would need to be extended to proposed location • Conveyance pipe alignment would need to divert around South Pond • Construction of new site access road for inspections and maintenance • Longer in-lake outfall than Locations A and B
Location D Nearshore discharge in Yellowknife Bay	• Discharge point well away from lake users • Takes advantage of higher flow rates in north Yellowknife Bay for better mixing potential • Discharge point well away from Foreshore Tailings Area • Outside of City of Yellowknife lease boundary • Mouth of Yellowknife River avoided by snow-machine traffic	• Longest conceptual conveyance pipe length • Conveyance pipe alignment would need to divert around several tailings areas • Risk of outfall siltation in the Yellowknife River mouth • Long in-lake outfall

WTP = water treatment plant.

Outfall Water Temperature

Water temperature of the treated effluent was highlighted as a potential safety concern during the Environmental Assessment as well as during the preliminary design (AECOM 2012). The safety concern relates to the water being discharged at a higher temperature than the receiving waterbody and potentially causing ice thinning in winter months. Two options, passive cooling and active cooling, were considered for cooling the water prior to discharge (pre-cooling), and a no-cooling option was also considered (AECOM 2012, 2017a).

- **Passive cooling option**—The preliminary design for passive cooling of the water involved discharging the treated water into a lakeside holding cell, where heat would naturally release to the atmosphere prior to entering the lake. The procedure would use minimal energy. Since the passive cooling cell would be built lakeside, this option would require permanent alteration of the shoreline; therefore, the passive cooling option scored and ranked lower in the options evaluation compared with the active cooling and no-cooling options. For a passive cooling option, detailed design would need to consider construction and maintenance access, blasting requirements, lake-bottom dredging requirements, and material sources for the holding cell perimeter berms.
- **Active cooling options**—Three options were considered with the active cooling options:
- **Dry cooler (heat exchanger)**—A glycol loop would transfer heat to an exterior radiator where a fan would drive outside air through the radiator. This option would be effective during the winter months, but would not provide sufficient cooling in the spring when there are warm days.
- **Mixing water**—This option would draw water from the lake and mix with the treated water prior to discharging back into the lake. A 3:1 (lake to effluent) mix at 100 L/s flow would drop the temperature by 2°C.
- **Refrigeration**—To sufficiently cool the maximum short-term water discharge flow of 34 L/s (AECOM 2012) on warm spring days, a large refrigeration system would be required. A smaller refrigeration system could be implemented if the treated water output can be reduced during warm spring days.
- For the active cooling options, the detailed design would need to consider construction and maintenance access, utility requirements, and ongoing operations and maintenance costs. For Locations B, C, and D, there would be additional costs to construct utilities and equipment access.
- **No cooling option:** A no-cooling option was also considered with the outfall evaluation criteria for the proposed outfall locations. The main concern with this, as previously noted, is the potential for ice thinning due to the warmer water discharging into the lake. However, the benefits include reduced footprint; minimal shoreline disturbance; lower potential for sedimentation during construction and operation, and reduced design, construction, and operating cost. Further, the requirement to locate the outfall near shore as per Measure 14, instead of further from shore in open areas of Yellowknife Bay, reduced the potential risk of thin ice to snowmobiles, skiers, and other members of the public (outlined below). Finally, the outfall location has sufficient depth to allow the pipe to be angled downward to reduce ice scour, as much as practicable without sediment scour.

Mixing and Water Quality Assessment

A water quality mixing study was completed to evaluate predicted mixing and dispersion in Yellowknife Bay for the four potential outfall locations. The results of the submerged pipe outfall assessment (AECOM 2017a) were as follows:

- A submerged single port outfall at Locations A, B, C, and D was estimated to provide enough mixing of effluent in Yellowknife Bay for parameter concentrations to meet aquatic life and drinking water quality guidelines at a distance of 200 m from the end-of-pipe, with the exception of total arsenic, for which concentrations will meet 10 µg/L of arsenic at the end-of-pipe.
- For a submerged single port outfall, dilution factors (i.e., mixing) at Locations A, B, and C were estimated to be similar to one another and greater than dilution factors at Location D.
- The plumes generated from a single port outfall are not expected to interact with the shoreline of Yellowknife Bay. The outfall placement, orientation and depth of installation is designed to prevent interaction with the Yellowknife Bay shoreline. Modelling predicts the plume to be directed into Yellowknife Bay and to move toward north Yellowknife Bay based on local currents (CIRNAC and GNWT 2019a).
- Using an outfall with a port diameter of 273 mm and placing the outfall at a greater depth in Yellowknife Bay is expected to provide improved mixing of effluent, especially at locations close to the shore (e.g., 10 m distance). Refer to Section 5.8.5.5 for additional design criteria.

Outfall Evaluation Criteria and Risk Matrix

For the four outfall locations, active pre-cooling, passive pre-cooling, and no cooling of the effluent prior to discharge into Yellowknife Bay were assessed, leading to a total of 11 assessed outfall options.

An evaluation criteria exercise was completed on November 16, 2016 as part of the outfall preliminary design work involving AECOM, Golder, PSPC and CIRNAC. The evaluation criteria were organized into three main categories: construction feasibility, environmental, and social considerations and community impact. The main categories were then sub-categorized and weighted in an evaluation matrix respective to each criterion's anticipated risk. The evaluation criteria and risk matrix are further detailed in the Outfall Location Options Analysis (AECOM 2017a). The overall score and rankings for each of the 11 outfall options considered are provided in the Table 5.8-7.

Table 5.8-7: Outfall Options Rankings

Outfall Option	Description	Overall Score	Ranking
A-3	Location A In vicinity of Baker Creek discharge (no cooling)	860	1
B-3	Location B Nearshore discharge south of Foreshore Tailings Area (no cooling)	820	2
A-1	Location A In vicinity of Baker Creek outfall w/ active cooling	800	3
C-3	Location C Nearshore discharge north of Foreshore Tailings Area (no cooling)	765	4
B-1	Location B Nearshore discharge south of Foreshore Tailings Area w/ active cooling	760	5
C-1	Location C Nearshore discharge north of Foreshore Tailings Area w/ active cooling	705	6
D-2	Location D Nearshore discharge in Yellowknife Bay (no cooling)	555	7
A-2	Location A In vicinity of Baker Creek outfall w/ passive cooling	550	8
D-1	Location D Nearshore discharge in Yellowknife Bay w/ active cooling	510	9
C-2	Location B Nearshore discharge south of foreshore tailings w/ passive cooling	495	10
B-2	Location C Nearshore discharge north of foreshore tailings w/ passive cooling	490	11

Note: passive cooling not assessed at Location D.

Summary

Location A (in the vicinity of Baker Creek) with no cooling was chosen as it scored the highest in the options analysis. See Figure 5.5-13 for a conceptual view of location and layout. This location and no-cooling option has the following benefits:

- satisfies the location preference of several affected party groups per the community engagement sessions (e.g., restrict project impacts in one location, i.e., do not spread contamination around)
- provides adequate mixing to achieve water quality objectives
- utilizes existing services and access points
- utilizes existing nearshore location for the outfall, which avoids impacting new area for installation of the pipe
- is at a location near shore that is readily signable if ice thinning is observed
- is adjacent to steeply graded shoreline, which reduces the required in-lake pipe length
- lower estimated design, construction and operating costs with no-cooling option

5.8.5 Engineering Work

5.8.5.1 Interim Operation of the Existing Effluent Treatment Plant

As noted in Section 5.8.1.1, there will be an interim period during which other remediation work will be completed in the Core Industrial Area which will then allow the new WTP to be constructed and commissioned. During this period, the existing ETP will be operated; operation will follow current practices (Section 5.8.2.2).

On the basis of data from the last five years, the current ETP can continue to operate until approximately 2026 provided upgrades are made. Both civil work upgrades to raise Dam 1 as well as process upgrade options aimed at improving the minewater effluent quality produced from the ETP, are being considered and will be assessed in future design work.

The ETP can meet MDMER, and with modification, is expected to meet the new lower MDMER discharge limits expected in 2021. The current influent and effluent relative to MDMER discharge criteria are summarized in Table 5.8-1; the proposed EQC for the existing ETP are listed in Table 5.8-8.

Table 5.8-8: Proposed Effluent Quality Criteria for the Existing Effluent Treatment Plant

Parameter	Units	Proposed Effluent Quality Criteria for Existing ETP[(a)]		95th Percentile Treated Effluent Concentration at SNP 43-1 (2011–2018)[(a)]		Predicted Future Treated Effluent Concentration – Existing ETP[(a)] (2019–2026)	
		Maximum Average Concentration	Maximum Grab Sample Concentration	Average	95th Percentile	Average	95th Percentile
pH	-	6.5 to 9.0		8.1	8.5	n/a	n/a
Total suspended solids	mg/L	15	30	1.4	3.4	n/a	n/a
Unionized ammonia	mg-N/L	0.5	1.0	Not calculated	Not calculated	n/a	n/a
Total arsenic	mg/L	0.3	0.6	0.29	0.35	0.3[(b)]	0.3[(b)]
Total copper	mg/L	0.03	0.06	0.012	0.017	0.011	0.014
Total lead	mg/L	0.003	0.006	0.00009	0.00024	0.00015	0.00018
Total nickel	mg/L	0.1	0.2	0.033	0.045	0.037	0.042
Total zinc	mg/L	0.1	0.2	0.006	0.009	0.005	0.007
Radium-226	Bq/l	0.37	1.11	0.006	0.012	n/a	n/a
Cyanide	mg/L	0.03	0.06	0.003	0.006	n/a	n/a
Total petroleum hydrocarbons	mg/L	3	5	Not measured	Not measured	n/a	n/a

(a) Refer to Effluent Quality Criteria Report (CIRNAC and GNWT 2019a) for more information.

(b) Future concentrations from the existing ETP for arsenic in treated effluent will meet the MDMER limit of 0.3 mg/L prior to discharge to the receiving environment.

n/a = not applicable; ETP = effluent treatment plant; SNP = Surveillance Network Program; MDMER = Metal and Diamond Mining Effluent Regulations.

This ETP will be replaced once the new long-term treatment facility is constructed. Following successful operation of the new WTP for one year, the ETP and associated infrastructure will be decommissioned. The decommissioning approach for buildings is detailed in Section 5.9.

5.8.5.2 Water Treatment Plant

This section describes the design and activities associated with the new WTP and near shore outfall at the Site. It is based on the preliminary design report (AECOM 2012), with additional engineering work to align with the ongoing work across the GMRP based new data from the EQC Report (CIRNAC and GNWT 2019a). Where more recent data was available at the time of writing the CRP, these have been shown in this section as design details under development / subject to future engineering work.

Design Inputs – Water Supply and Quality

Pumping System

Influent to the new WTP will be sourced from a new dual deep well pump system near the C Shaft area. The wells will be drilled from surface, intersecting the mine workings below the 750L to allow control of the water level in the mine pool. Each well will contain a 100 HP submersible turbine pump, which will include a variable speed drive, so it can be matched to inflows and plant needs.

The mine pumping systems will be reliably and carefully controlled to avoid interruptions or short-term fluctuations that would affect the performance of the plant. The pumping systems will be operated, maintained, and replaced from surface and will not require access to the underground mine.

Volume and Rate of Water to be Treated

The two key design criteria for the construction of the WTP are the total annual flows into the mine and the maximum instantaneous flows for the WTP to process. These values form the basis of the design parameters listed in Table 5.8-9. These volumes of water require treatment to maintain the minewater at 750L (-77 m amsl).

The estimated annual flows into the mine (flows rounded from AECOM 2012)* are:

- 630,000 m^3/yr (short-term average flow)
- 825,000 m^3/yr (short-term wet year peak flow)
- 405,000 m^3/yr (long-term average flow)
- 520,000 m^3/yr (long-term wet year peak flow)

* Note, there are design specifications which are under development.

Wet Year Peak Flow

The annual mine groundwater and infiltration increases in a wet year to a short-term wet year peak month flow of 280,173 m^3/month (136 L/s including downtime and contingency) and a long-term wet year peak month flow of 127,818 m^3/month (62 L/s including downtime and contingency)*.

Instead of establishing a WTP with design capacity to handle the wet year peak month flows of 136 L/s, equalization storage within the mine will be used. Approximately 177,000 m^3 of storage will be provided for early wet years to accommodate seasonal storage of water. For details on the impact of equalization storage and management of the minewater level, refer to Section 5.1 Underground.

Using the equalization storage, the estimated maximum flows for the WTP to process (AECOM 2012), with 10% plant downtime (e.g., membrane cleaning, backwashing) and a 20% contingency, are as follows: The maximum flow into the new WTP based on the short-term peak wet year flow is estimated to be 34 L/s, and The long-term average flow is estimated at 17 L/s. The short-term design flow will be accommodated by two parallel trains designed for 17 L/s each.

Average Flow

Once the arsenic chambers are frozen, the site surface is remediated, and the reduced long-term flow rates are established, the average treatment flow rate required will be 16.7 L/s. Therefore, the process trains will operate in a duty-standby configuration (i.e., only one train in operation) to accommodate the design 17 L/s flow.

The maximum month storage volume required in the long term is 0 m^3 as on a month by month basis the treatment plant has capacity to treat and maintain the minewater level.

Table 5.8-9: Design Criteria for Giant Minewater Treatment Plant

Flows and Storage	
Item	**Specification [(a)]**
Short-term (until freeze achieved)	
Average treatment flow rate	26.0 L/s
Peak wet year flow rate	33.9 L/s
Maximum equalization storage volume required	177,071 m^3
Long-term (post-freeze)	
Average treatment flow rate	16.7 L/s
Peak wet year flow rate	21.3 L/s
Maximum equalization storage volume required	0 m^3

(a) Source: AECOM 2012.

Note: Future engineering work will address revised assumptions from effluent quality criteria, minewater influent, water treatment plant design, etc.

Influent Quality

The WTP will source water from the C Shaft area. The EQC report (CIRNAC and GNWT 2019a) outlines the assumed future WTP influent quality which the WTP will receive, and these data form the basis of the design of the WTP. The influent data are provided in Table 5.8-10.

Effluent Quality Criteria

The proposed EQC for the new WTP are listed in Table 5.8-10 (CIRNAC and GNWT 2019a); the new EQC for arsenic, copper, lead, nickel, and zinc are notably lower than the current limits for the existing ETP and MDMER limits. For example, the new EQC for total arsenic of 0.01 mg/L is much lower than the current MDMER limit for total arsenic is 0.5 mg/L, which was presented in the DAR and in AECOM (2012).

Water Treatment Plant Design

The WTP will treat the future WTP influent to meet the EQC, as presented in Table 5.8-10, to contribute to the achievement of the GMRP objectives and criteria (Section 5.8.3). The values for EQC were selected such that they meet the Measures from the EA, are protective of the receiving environment, and are reasonably and consistently achievable (CIRNAC and GNWT 2019a). To achieve this, a new WTP consisting of a treatment train using ion exchange (adsorption with media) will be built. A schematic of the treatment process is provided in Figure 5.8-1, and the process stages are described in the following paragraphs.

Chemical Pre-treatment

Equalization and mixing of the influent with chemicals will be completed to support the sustainable operation of the downstream treatment processes. The chemical pre-treatment process will be similar to that of the existing ETP to precipitate metals and arsenic to traditional mining treatment standards. The specific chemicals and dosage rates will be determined based on final plant design and operation. This treatment stage is represented by the following stages in the flow schematic (Figure 5.8-1):

- blending/equalization tank
- addition of coagulant and polymer, oxidant, and lime slurry
- reactor tank
- addition of polymer

Clarification and Filtration

Following the reactor tank stage explained above, clarification and filtration will be provided. The clarification will be a gravity sedimentation process designed to remove a minimum of 95% of the particulate material from the process stream. The primary purpose of the clarification step is to condition the water sufficiently that the filtration process can function sustainably. Following clarification, the effluent will be filtered for further removal of the particulate matter from the process stream. Filtration will be designed to remove the majority of the remainder of the particulate matter from the process stream. The filtered water will have 99% of the particulate matter removed.

The precipitated waste material will be removed from the clarification process as a dilute sludge for further thickening. The other waste will be filter backwash, which will be typically an order of magnitude more dilute than clarifier sludge. These two waste process streams will be blended, equalized, and treated to further thicken the sludge while providing an effluent that is suitable for recycling to the head of the primary treatment process. The sludge will be dewatered to produce a sludge cake, meeting the definition of solid waste, such that can be disposed of in a landfill (see Section 5.8.5.5 for additional details). The clarification and filtration process is represented in the flow schematic (Figure 5.8-1) by the following stages:

- high rate clarification
- filtration

Adsorption with Media – Specific Stage for Arsenic and Antimony Removal

Once the water stream is filtered, the final step is adsorption with media designed to target the removal of arsenic and antimony, as well as a pH adjustment. The adsorptive media is an ion exchange process that targets the removal of arsenic and antimony while allowing the other ions present in the process flow to pass. The specific chemical and dosage rates for the pH adjustment will be determined based on final plant design and operation. The adsorptive media is typically sensitive to the pH of the water, so provision for controlling the pH in the process is provided. This process is represented by the following stages in the flow schematic (Figure 5.8-1):

- pH adjustment
- arsenic adsorptive media

Further on-site pilot testing of the adsorptive media began in 2018, and will be used to further evaluate the suitability of media products for use in the WTP. These tests will be completed to finalize selection of the adsorptive media to be potentially used at the site. The results from the testing will be used to evaluate products and provide a recommendation for the media suppliers that could be used to meet the performance targets of the WTP.

Instrumentation and Testing

The new WTP will be fully automated based on process control logic developed from the pilot test results and engineering requirements developed during detailed design. The correct function of the WTP will be monitored with on-line analytical instrumentation. If measurements are recorded that do not meet the targeted water quality objectives, the control system will generate alarms to initiate operator intervention. Depending on the alarm category, the flow through the WTP will be stopped until the operator has remediated the concern.

The design of the control system will be configured in a fashion to confirm the quality of the treated water prior to discharge. Non-compliant water will be retained on site for further treatment. The direct monitoring for arsenic with an on-line analytical instrument is not typical, but some of the monitoring approaches being planned for the WTP are:

- pH monitoring throughout the treatment process
- turbidity and particle counters
- conductivity

In addition to the on-line analytical instrumentation, grab samples will be collected on a routine schedule for analysis at an off-site laboratory. These samples will provide quality assurance data to confirm that the instrumentation and automation within the WTP is meeting the design objectives for the treated water quality.

Supporting Infrastructure

The WTP has a wide variety of supporting infrastructure components, including Interim treated water storage with two below-ground concrete cells, each capable of storing approximately 800 m^3 of effluent. These will be used to monitor the effluent and equalize variations in effluent quality prior to discharge. Water from the effluent storage cell will be used to supply process and backwash water. One backwash pump, process pump, and return/recycle pump will be provided per train, and the pumping system will be designed such that each pump can supply either train. Similarly, up to four discharge pumps will be available to transfer the effluent to the outfall. In the event of a malfunction in the WTP resulting in the production of water that does not meet the discharge criteria, the water would be contained in the holding system. The water could be recycled through the plant or returned to underground storage.

The infrastructure will also include process and mechanical piping, utilities including sewerage holding tanks (to be pumped and disposed of off site), electricity, process and mechanical equipment, instrumentation and controls, heating, ventilation, and air conditioning requirements, electrical systems, and civil and structural systems such as the building and foundations.

The preliminary design report (AECOM 2012) describes the full WTP system design. The report includes preliminary engineering design documents for the treatment train option. It also details how the selected configuration of the WTP combines important elements of water treatment with a small footprint and the ability to respond to variations in influent and flow fluctuations.

The preliminary design report (Appendix 5.8A; AECOM 2012) describes the full WTP system design. The report includes preliminary engineering design documents for the treatment train option. It also details how the selected configuration of the WTP combines important elements of water treatment with a small footprint and the ability to respond to variations in influent and flow fluctuations.

Figure 5.8-2: Giant Mine Remediation Project New Water Treatment Plant Process Flow Schematic

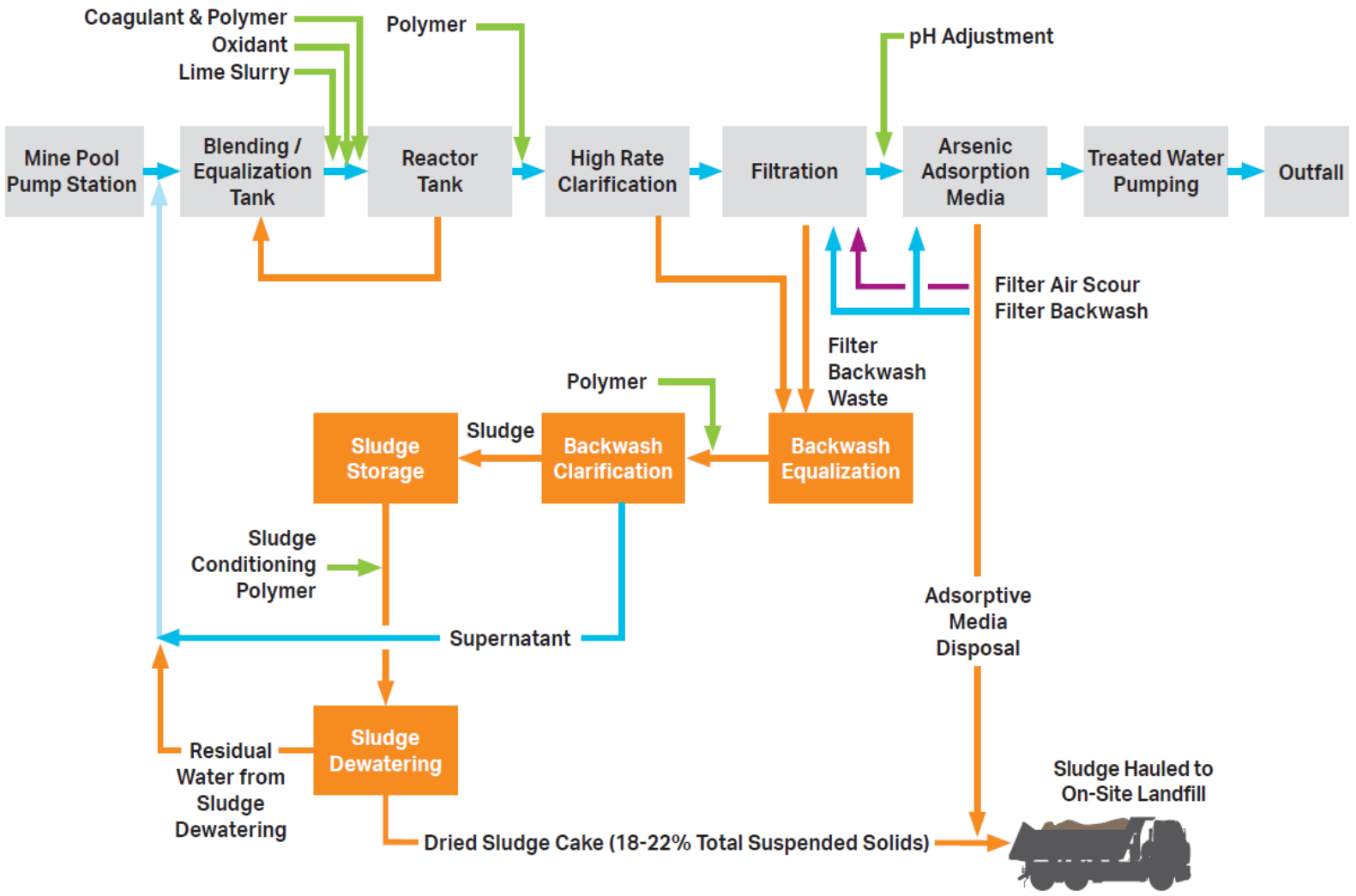


Table 5.8-10: Summary of Modelled Water Chemistry Results for the Future Water Treatment Plant and Effluent Quality

Parameters	Units	Future WTP Influent (2026–2040) [a]			Future WTP Effluent (Only Existing Removal Efficiency Applied) (2026–2040) [a]			MDMER [b]			EQC for the WTP (2026–2040)	
		Median	Average	95th percentile	Median	Average	95th percentile	Maximum Monthly Mean	Maximum Composite Sample	Maximum Grab Sample	Monthly Average Concentration	Maximum Grab Concentration
Field Parameters [c]												
Field pH	-	-	-	-	8.3	8.1	8.5	-	-	-	-	-
Field-specific conductivity	µS/cm	-	-	-	3,054	3,023	3,476	-	-	-	-	-
Field temperature	°C	-	-	-	6.0	6.0	6.0	-	-	-	-	-
Field dissolved oxygen	mg/L	-	-	-	9.4	9.7	13	-	-	-	-	-
Conventional Parameters [c]												
pH	-	-	-	-	-	-	-	6.5 to 9.5			6.5 to 8.0	
Specific conductivity	µS/cm	-	-	-	-	-	-	-	-	-	-	-
Hardness, as $CaCO_3$	mg/L	737	692	1,037	737	692	1,037	-	-	-	-	-
Total alkalinity, as $CaCO_3$	mg/L	-	-	-	-	-	-	-	-	-	-	-
Total dissolved solids, calculated	mg/L	1,220	1,122	1,691	1,220	1,122	1,691	-	-	-	-	-
Total suspended solids	mg/L	-	-	-	-	-	-	15	23	30	15	30
Total organic carbon	mg/L	-	-	-	5.7	5.7	6.6	-	-	-	-	-
Dissolved organic carbon	mg/L	-	-	-	5.6	5.5	6.1	-	-	-	-	-
Major Ions												
Calcium	mg/L	199	188	290	199	188	290	-	-	-	-	-
Chloride	mg/L	127	122	216	127	122	216	-	-	-	-	-
Fluoride	mg/L	0.094	0.092	0.12	0.094	0.092	0.12	-	-	-	-	-
Magnesium	mg/L	57	54	77	57	54	77	-	-	-	-	-
Potassium	mg/L	7.0	6.6	9.8	7.0	6.6	9.8	-	-	-	-	-
Sodium	mg/L	71	66	95	71	66	95	-	-	-	-	-
Sulphate	mg/L	499	458	747	499	458	747	-	-	-	-	-
Nutrients												
Nitrate	mg-N/L	0.93	1.1	2.1	0.93	1.1	2.1	-	-	-	-	-
Nitrite	mg-N/L	0.01	0.013	0.028	0.01	0.013	0.028	-	-	-	-	-
Total ammonia	mg-N/L	0.18	0.16	0.28	0.18	0.16	0.28	-	-	-	-	-
Unionized ammonia	mg-N/L	-	-	-	-	-	-	0.5	-	1.0	0.5	1.0
Total phosphorus	mg-P/L	0.042	0.042	0.073	0.042	0.042	0.073	-	-	-	-	-
Dissolved phosphorus	mg-P/L	-	-	-	-	-	-	-	-	-	-	-
Total Metals												
Total aluminum	mg/L	0.02	0.021	0.024	0.0086	0.0089	0.01	-	-	-		
Total antimony	mg/L	0.56	0.63	1.1	0.27	0.30	0.52	-	-	-	0.2	0.3
Total arsenic	mg/L	16	22	49	0.01 [d]	0.01 [d]	0.01 [d]	0.3	0.45	0.6	0.01	0.02
Total barium	mg/L	0.019	0.018	0.023	0.0073	0.0071	0.0092	-	-	-	-	-
Total beryllium	mg/L	0.000066	0.000085	0.00018	0.000066	0.000085	0.00018	-	-	-	-	-
Total bismuth	mg/L	0.000039	0.000038	0.000049	0.000039	0.000038	0.000049	-	-	-	-	-
Total boron	mg/L	0.29	0.29	0.33	0.28	0.28	0.32	-	-	-	-	-
Total cadmium	mg/L	0.00022	0.00025	0.00038	0.000038	0.000043	0.000065	-	-	-	-	-

Table 5.8-10: Summary of Modelled Water Chemistry Results for the Future Water Treatment Plant and Effluent Quality

Parameters	Units	Future WTP Influent (2026–2040) [a]			Future WTP Effluent (Only Existing Removal Efficiency Applied) (2026–2040) [a]			MDMER [b]			EQC for the WTP (2026–2040)	
		Median	Average	95th percentile	Median	Average	95th percentile	Maximum Monthly Mean	Maximum Composite Sample	Maximum Grab Sample	Monthly Average Concentration	Maximum Grab Concentration
Total cesium	mg/L	-	-	-	-	-	-	-	-	-	-	-
Total chromium	mg/L	0.00047	0.00045	0.00054	0.00047	0.00045	0.00054	-	-	-	-	-
Total cobalt	mg/L	0.017	0.021	0.04	0.002	0.0024	0.0046	-	-	-	-	-
Total copper	mg/L	0.0072	0.010	0.02	0.007	0.010	0.020	0.3	0.45	0.6	0.024	0.033
Total iron	mg/L	0.18	0.19	0.25	0.036	0.039	0.05	-	-	-	-	-
Total lead	mg/L	0.0048	0.0048	0.0078	0.00082	0.00081	0.0013	0.1	0.15	0.2	0.003	0.008
Total lithium	mg/L	0.023	0.023	0.033	0.022	0.022	0.031	-	-	-	-	-
Total manganese	mg/L	0.15	0.14	0.19	0.003	0.0028	0.0038	-	-	-	-	-
Total mercury	mg/L	-	-	-	-	-	-	-	-	-	-	-
Total molybdenum	mg/L	0.011	0.01	0.017	0.011	0.01	0.017	-	-	-	-	-
Total nickel	mg/L	0.027	0.036	0.069	0.018	0.025	0.047	0.5	0.75	1	0.1	0.15
Total rubidium	mg/L	-	-	-	-	-	-	-	-	-	-	-
Total selenium	mg/L	0.00047	0.0005	0.00086	0.00047	0.0005	0.00086	-	-	-	-	-
Total silver	mg/L	0.000019	0.00002	0.000026	0.000019	0.00002	0.000026	-	-	-	-	-
Total strontium	mg/L	1.4	1.2	1.8	1.3	1.2	1.7	-	-	-	-	-
Total thallium	mg/L	0.000037	0.000036	0.000056	0.000037	0.000036	0.000056	-	-	-	-	-
Total tin	mg/L	0.00015	0.00017	0.0003	0.00015	0.00017	0.0003	-	-	-	-	-
Total titanium	mg/L	0.0022	0.0033	0.0078	0.0022	0.0033	0.0078	-	-	-	-	-
Total uranium	mg/L	0.0036	0.0037	0.0055	0.0019	0.0019	0.0029	-	-	-	-	-
Total vanadium	mg/L	0.00097	0.0011	0.002	0.00097	0.0011	0.002	-	-	-	-	-
Total zinc	mg/L	0.28	0.35	0.71	0.022	0.028	0.057	0.5	0.75	1	0.08	0.16
Other												
Radium-226	Bq/L	-	-	-	-	-	-	0.37	0.74	1.11	0.37	1.11
Cyanide	mg/L	-	-	-	-	-	-	0.50	0.75	1.0	0.5	1
Total petroleum hydrocarbons	mg/L	-	-	-	-	-	-	-	-	-	3	5

a) Future WTP concentrations were calculated based on underground model Base Case results, as "Influent" (no removal efficiency applied) and "Effluent" (present-day removal efficiency applied). Refer to CIRNAC and GNWT (2019a) for more information.

b) Government of Canada. 2017. Proposed Amendments to the Metal Mining Effluent Regulations. Canada Gazette, Part I, Vol. 151, No. 19. Available at: http://www.gazette.gc.ca/rp-pr/p1/2017/2017-05-13/pdf/g1-15119.pdf. Accessed November 2017.

c) Field measurements and concentrations of dissolved organic carbon and total organic carbon for the future WTP effluent were obtained from monitoring data at Surveillance Networking Program site 43-1 (SNP 43-1) from July 2011 to August 2018; effluent temperature at the new WTP will be maintained at 6 °C year-round based on a recommendation from AECOM at the Model Workshop (September 2017).

d) For the future WTP effluent, the modelled concentrations of arsenic were capped at 10 µg/L for arsenic.

mg-N/L = milligrams nitrogen per litre; mg-P/L = milligrams phosphorus per litre; µg/L = micrograms per litre; µS/cm = microsiemens per centimetre; Bq/L = bequerels per litre; NTU = nephelometric turbidity units; $CaCO_3$ = calcium carbonate; "-" = no data or no guideline; median = median value from dataset; 95th percentile = 95th percentile value from dataset; WTP = water treatment plant; MDMER = Metal and Diamond Mining Effluent Regulations; EQC = effluent quality criteria

5.8.5.3 Outfall Design

As outlined in Section 5.8.4, treated water that meets the discharge criteria will be pumped through a pipeline to a new nearshore outfall system and into Yellowknife Bay. This section describes the preliminary engineering design for the selected outfall at Location A – vicinity of Baker Creek, with no cooling. Figure 5.5-13 and Figure 5.8-2 shows the schematics of the outfall system, and Figure 5.8-3 shows the map of the modelled outfall mixing zone.

Conveyance Pipeline

Treated effluent will be conveyed via pipeline to the outfall for discharge to Yellowknife Bay. The conveyance pipeline preliminary design is as follows (AECOM 2012):

- Alignment is assumed to follow the old water supply main alignment to Yellowknife Bay.
- Assumed Pipe details: high density polyethylene (HDPE) pipe with a diameter of 273 mm (nominal diameter of <10 inches, standard dimension ratio 13.5 to resist possible pressure surge and vacuum from the pump, diameter and wall thickness sizing based on a velocity in the pipeline between 0.26 and 0.58 m/s with expected flow rate through the pipeline between 15 and 34 L/s, one valve and tee junction at either end of the pipeline to allow maintenance and repair, and one additional tee junction at the high point for fitting an air valve.
- Soil cover over pipeline for freeze protection.

Further details on pump design and the sizing will be confirmed with detailed design once the alignment, length, and pressure head of the conveyance pipeline are finalized. Also considered with detailed design will be provision of accesses to insert probes for inspection and cleaning the internal walls of the pipe.

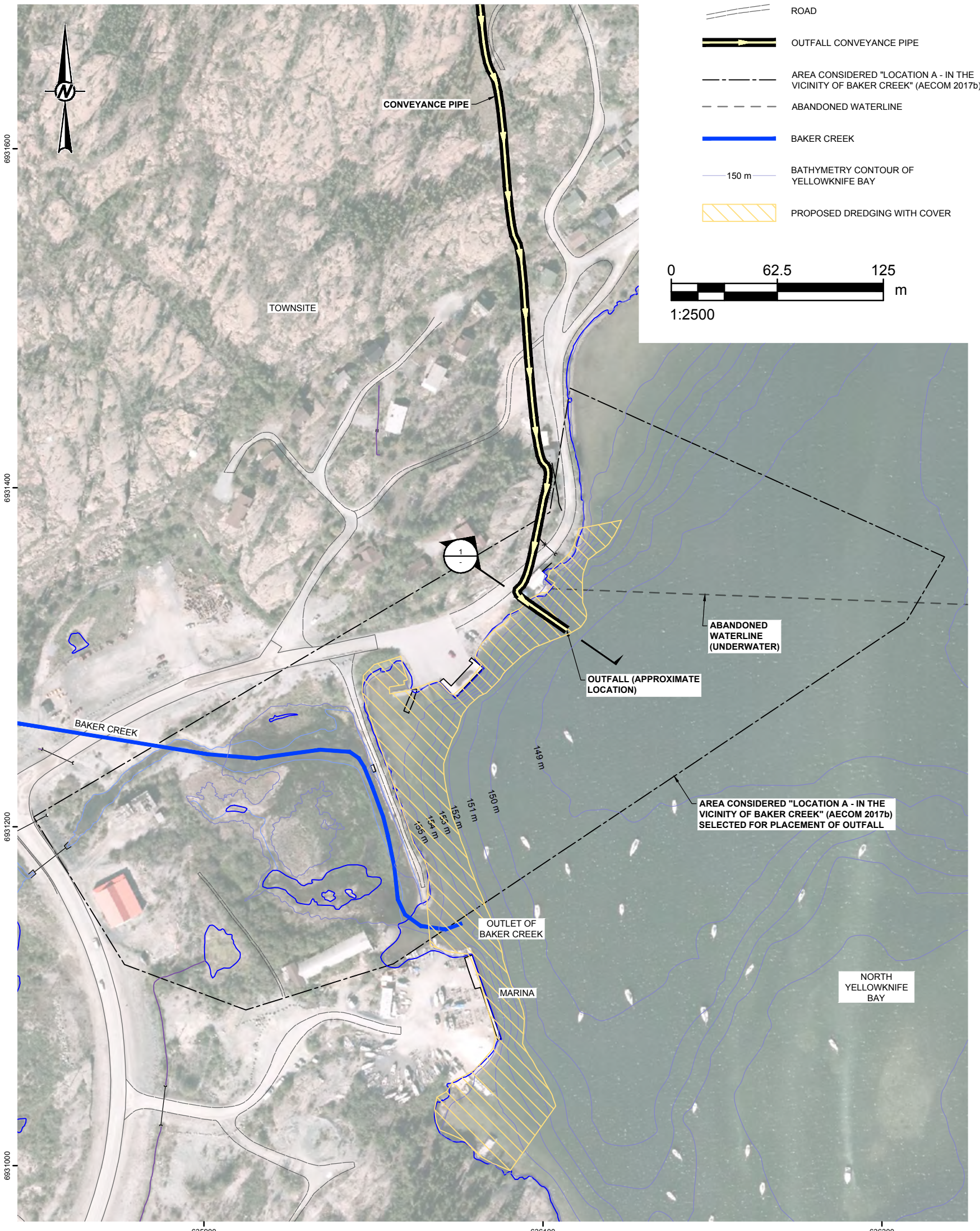
Outfall

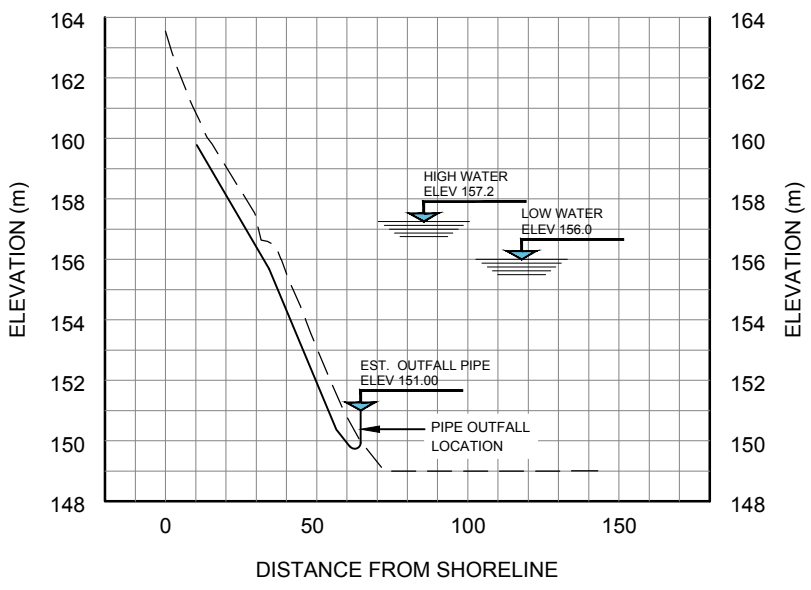
Preliminary design for the single port outfall at Location A includes the following (AECOM 2017a):

- The in-lake outfall will be relatively short HDPE pipe, terminating at a 6 m depth of water to position the single port to avoid disturbing bottom sediments and ice and allow sufficient freeboard below the anticipated ice level).
- The nearshore outfall pipe will be weighted to overcome buoyancy to the extent required.
- Signage and barriers will be installed at the outfall along the shoreline and potentially in the water/ice to warn lake users of infrastructure in the area.
- The outfall line will likely be armoured to prevent ice damage and scour (e.g., riprap and bank embedment), and to meet engineering and fisheries habitat requirements.

Future engineering activities that will need to be confirmed with detailed design of the outfall (AECOM 2017a). this includes review of dredging and/or cover of the lake bottom at the outfall installation to mitigate sediment re-suspension and meet Measure 16 (Section 5.8.1.2).

P:\60540587\900-CAD_GIS\910-CAD\30-FIGURES\H\01\60540587-FIG-01-0000-H-0583.dwg





SECTION 1

SCALE 1:2500 (H)
SCALE 1:250 (V)

PROJECT
Giant Mine Remediation Project

TITLE
PIPE OUTFALL LOCATION

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

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-23
DESIGNED	S. Marsanich
PREPARED	C. Eros
REVIEWED	G. Woollett
APPROVED	R. Schmidtke

REV. 0
FIGURE 5.8-3

640000

B4 PIT
SETTLING POND
POLISHING POND
JO-JO LAKE
NORTH POND
Baker Pond
CALCINE POND
CENTRAL POND
B1 PIT
B2 PIT (UBC)
BROCK PIT
SOUTH POND
MILL POND
C1 PIT
A1 PIT
A2 PIT
Yellowknife Bay

DETAIL MAP

Yellowknife Bay

6930000

0 100 200
1:5,000 METRES

640000

LEGEND

- PUMPHOUSE OUTFALL LOCATION
- WATER TREATMENT OUTFALL PIPE
- WATER LINE (UNDERWATER)
- BAKER CREEK OUTLET AND PUMPHOUSE OUTFALL MIXING ZONE
- BREAKWATER
- ISOBATH (1 m INTERVAL)
- HIGHWAY
- ROAD
- GIANT MINE PROJECT BOUNDARY
- PIT BOUNDARY

REMEDIATION STRATEGY

- ENGINEERED COVER/DREDGING
- FORESHORE TAILINGS COVER

WATER DEPTH (m)

0
22

0 0.5 1
1:30,000 KILOMETRES

REFERENCE(S)
HYDROLOGY AND TRANSPORTATION DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 11

PROJECT
Giant Mine Remediation Project

TITLE
GIANT MINE OUTFALL LOCATION AND MIXING ZONE

PROPONENT
Crown-Indigenous Relations and Northern Affairs Canada
Relations Couronne-Autochtones et Affaires du Nord Canada
Government of Northwest Territories Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-23
DESIGNED	TH
PREPARED	AA
REVIEWED	HILARY MACHTANS
APPROVED	BJORN WEEKS

REV. 0
FIGURE 5.8-4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm
0

PATH: I:\20\13-13-1377\13-1377-0116\Mapping\MXD\CRP_250001313779115_25000_Fig_5_8_4_MixingZones_Overview_Rev0.mxd PRINTED ON: 2019-01-23 AT: 2:48:59 PM

Outfall Mixing Zone

As outlined in MVLWB et al. (2017), the size of a mixing zone may be established on a case-by-case basis depending on factors including effluent discharge (e.g., quality, flow, outfall design) and the receiving waters (e.g., quality, water uses). The size of mixing zones should be large enough to allow for initial dilution and mixing of the effluent, but small enough to avoid causing adverse effects to the receiving waterbody as a whole. Water quality objectives are typically applied at the edge of the mixing zone (MVLWB 2011), recognizing that conditions in the mixing zone should not cause acute toxicity to aquatic organisms. As noted above, Measure 15 specifies that "Water quality changes due to effluent discharge will not reduce benthic invertebrate and plankton abundance or diversity beyond 200 metres (m) of the outfall." …and that "There is no increase in arsenic levels in Yellowknife Bay water at 200 m from the outfall." The GMRP has interpreted this to mean that a mixing zone with a radius of 200 m is acceptable for protection of water uses in Yellowknife Bay. As well, Measures 12 and 13 specify that water quality objectives should be met in the vicinity of the outlet of Baker Creek.

As outlined above, the decision to place the outfall in the vicinity of Baker Creek was based on affected party engagement in which the majority of affected parties clearly communicated that they prefer the project in part to keep the cumulative effects of contaminants from the Site in one place and keep any possible thin ice areas, should they develop, close to shore in a visible area.

The selected location also simplifies monitoring; to meet both Measures 15 (protect of water uses 200 m from the outfall), and Measures 12 and 13 (meet water quality objectives in the vicinity of Baker Creek), the GMRP is proposing a combined mixing zone that includes inflows from both the WTP effluent and Baker Creek. The conceptual combined mixing zone for Giant Mine is illustrated in Figure 5.8-3. The mixing zone area identified in red in Figure 5.8-3 is defined by the extent of two overlapping mixing zones with a radius of 200 m into Yellowknife Bay from the outlet of Baker Creek and the selected outfall location, respectively.

Water quality objectives will be met at the edge of the combined mixing zone; therefore, EQC were calculated for the WTP such that the influence of Baker Creek water quality in the mixing zone incorporated (CIRNAC and GNWT 2019a). The influence of Baker Creek in the mixing zones results in lower EQC for many parameters than if the influence of Baker Creek was not included in the mixing zone because the assimilative capacity of the mixing zone is reduced due to Baker Creek inflow, or if the influence of Baker Creek was ignored. A combined mixing zone allows cumulative impacts of the mine site on Yellowknife Bay to be measured and assessed in one area, and for the calculation of EQC that are reasonably and consistently achievable for POPCs under various conditions. The proposed EQC are listed in Table 5.8-10. A full description of the modelling and development of the EQC and the water quality objectives is found in the EQC Report (CIRNAC and GNWT 2019a).

The Aquatic Effects Monitoring Program for Yellowknife Bay (CIRNAC and GNWT 2019c) and the Surveillance Network Program (CIRNAC and GNWT 2019d) outline the monitoring program for the mixing zone area and Yellowknife Bay receiving environment.

5.8.5.4 Water Treatment Residuals – Waste Disposal

Waste Production in the Water Treatment Plant

The WTP will treat contaminated minewater and in turn will continually produce residual wastes consisting of spent ion exchange media, sludge, and other process residuals.

As represented in Photo 5.8-1, the residual flow from clarification and filtration processes will be equalized and clarified, and dewatered. Both the arsenic and the metal removal units can be operated with a sludge underflow recycle, which is directed back to the upstream reactor tank to increase the sludge solids content. The effluent is returned to the head of the primary treatment process and the dried sludge cake is hauled to the landfill.

To achieve a sludge suitable for disposal in the on-site landfill a dedicated thickening, storage, and dewatering unit is included in the design. This unit processes the dried sludge cake to achieve a concentration of 18% to 22% of total suspended solids. Generally, at 18% total suspended solids sludge cake can be accepted by a non-hazardous waste landfill; furthermore, at 18% total suspended solids, the material is manageable with standard earthmoving equipment. Sludge dewatering will use gravity thickeners for residual thickening and mechanical dewatering processes.

Photo 5.8-1: Example of De-watered Sludge – City of West Kelowna, Powers Creek Water Treatment Plant, De-watered Sludge Bin



The WTP will also produce waste adsorptive media, from the ion exchange process, for disposal in the landfill.

Non-hazardous Waste Landfill Facility - Waste Disposal

The wastes produced from the WTP will be disposed of in the on-site in the landfill, within the purpose built WTP process residuals landfill cell. Details of the landfill are captured in Section 5.10. The waste would also be suitable for off-site disposal if a facility was identified and approved to accept the waste.

Waste Parameters - Sludge

Existing ETP wastes have been assessed as a surrogate for the waste stream residuals which will require on-site disposal from the WTP. It is expected that the waste streams generated by the new WTP will differ from the existing WTP wastes, reflecting the additional chemical reagents used, greater volumes of sludge, and generation of spent filter media as a waste. Despite these differences, the existing ETP waste is considered a reasonable surrogate as a similar treatment process is being adopted in the new WTP. The coagulation chemicals, and the influent constituents will remain the same which is expected to result in a sludge with similar properties.

Two samples of the sludge currently being generated from the existing ETP were analyzed for leachate characteristics. These samples were analyzed following Environmental Protection Agency SW-846 Test Method 1311: Toxicity Characteristic Leaching Procedure. The analytical results were compared against the NWT Guideline for Hazardous Waste Management (GNWT 2017), Schedule I: Leachate Disposal Standards for Solid Waste/Process Residuals. As indicated in the non-hazardous waste disposal options waste uncertainty study (AECOM 2017b), there were no concentrations of leachable metals above the NWT disposal regulations, and the majority of the analyzed metal parameters reported were below the laboratory detection limits. Based on these data, the sludge that is currently generated is considered non-hazardous.

Additional testing of the sludge is planned to be completed with future engineering work.

Waste Parameters – Ion Exchange Media

Further testing is being undertaken to verify that spent adsorptive media is suitable for disposal in the on-site landfill. During 2018, an off-site and on-site testing program began to evaluate media products which are potentially suitable for use in the new WTP. The testing program will be completed to finalize selection of the adsorptive media to be potentially used at the site. The results from the testing will be used to evaluate products and provide a recommendation for the media suppliers that could be used to meet the performance targets of the WTP. As part of this program the ion exchange media will be analyzed following Environmental Protection Agency SW-846 Test Method 1311: Toxicity Characteristic Leaching Procedure. This further testing is planned will also confirm the volume of waste adsorptive media to be disposed in the landfill.

Waste Quantities

The quantity of water treatment sludge requiring disposal will decrease over time, as the concentration of contaminants in the mine pool decreases, but is expected to remain great enough to require on-site disposal in the landfill as described in Section 5.10. The landfill will be designed to accommodate the wastes with some contingency.

The estimated quantity of sludge is 275 m^3/yr, totaling 27,500 m^3 over 100 years (AECOM 2017b). The sludge will be composed mostly of iron hydroxides, with ferric arsenate, ferric antimonate, calcium sulphate (formed in the reaction vessel), and any residual suspended particulate matter present in the influent. Initial estimates for the volumes of waste adsorptive media are between 40 to 200 m^3/yr.

5.8.6 Final Site Conditions

During and after remediation, contaminated minewater will continue to be treated. A WTP will remain operational until treatment of water is no longer required to meet EQCs. The final site conditions for the WTP and outfall are shown in the system schematics in Table 5.8-2 and Table 5.8-3. The locations shown in these figures are preliminary only and are subject to change during detailed design. The final site conditions are also shown in Figure 3.4-1, illustrating the TCA covers, filled pits, realigned Baker Creek, and decommissioned ETP building area.

Pumping System

Contaminated minewater will be pumped from the underground from a new deep well system installed in the C Shaft area. This is discussed in detail in Section 5.8.5.

New Water Treatment Plant

The new WTP will be built within the fenced Core Industrial Area, in an area of existing disturbance. The WTP will meet the EQC. (Table 5.8-10) such that discharge meets the Measures from the EA, is protective of the receiving environment (i.e., Yellowknife Bay), and is reasonably and consistently achievable (CIRNAC and GNWT 2019a). Discharge of treated effluent to Baker Creek will cease, and treated effluent will be discharged via the nearshore outfall in Yellowknife Bay.

Outfall

The new discharge location for treated effluent will be in the vicinity of the mouth of Baker Creek (Figures 5.8 2 and 5.8-3). This is an area of existing disturbance selected based on affected party preference (Section 5.8.4.3.1), the Report of EA Measures (Section 5.8.1.2), and additional design criteria including depth to bottom.

An above-ground pipeline will run from the WTP to the outfall. There will be minimal aboveground infrastructure for the conveyance pipe, limited to pipe valves, inspection and cleanout ports, freeze protection system equipment (if required), and signage. A relatively short length of in-lake pipe will lead to a subsurface outfall at approximately 6 m depth. There will be barriers and signage near the outfall location.

5.8.7 Uncertainties

Engineering designs for the closure plan are currently at a conceptual level. As such, the basis for estimates and analyses include engineering judgement. Additional design works are planned to address key assumptions and reduce relevant uncertainties and these will be developed whilst the existing ETP continues to operate.

The key uncertainties that affect the WTP and outfall are summarized below in Table 5.8-11, together with the engineering studies and other activities planned to address these uncertainties.

Table 5.8-11: List of Uncertainties Related to Water Treatment

Uncertainty	Potential Impact of Uncertainty	Plan to Address Uncertainty
The future quality of the influent to the WTP (i.e., proportion of metals, salts and nutrients) is uncertain. Water quality in the mine pool is variable with depth, and data from C Shaft are limited. As outlined in Chapter 2, parameter concentrations are generally higher at deeper locations in the mine. The exact location (i.e., mine level) in C Shaft from which WTP influent will be pumped is uncertain.	The EQC are expected to be reasonably and consistently achievable. If the WTP influent varies notably from current and predicted concentrations or model predictions, the WTP may require modifications to continue to meet EQC.	A three-dimensional model of the underground is underway, to further refine underground minewater quality and flow dynamics. Focused monitoring underground will continue to build a multi-year dataset for quality of water in the C Shaft and fill data gaps. Further investigation is underway into water treatment contingencies, and adsorptive media selection (refer to pilot plant testing program below) to understand the range of conditions under which EQC can be met.
Performance of adsorptive media is uncertain given a wide range of possible WTP input chemistry outside the range of standard water treatment plant influent.	The adsorptive media performance will affect the design of the WTP.	Work is underway to address the uncertainty and define adsorptive medias that target both arsenic and other parameters of potential concern (e.g., antimony) effectively. Relevant testing includes off-site screening tests and on-site pilot plant testing of alternatives. This work will identify effective media for the site water characteristics and determine the life expectance of the media. Results will be available by Jan 2019.
The suitability of the ion exchange / adsorption media to be disposed of in the landfill is uncertain. Specifically, if the leachable arsenic concentrations are less than 2.5 mg/L, the limit for classifying the material as non-hazardous waste, they can be deposited in a landfill.	If the studies determine the waste residuals need to be treated as hazardous waste (e.g., the residuals contain leachable levels of arsenic above the 2.5 mg/L limit), an alternative disposal method for the WTP process residuals will be required.	Pilot testing of candidate adsorption media is planned during the summer of 2018. Part of the testing program is to confirm that the exhausted media complies with the EPA's SW-846 Test Method 1311: Toxicity Characteristic Leaching Procedure. Only adsorptive media that complies will be selected for the full-scale WTP, so the exhausted media can be disposed of in the landfill.
The mixing near the outfall is uncertain. Minimum (conservative) dilution factors from model the model exercise were used to calculate EQC.	If mixing near outfall is less than anticipated, site-specific water quality objectives may not be met at the edge of the mixing zone.	In-lake monitoring will continue near the proposed outfall location (EEM/MDMER and project monitoring) to build the dataset in this area. A plume delineation study will be completed once the outfall is installed.

WTP = water treatment plant; EPA = Environmental Protection Agency; EQC = effluent quality criteria; EEM/MDMER = Environmental Effects Monitoring / Metal and Diamond Mining Effluent Regulations.

SECTION 5.9
Buildings and Site Infrastructure

5.9 Buildings and Site Infrastructure

5.9.1 Description

This section describes the proposed closure and reclamation activities for the site buildings and infrastructure including requirements for decontamination, deconstruction, and waste disposal. This section also includes a description of site infrastructure that will be constructed to support ongoing operation, maintenance, and monitoring of the Site. Infrastructure in this context refers to civil infrastructure, such as buildings, structures, roads, utilities, supporting infrastructure, debris, and existing waste disposal locations.

Throughout active remediation, all buildings and infrastructure with no future use will be decontaminated (following an abatement program) and deconstructed, as follows:

- removal of approximately 101 on-site structures associated with mining activities such as waste and equipment storage, ore production, water treatment, offices, maintenance facilities, and staff housing
- removal and disposal of approximately 25 areas where surface debris and non-hazardous wastes are stockpiled
- closure of all existing waste disposal sites and waste storage areas
- removal of all non-required utilities, site access roads, and fencing

Hazardous wastes, arsenic wastes, and non-hazardous wastes will be produced from these remediation activities. The GMRP plans to dispose of these waste streams as follows: hazardous waste will be disposed off site at licensed facilities; arsenic waste will be placed in a freeze zone (Sections 5.1 and 5.2); and, non-hazardous waste will be disposed in a new on-site landfill (Section 5.10).

Finally, to support the ongoing operation, maintenance, and monitoring activities, new infrastructure will be installed, including fencing, signage, security, transport network, and utilities.

5.9.2 Existing Site Conditions

Currently there are buildings, structures, roads, utilities, supporting infrastructure, debris, and existing waste disposal locations in various states of use and condition across the site. These are described below.

5.9.2.1 Buildings and Structures

Approximately 101 on-site buildings will require demolition as part of the remediation program. The existing buildings were constructed between the 1940s and 1990s and are concentrated in the following areas of the Site:

- **Townsite**—The former Townsite is located at the southern portion of the Site, along the shore of Great Slave Lake (Yellowknife Bay) and has 22 residential homes and garden sheds, a sewage pump house, and two domestic water pump houses.
- **A Shaft**—The A Shaft area is located near the mouth of Baker Creek where it drains into Yellowknife Bay. This area includes a boat launch ramp and the GSSC. The remaining Site structures in this area are a former diesel plant, electrical substation, sewage lift station, boiler house, and the Yellowknife Historical

Society (formerly the NWT Mining Historical Society) structures; former exploration shop and former recreation hall.

- **C Shaft**—The C Shaft Complex contains the majority of the structures at the Site, including the C-Dry, which is the main administration building for the ongoing care and maintenance of the Site. Remaining facilities in the C Shaft complex are the C Shaft hoist building, Mill, Mill Labs, mobile equipment garage, machine, electrical, carpentry and planner shops, refinery, diesel plant, boiler house, and other associated warehouses, supporting structures, and equipment lay-down areas.
- **B Shaft**—The B Shaft Complex is northwest of the C Shaft Complex, east of Baker Creek, and contains the operating ventilation plant (B Vent), compressor, and electrical substation.
- **Tailings retreatment plant (TRP)**—The TRP is located on the northeast side of the Site, on the west side of the North Pond. The TRP is an abandoned tailings reprocessing facility.
- **Effluent treatment plant (ETP)**—The ETP is located on the northeast side of the Site, on the west side of the North Pond. The ETP facility is operated as part of the ongoing care and maintenance of the Site and treats minewater seasonally for discharge.
- **Akaitcho Complex**—The Akaitcho Complex is located at the north end of the Site and includes the Akaitcho headframe, compressor facility, and warehouse. The Akaitcho Complex area also includes the mine dewatering pumps and piping system which delivers minewater to the Northwest Pond.
- **Norseman building**—Located near the southwest corner of the Central Pond is a temporary Norseman building, which was previously used by contractors for paste backfill activities.
- **Other buildings and site infrastructure**—Smaller structures are scattered around the Site, including protective structures around existing groundwater monitoring wells, small storage buildings, B3 Vent Facility near the ETP, and structures previously used as explosive storage.

The locations of the existing buildings and structures are presented in Figures 5.9-1, 5.9-2, and 5.9-3.

5.9.2.2 Roads

Approximately 30 km of access roads are currently located on the Site, with associated culverts and bridges. The locations of the major existing roads are shown in Figures 5.9-1 to 5.9-5, and culverts are presented in Figure 5.9-6.

5.9.2.3 Utilities and Supporting Infrastructure

A network of surface utilities and infrastructure is located across the Site. Utilities and supporting infrastructure include:

- surface infrastructure to support ongoing underground work activities including; two access portals, ventilation buildings, power substations, underground utilities (electrical power and communications), sewage disposal line into C Shaft, and other shafts
- fuel, water, and sewage holding tanks, and associated distribution piping
- abandoned water and tailings distribution piping

- utilities including utilidors, electrical distribution lines and poles, abandoned electrical lines, electrical sub-stations and transformers
- fencing

The locations of the major existing utilities and supporting infrastructure (such as culverts, fencing, utilidors, and powerlines) are shown in Figure 5.9-6.

5.9.2.4 Existing Debris

A total of 25 historical surface debris disposal areas are scattered around the Site. Figure 5.9-4 shows the aerial extent of the locations where the debris is encountered. The surface debris is commonly located in accessible areas in discontinuous piles; however, in some areas, the debris is covered with vegetation regrowth or located in areas of standing water. The surface debris includes used mine vehicles, discarded ore handling and process equipment, miscellaneous vehicle and process equipment parts, empty barrels, building demolition waste, used tires, and drill core. In addition to these historical debris storage areas, three stockpiles of non-hazardous wastes (e.g., steel, shredded wood) generated during the recently completed demolition projects for the roaster, A Shaft, and C Shaft are stockpiled in the laydown areas east and south of the Mill in the C Shaft area for future landfilling and disposal. The location of these laydown areas is presented in Figure 5.9-5. For additional information on progressive works to date, refer to Chapter 4.

5.9.2.5 Existing Waste Disposal Locations

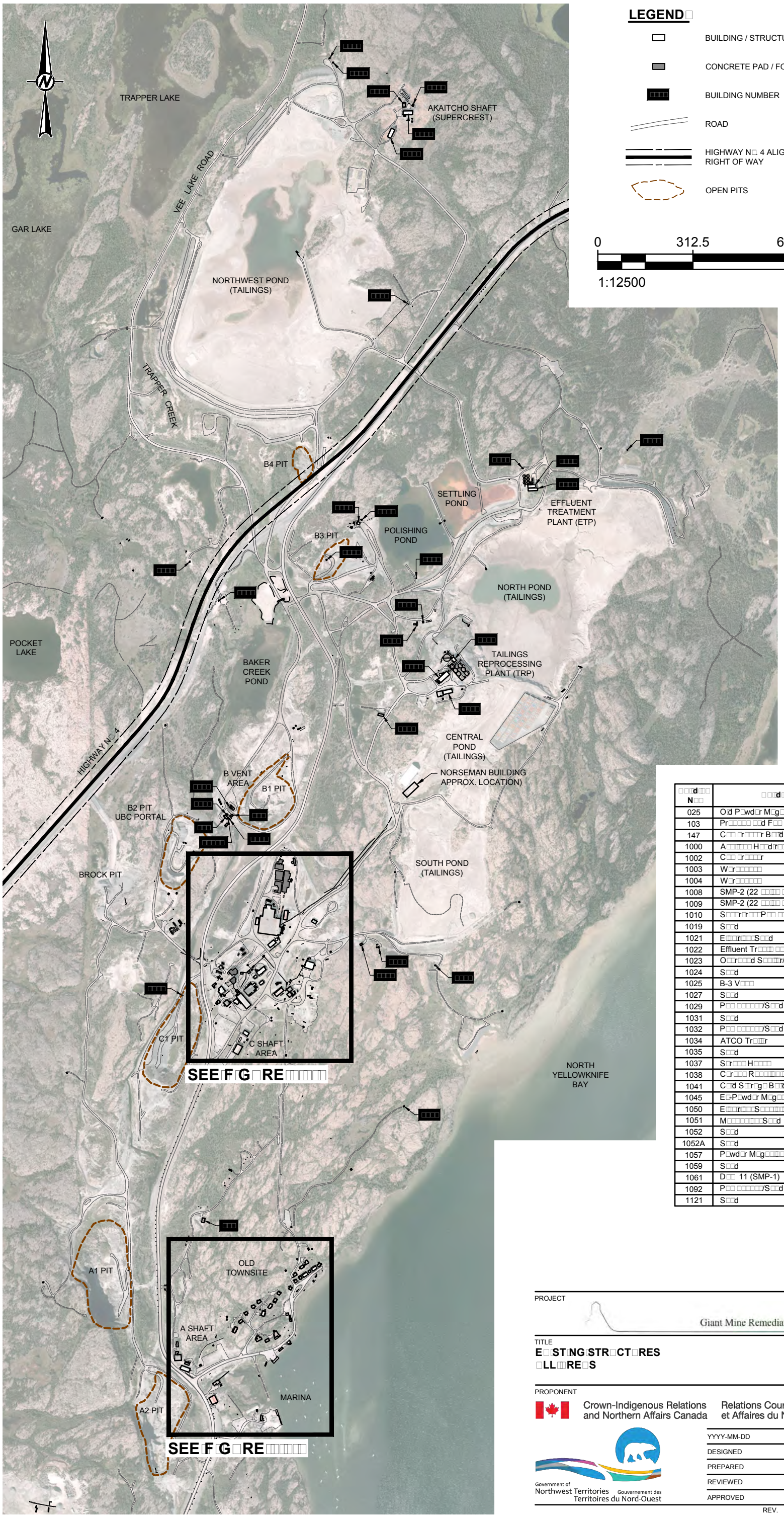
Current waste disposal and storage areas which have been used during care and maintenance and will continue to be used in early remediation are shown in Figure 5.9-5, and the details of these locations are summarized in the following paragraphs.

Northwest Pond non-hazardous waste disposal site—A disposal site for non-hazardous waste is currently located at the north end of the Northwest Pond. This waste disposal site has been in place since 1987, and during mine operation the waste was covered with tailings. Currently, the site is being used to dispose of waste generated by the care and maintenance contractor and other non-hazardous waste generated from other on-site contractors. Typical wastes deposited in this area include steel, wood, rubber, plastics, office, and lunch room wastes which are periodically covered with tailings.

Northwest Pond hazardous waste area—Hazardous and asbestos wastes were historically disposed of in a former rock quarry located in the northeast corner of the Northwest Pond. More recently, the site has been used as a temporary storage location for arsenic wastes as well as a disposal site for asbestos wastes. Currently, 1,600 barrels of arsenic wastes (consisting of arsenic dusts and arsenic-contaminated materials, tools, and PPE that were generated from previous clean-up projects) are stored within a fenced compound at this location. Bagged asbestos waste generated from building demolition programs has also been placed in a trench and covered with tailings in this area. No asbestos wastes have been placed at this location since 2015.

Material Storage Area (MSA)—Arsenic trioxide dust, and other arsenic-contaminated building materials generated from the decontamination and deconstruction of the Roaster Complex (Chapter 4), is currently stored in the fenced MSA located on the Central Pond. This material was containerized in Transportation of Dangerous Goods (TDG) approved bags or over pack drums and then placed into marine shipping containers. Any wastes that were too bulky to containerize were placed directly into lined marine shipping containers. Approximately 330 marine shipping containers filled with arsenic-contaminated wastes are stored at the MSA.

P:\60541111\900-CAD_GIS\910-CAD\30-FIGURES\G\60541111-FIG-00-0000-G-0591.dwg



□□□d□□□ N□□	□□□d□□□N□□ □
025	O□d P□wd□r M□g□□□□
103	Pr□□□□□ □□d F□□ B□□d□g□
147	C□□ □r□□□□r B□□d□g
1000	A□□□□□□ H□□d□r□□ □
1002	C□□ □r□□□r
1003	W□r□□□□□□
1004	W□r□□□□□□
1008	SMP-2 (22 □□□□ □□□□)
1009	SMP-2 (22 □□□□ □□□□)
1010	S□□□r□r□□□P□□ □□g S□□□□□
1019	S□□d
1021	E□□□r□□□S□□d
1022	Effluent Tr□□□ □□□P□□□
1023	O□□r□□□d S□□□□r/L□□d□w□ Ar□□
1024	S□□d
1025	B-3 V□□□
1027	S□□d
1029	P□□ □□□□□□/S□□d
1031	S□□d
1032	P□□ □□□□□□/S□□d
1034	ATCO Tr□□r
1035	S□□d
1037	S□r□□□ H□□□□
1038	C□r□□□ R□□□□□□r B□□d□g
1041	C□d S□r□g□ B□□d□g
1045	E□-P□wd□r M□g□□□□/E□-PCB S□□r□g□
1050	E□□□r□□□S□□□□□□□
1051	M□□□□□□□□S□□d
1052	S□□d
1052A	S□□d
1057	P□wd□r M□g□□□□
1059	S□□d
1061	D□□ 11 (SMP-1)
1092	P□□ □□□□□□/S□□d
1121	S□□d

PROJECT

Giant Mine Remediation Project

TITLE

E□□ST□NG□STR□CT□RES □LL□□RE□S

PROPONENT

Crown-Indigenous Relations and Northern Affairs Canada

Relations Couronne-Autochtones et Affaires du Nord Canada

Government of Northwest Territories

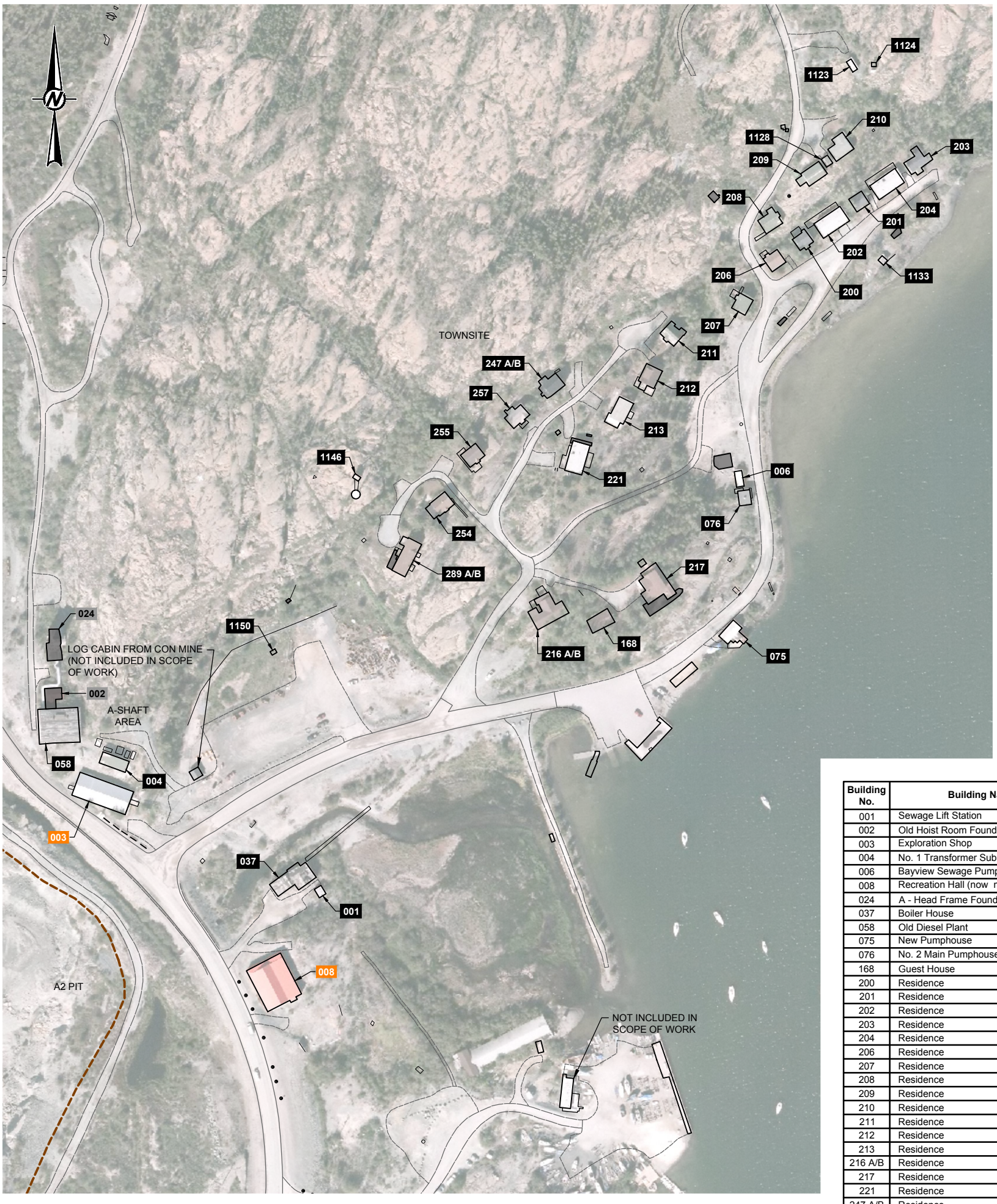
Gouvernement des Territoires du Nord-Ouest

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REVIEWED	G. W□□□□□
APPROVED	R. S□□□ □d□□

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FIGURE 5.9-1

P:\60541111\900-CAD_GIS\910-CAD\30-FIGURES\G\60541111-FIG-00-0000-G-0592-0593.dwg



Building No.	Building Name
001	Sewage Lift Station
002	Old Hoist Room Foundation
003	Exploration Shop
004	No. 1 Transformer Substation
006	Bayview Sewage Pumphouse
008	Recreation Hall (now mine museum)
024	A - Head Frame Foundation
037	Boiler House
058	Old Diesel Plant
075	New Pumphouse
076	No. 2 Main Pumphouse
168	Guest House
200	Residence
201	Residence
202	Residence
203	Residence
204	Residence
206	Residence
207	Residence
208	Residence
209	Residence
210	Residence
211	Residence
212	Residence
213	Residence
216 A/B	Residence
217	Residence
221	Residence
247 A/B	Residence
254	Residence
255	Residence
257	Residence
289 A/B	Residence
1123	ATCO Trailer
1124	Shed
1128	Shed
1133	Shed
1146	Shed
1150	Shed

LEGEND:

- BUILDING / STRUCTURE
- BUILDING / STRUCTURE PREVIOUSLY REMOVED
- CONCRETE PAD / FOUNDATION
- 1121 — BUILDING NUMBER
- 002 — BUILDING NUMBER (PREVIOUSLY REMOVED)
- 008 — BUILDING NUMBER (TO REMAIN FOR HISTORICAL SOCIETY)
- ROAD
- OPEN PITS

0 62.5 125 m

1:2500

PROJECT

Giant Mine Remediation Project

TITLE

EXISTING STRUCTURES
TOWNSITE AND A-SHAFT AREAS

PROPONENT

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

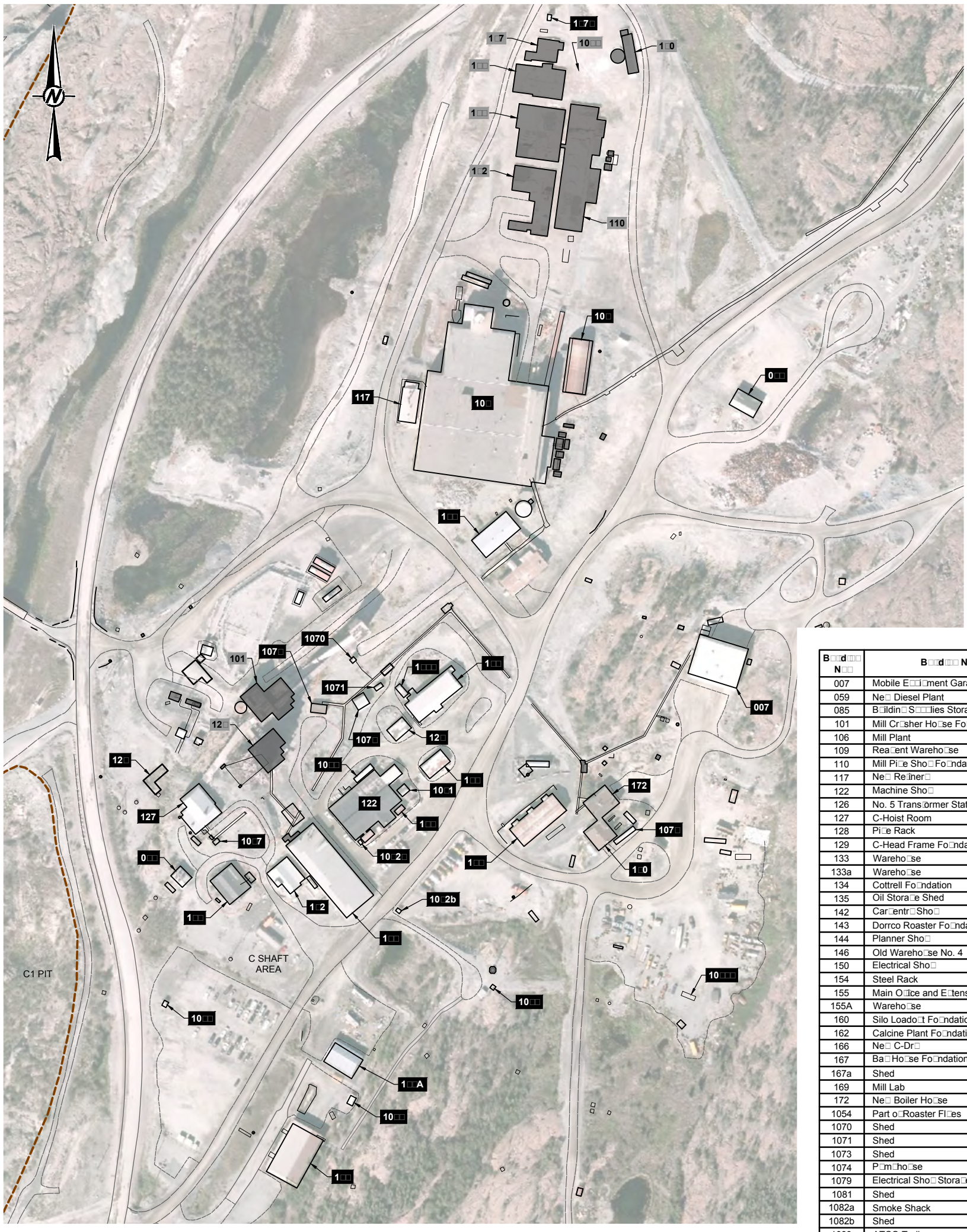
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FIGURE 5.9-2

P:\60541111\900-CAD_GIS\910-CAD\30-FIGURES\G\60541111-FIG-00-0000-G-0592-0593.dwg



B□□d□□□ N□□	B□□d□□□ N□□ □
007	Mobile E□□i□ment Gara□e
059	Ne□ Diesel Plant
085	B□ildin□ S□□□lies Stora□e
101	Mill Cr□sher Ho□se Fo□ndation
106	Mill Plant
109	Rea□ent Wareho□se
110	Mill Pi□e Sho□ Fo□ndation
117	Ne□ Re□iner□
122	Machine Sho□
126	No. 5 Trans□rmer Station
127	C-Hoist Room
128	Pi□e Rack
129	C-Head Frame Fo□ndation
133	Wareho□se
133a	Wareho□se
134	Cottrell Fo□ndation
135	Oil Stora□e Shed
142	Car□entr□ Sho□
143	Dorrco Roaster Fo□ndation
144	Planner Sho□
146	Old Wareho□se No. 4
150	Electrical Sho□
154	Steel Rack
155	Main O□ice and E□tension
155A	Wareho□se
160	Silo Loado□t Fo□ndation
162	Calcine Plant Fo□ndation
166	Ne□ C-Dr□
167	Ba□ Ho□se Fo□ndation
167a	Shed
169	Mill Lab
172	Ne□ Boiler Ho□se
1054	Part o□Roaster Fl□es
1070	Shed
1071	Shed
1073	Shed
1074	P□m□ho□se
1079	Electrical Sho□ Stora□e Trailer
1081	Shed
1082a	Smoke Shack
1082b	Shed
1083	ATCO Trailer
1086	ATCO Trailer
1087	Shed
1093	Shed
1094a	ATCO Trailer
1096	Shed

LEGEND:

- BUILDING □STRUCTURE
- BUILDING □STRUCTURE PREVIOUSLY REMOVED
- CONCRETE PAD □FOUNDATION
- 1121 BUILDING NUMBER
- 002 BUILDING NUMBER (PREVIOUSLY REMOVED)
- 00□ BUILDING NUMBER (TO REMAIN FOR HISTORICAL SOCIETY)
- ROAD
- OPEN PITS

0 62.5 125 m

1:2500

PROJECT

Giant Mine Remediation Project

TITLE

EXISTING STRUCTURES
C-SHAFT AREA

PROPONENT

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

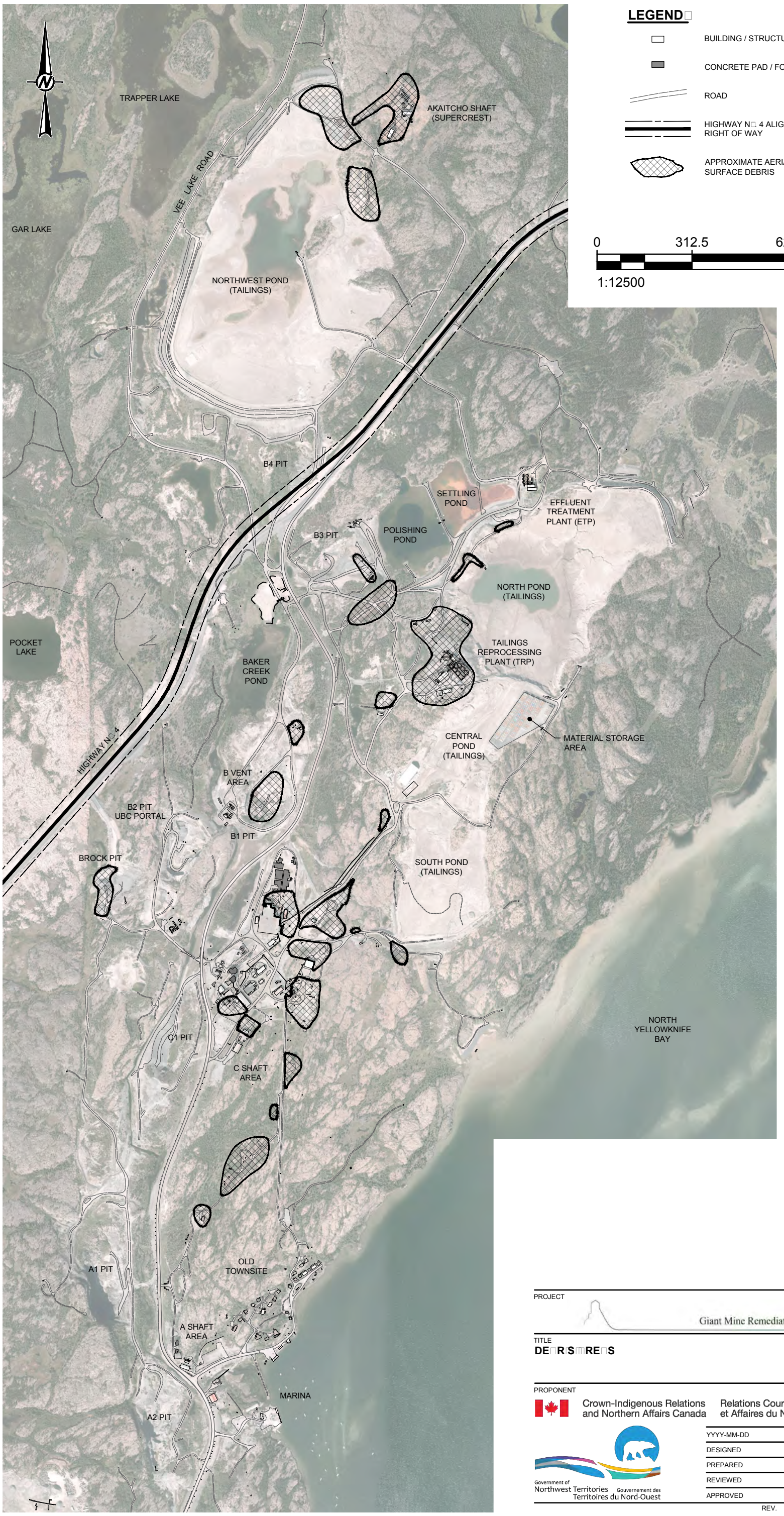
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FIGURE 5.9-3

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LEGEND

- BUILDING / STRUCTURE
- CONCRETE PAD / FOUNDATION
- ROAD
- HIGHWAY N□ 4 ALIGNMENT AND 60 □ RIGHT OF WAY
- APPROXIMATE AERIAL EXTENT OF SURFACE DEBRIS

0 312.5 625 □

1:12500

PROJECT

Giant Mine Remediation Project

TITLE

DE□R□S□□RE□S

PROPONENT

Crown-Indigenous Relations and Northern Affairs Canada

Relations Couronne-Autochtones et Affaires du Nord Canada

Government of Northwest Territories

Gouvernement des Territoires du Nord-Ouest

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APPROVED	R. S□□□ d□□□

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FIGURE 5.9-4

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PROJECT

Giant Mine Remediation Project

TITLE

M□□OR S□TE FE□T□RES □□E□ST□NG COND□T□ONS

PROPONENT

Crown-Indigenous Relations and Northern Affairs Canada

Relations Couronne-Autochtones et Affaires du Nord Canada

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REV. 0

FIGURE 5.9-5

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LEGEND

- BUILDING / STRUCTURE
- CONCRETE PAD / FOUNDATION
- HIGHWAY N□ 4 ALIGNMENT AND 60 □ RIGHT OF WAY
- FENCING
- CULVERT
- POWER LINE

0 312.5 625 □

1:12500

PROJECT

Giant Mine Remediation Project

TITLE

E□ST□NG□FENC□NG□□C□L□ERTS□□ND□□O□ ER

PROPONENT

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

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

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APPROVED	R. S□□□ d□□□

REV. 0

FIGURE 5.9-6

5.9.3 Closure Objectives and Criteria

Based on the goals and principles for the GMRP, closure objectives were identified specifically for the closure and reclamation of the buildings and site infrastructure project component. These objectives and criteria are presented in Table 5.9-1.

Table 5.9-1: Site Infrastructure Closure Objectives and Criteria

Closure Objectives	Closure Activity	Closure Criteria	Monitoring/Maintenance and Inspection
SI1. Site infrastructure with no future use has been removed and contaminated portions have been remediated so they are not, and will not become, a safety hazard or a source of contamination to the environment	• Decommission and demolish site infrastructure with no future use, consisting of approximately 101 structures, 25 debris stockpiles, up to 30 km of road network, utilities, and fencing. • Submittal of a demolition plan in accordance with WSCC and Mine Manager as per *Mines Health and Safety Act*. • Remove hazardous waste and arsenic hazardous waste from site infrastructure using appropriate decontamination methods. • Prior to deconstruction, remove and dispose of any documented heavily-impacted arsenic wastes within a frozen shell (see Section 5.2), dispose of hazardous waste in an approved off-site hazardous waste facility and place non-hazardous waste in the landfill (see Section 5.10). • Contour and grade surfaces to match existing/natural topography leaving limited visual evidence of previous site infrastructure presence, e.g., areas of decommissioned site infrastructure (transport routes, buildings) are scarified and contoured to match the natural topography.	• **SI1- 1** Wastes are appropriately handled, containerized, and disposed of and results from confirmation testing are within WSCC/GNWT industrial hygiene standards* • **SI1- 2** Surface drainage is not interrupted as evidenced by no ponding of water. • **SI1- 3** Design engineering drawings are signed and sealed by a Qualified Professional and the specifications outlined therein are met; Building decontamination and demolition plans to be prepared and signed and sealed by a Qualified Professional.	*Active Remediation* • As-built engineering record drawings signed and sealed by Qualified Professional and submitted to MVLWB. • Satisfactory final inspection by Land Use inspector. • Operational monitoring/inspection of surface drainage and demolition. • Water Management and Monitoring Plan - Surface water sampling of sumps, seeps, runoff (per Objective BC3). • Waste Management and Monitoring Plan – waste types, recycling. • Industrial Hygiene Air Quality Monitoring. • Manifests for waste disposal – off site hazardous materials. *Adaptive Management and Post-Closure Phases* • Air Quality Monitoring Plan (refer to Objective SW1). • Operational monitoring/inspection of surface drainage and demolition. • Water Management and Monitoring Plan - Surface water sampling of sumps, seeps, runoff (per Objective BC3).

SI2. Site infrastructure that remains during the long-term operation and maintenance phase is not, and will not become, a safety hazard, or a source of contamination to the environment	• Construct, or maintain, the road network (bridges, roads, culverts) confirming physical stability.
	• Construct or maintain, the power supply to support long term operations and monitoring.
	• Construct security measures, including core infrastructure area fence,
	• Remove and dispose of any renaming hazardous materials (asbestos, PCBs, lead, mercury, ODS) from any remaining infrastructure.
	• Construct any new infrastructure to meet the design intent as described in each of the sections of Chapter 5.
	• Remove hazards to humans/wildlife.
		• **SI2-1** New facilities designed to meet requirements of National Building Code, National Fire Code, National Plumbing Code.
		• **SI2-2** Permanent buildings, such as the WTP, are founded on bedrock
		• **SI2-3** WSCC Mines Inspector and Qualified Professional Engineer inspection confirms Building Codes met.
		• **SI2-4** Design engineering drawings are signed and sealed by a Qualified Professional and the specifications outlined therein are met for the remaining infrastructure (roads, WTP, culverts, etc.).
			Active Remediation, Adaptive Management and Post-Closure Phases:
			• As-built engineering record drawings signed and sealed by Qualified Professional and submitted to the MVLWB.
			• Satisfactory final inspection by Land Use inspector.
			• Operational Monitoring and Inspection: risk thaw settlement, slope failure, erosion, slumping, or collapse.
			• Operational Monitoring Program:
			  • Periodic inspections of buildings and infrastructure to confirm compliance with codes.
			  • Monitoring to confirm no significant adverse impacts to existing permafrost.
			• Emergency Response Plan and Spill Contingency Plan for reagents and fuel for final site infrastructure.

SI3. Post-closure access to remaining Site infrastructure has been designed for the safety of humans and wildlife	• Fence the Core Industrial Area as per Objective CS1, which also restricts access to key infrastructure. • Site presence and on-site security used to discourage unauthorized entry to restricted areas. • Implement administrative controls to communicate residual hazards such as by installing signs (see Objective SW4). • Engineering controls are in place to manage residual risks. Restrict access to operational transport and utility routes using fences and barricades.	• **SI3-1** Engineered controls are in place, and are maintained / monitored, to manage residual risks (e.g., signs and physical barriers along the shoreline near the outfall pipe are in place) (refer to Objective SW4). • *Refer to CS1 for fence criterion* *Criteria in Development with engineering works and Perpetual Care Plan* • **SI3-2** Security log records a reduction in number of trespasser sightings in restricted areas.	*Active Remediation, Adaptive Management and Post-Closure Phases:* • As-built engineering record drawings signed and sealed by Qualified Professional and submitted to the MVLWB. • Wildlife and Wildlife Habitat Management and Monitoring Plan – monitoring of wildlife presence near infrastructure (roads, bridges, water treatment plant). • Operational Monitoring Program and Perpetual Care Plan • Periodic inspections of access control, e.g., fences and signage.

GNWT = Government of the Northwest Territories; MVLWB = Mackenzie Valley Land and Water Board; NWT = Northwest Territories; WTP = water treatment plant; *standards such as guideline for Hazardous Waste Management (GNWT, 2017) Guideline for the Management of Waste Asbestos (GNWT, 2004); Asbestos Abatement, Northwest Territories and Nunavut Codes of Practice, WSCC (Sept 2018)

5.9.4 Consideration of Closure Options and Selection of Closure Activities

5.9.4.1 Existing Site Infrastructure

There are a variety of equipment and procedural alternatives that could be applied to the decontamination and demolition of buildings and site infrastructure. The specific methods selected are not anticipated to have a material impact on the nature of the proposed CRP activities for the buildings and infrastructure component.

In general, closure options are limited to either restoring assets, such as transport networks required post closure, or removing assets such as non-required infrastructure through decontamination, demolition, and disposal. Options have been discussed in the *Preliminary Design Report for Surface Demolition and Debris Removal* (Appendix 5.9A). Where practicable, removal of infrastructure and buildings has been preferred as a permanent remediation option. Disposal of wastes is a key consideration, and there are a variety of design, construction, and operation alternatives that could be applied to the management of wastes produced at the Site. Several alternatives were considered for waste management, with on-site and off-site disposal options explored for each waste stream.

Option assessments for the decontamination and demolition work centered on the management of waste generated from the decontamination and demolition activities, and waste disposal options were considered based on the volumes estimated in waste audits.

Disposal options considered the following:

- Recycling or reusing building materials, equipment, and infrastructure where possible to reduce waste — This option will be included, where possible, in the closure of the Site. See Section 5.10.5 for additional details.
- Directing non-hazardous demolition waste to third party commercial waste management facilities or constructing an on-site non-hazardous waste landfill—Off-site disposal was discounted as currently the City of Yellowknife will not accept the construction debris wastes from the Site; therefore, non-hazardous demolition waste is to be directed to the on-site landfill described further in Section 5.10.
- Directing hazardous waste to third party commercial waste management facilities or constructing an on-site hazardous waste landfill—Disposal of hazardous waste at an on-site landfill was discounted due to regulatory requirements; therefore, hazardous wastes will be directed to an approved off-site facility.
- The options for disposing of arsenic wastes were discussed in Section 5.1.

The closure activities selected for the buildings and site infrastructure are described in Section 5.9.5. The key factors driving the choice of these closure activities is shown in Figure 5.9-7. From review of the options, the GMRP Team decided to salvage and recycle as much as practical, ship all hazardous wastes off site, freeze all hazardous and non-hazardous waste streams that are arsenic-contaminated in a freeze zone (Section 5.2), and dispose of all non-hazardous wastes in an on-site landfill (Section 5.10).

Buildings and Site Infrastructure – Key Drivers for Closure Decisions

Higher ↑ Priority ↓ Lower

Drivers	Design Considerations
Physical stability and Manage health, safety and environmental impacts	➢ Deteriorated infrastructure represents a potential safety and environmental risk to onsite workers, public and the environment ➢ Removal of infrastructure that serves no purpose ➢ Sort wastes (hazardous, arsenic impacted, and non-hazardous) and consider disposal options ➢ Meet commitments to asbestos and arsenic abatement made in the environmental assessment
Align with other remediation activities	➢ Build new infrastructure based on needs for long-term care: new water treatment plant, security ➢ Account for need for access for freeze pads and other closure work for maintenance and inspections ➢ Prevent/reduce trespassing around core required infrastructure and closure works

Selected Options

- Remove on-site structures, utilities, roads and fencing, surface debris that are not needed
- Closure waste disposal sites and storage areas
- Secure central area of site including new building for Water Treatment Plant
- Build or upgrade a subset of necessary roads, culverts/bridges needed for maintenance, inspections access and site security

Sort wastes: hazardous waste off site, construct on-site Landfill for non-hazardous waste

PROPONENT

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

Government of Northwest Territories | Gouvernement des Territoires du Nord-Ouest

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PROJECT

Giant Mine Remediation Project

TITLE

KEY CONSIDERATIONS DRIVING THE SELECTION OF CLOSURE ACTIVITIES FOR SITE INFRASTRUCTURE

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FIGURE 5.9-7

5.9.4.2 New Site Infrastructure

The options explored for the construction of new key infrastructure is discussed in the respective component section e.g., Section 5.2 Freeze Program, Section 5.8 Water Treatment and Outfall Systems, Section 5.10 Landfill. Additional site infrastructure is discussed in Section 5.9.5, but limited options have been explored as the civil works, such as fencing and signage, will be designed build in accordance with local standards and codes.

5.9.5 Engineering Work

The following subsections provide engineering detail for the removal of buildings and site infrastructure required for the closure and remediation of the Site. Across the Site, remediation and removal of the buildings and site infrastructure will follow a similar process of:

1. Hazardous waste and arsenic waste abatement and containerization.
2. Structural demolition of buildings and site infrastructure.
3. Waste disposal according to waste type.

During building deconstruction and on-site remedial activities, it will be necessary to separate the waste streams to prepare for appropriate disposal. This includes current waste stockpile locations, buildings and site infrastructure of no future use, and underground hazardous materials.

The majority of the on-site buildings contain various amounts of asbestos, cyanide, arsenic, process chemicals and petroleum products, and other hazardous materials. Engineering designs and studies will be completed to develop programs and plans to manage the hazardous and other materials that will be recovered and disposed of on site or off site. All hazardous materials present in the on-site infrastructure will be decontaminated through abatement following the engineering plans and removed, with appropriate disposal, prior to demolition. Site infrastructure such as utilities, roads, and debris piles will also be decontaminated prior to demolition. The objective of the decontamination process is to remove the hazardous wastes to a degree that will allow the safe demolition of the structures and safe transport of the waste to an approved disposal location. In addition, all existing roads that are identified to be constructed with arsenic contaminated granular fill will be remediated according to Section 5.4.

Site infrastructure, and wastes present on site, is shown in Figures 5.9-1 to 5.9-6. During future detailed design stages, options for new infrastructure will be evaluated to determine site requirements and to evaluate options for access and utilities. Future studies will include items such as the evaluation of new access roads, office space requirements, potential requirements of a vehicle garage, and required utilities.

The following subsections also provide engineering detail for the construction of new site infrastructure required for the closure and remediation of the Site.

5.9.5.1 Work Planning

Air quality monitoring and dust abatement planning is required for the removal of buildings and infrastructure as such activities can create hazards which can contribute to the overall air emissions, especially through the re-suspension of dust, arsenic, and other contaminants. Furthermore, due to the close proximity of the Site to large populations, airborne releases of fine particulates could expose people to health risks.

Specific prevention, reduction and monitoring activities will be implemented to address the Measures identified in the Report of EA (MVEIRB 2013) which address deconstruction activities directly. These measures include:

- *Measure 20 – Completion of all major demolition and construction activities, with the potential to release large amounts of dust or contaminants into the air, when wind directions will minimize the chances of dust and contaminants blowing into the City of Yellowknife, Dettah and Ndilǫ.*
- *Measure 21 – Collection of dust, soil and vegetation samples will be collected and analyzed for contaminants before and after major demolition activities. The data will serve as a baseline for any related future adaptive management activities.*
- *Suggestion 11 -To manage the risks of airborne exposure of contaminated dust from deconstruction of buildings or other structures on site, the Developer should:*
  - *prepare a dispersion model of dust plume given typical wind direction and speed*
  - *define the meteorological window of opportunity to describe acceptable wind conditions to eliminate the potential for a dust cloud release and transport of surrounding communities.*
  - *consult a meteorologist to develop a sound model of weather conditions, to indicate when winds are steady and not gusting, blowing to the north*
  - *stop if winds change or any dust controlling equipment fails.*

Prior to the start of abatement and deconstruction activities, submittals, including safe work procedures, and demolition and deconstruction plans will be developed by the contractor to set out the steps for the safe execution of the remediation activities to protect workers, the public, and the environment as well as consider the project measures listed above.

The plans will include the following:

- Air quality monitoring and dust abatement activities will be outlined in a Dust Management and Monitoring Plan. The plan will be consistent with requirements of the AQMP including ambient air monitoring requirements. During decontamination work activities, air monitoring will be completed in accordance with these plans to confirm that workers and the public are not being exposed to conditions in excess of occupational guidelines and to confirm ambient air monitoring objectives are not being exceeded. Mitigative measures as identified in the Dust Management and Monitoring Plan and AQMP, such as revising demolition methodology, saturating work areas, and halting work activities, will be initiated in the event that ambient conditions approach air monitoring action levels.
- The plans will be prepared in accordance with the approved Waste Management and Monitoring Plan, Water Management and Monitoring Plan, SNP, and OMP, and be based on contract requirements, building specific conditions, abatement water management (capture and treatment), and Water Licence conditions.
- Abatement work plans and deconstruction work plans will be prepared detailing how the work will be completed in a fashion that is consistent with the engineering plans and design as well as with regulatory requirements ranging from building deconstruction, collection of site debris piles, removal of buildings/material in close proximity to water bodies (i.e., boiler house and pump house / water intake, see Figure 5.9-2, Buildings 037 and 075).

- A requirement for a pre-demolition inspection will be included, which will be completed to confirm all hazardous wastes have been removed e.g., prior to building demolition air samples to confirm interior air quality meets the applicable standards can be taken.
- These plans will be based on requirements of the NWT Workers' Safety and Compensation Commission and the *Mine Health and Safety Act* (GNWT 2010).
- A requirement to verify that appropriate safety protocols are considered to manage risks associated with lowering the structure, sub-excavations, or advancement into debris piles (if required) will be included.

For details on the management plans for the CRP refer to Chapter 1, Table 1.1-1 Management Plans List.

5.9.5.2 Hazardous Waste and Arsenic Waste: Abatement and Containerization

Throughout active remediation, all buildings and infrastructure with no future use will be abated of contaminated or hazardous materials and deconstructed for the wastes to be appropriately disposed of. This is presented in Figures 5.9-1 to 5.9-6.

Abatement techniques will be undertaken to identify, decontaminate, and containerize hazardous wastes prior to deconstruction activities, such as arsenic, asbestos, and cyanide dusts located in buildings. Methods used will follow territorial guidelines in order to protect the safety of on-site workers, the public and the environment. The purpose of abatement activities is to decontaminate buildings and site infrastructure so that non-hazardous deconstruction work can be undertaken.

Key abatement activities are described below:

- Arsenic will be collected from the mill (Building 106, Figure 5.9-3) and TRP facilities (Buildings 1037 and 1038, Figure 5.9-1) following a strict abatement and decontamination procedure to protect the health and safety of workers, and to recover arsenic wastes.
- Surfaces will be cleaned with water, which will subsequently be collected and treated.
- Recovered arsenic dust/waste from cleaning will be handled and packed using appropriate techniques.
- Any items which cannot be cleaned of arsenic will be categorized as arsenic waste; including hazardous waste, mill process wastes, non-hazardous wastes, and asbestos.

Arsenic waste will be placed in Transportation of Dangerous Goods approved containers.

- Hazardous waste will be collected following a strict abatement and decontamination procedure to protect the health and safety of worker. Requirements for the handling and disposal of hazardous waste are presented in the *Guideline for Hazardous Waste Management* and the *Guideline for the Management of Waste Lead and Lead Paint* (GNWT 2017a,b). All hazardous wastes will be packaged in Transportation of Dangerous Goods approved containers for transportation and storage. Surfaces may be cleaned with water; any wash water will subsequently be collected and treated.
- All mill process wastes, semi-processed ores, and residual materials located in process tanks will be collected. Mill process wastes are soil like, with some oversize particles which are less than 3 inches in diameter.

- All asbestos wastes will be removed following protocols established by the WSCC Workers' Safety Compensation Commission (WSCC 2018). All asbestos waste will be containerized using Transportation of Dangerous Goods approved bags and disposed of according to the requirements of the GNWT *Guideline for the Management of Asbestos Waste* (GNWT 2004) and the GNWT *General Guidelines for Asbestos Removal and Disposal* (GNWT 2010).

In the event that all hazardous wastes, arsenic wastes, or asbestos wastes cannot be removed, the impacted wastes will be isolated and encapsulated to reduce the potential for the release of contaminants during the deconstruction work activities. Following deconstruction, the waste(s) will be appropriately collected and containerized.

During abatement activities, dust conditions will be monitored and controlled to confirm industrial hygiene requirements are met in addition to on-site dust monitoring requirements. On-site dust suppression measures (including the use of water and dust suppressants) will be used to control and reduce the generation of dust. Air monitoring will be completed to confirm air monitoring objectives identified in Dust Management and Monitoring Plan are not being exceeded.

5.9.5.3 Deconstruction

Following the completion of abatement activities, deconstruction of the buildings and site infrastructure can proceed. Planned deconstruction activities for the buildings and site infrastructure project subcomponents include:

- Unprocessed crushed ore, semi-processed ores, and residual materials that remain within the mill building will be disposed of in the tailings ponds. Removal will occur prior to deconstruction.
- All buildings will be deconstructed down to foundations. Expected structural conditions vary from old to new for the buildings as follows; most of the older buildings at the Site are constructed out of wooden columns, beams, and roof trusses, whereas the new buildings consist of metal siding over structural steel columns and beams.
- Buildings will be demolished down to the foundation, with foundation left in place, and covered with fill, including building foundations/slabs/pads, concrete retaining walls, and elevated pads. The foundations will be removed in the following cases:
- Foundations located in the Townsite will be removed.
- Any foundations confirmed to contain concentrations of leachable metals less than the standard listed in the Guideline for Hazardous Waste Management (GNWT 2017a) will be removed and handled under the applicable waste stream.
- Approximately 7,500 m^3 of granular borrow material would be needed to fill in excavated foundations from the townsite, or cover foundations left in place. Covers are assumed to be of 0.3-0.5 m thickness.
- All debris located within the project boundary will be collected, sorted into different waste types, and disposed of according to waste type.
- All utilidors, overhead power lines, and power poles that are no longer required will be removed, sorted into different waste types, and disposed of according to their waste type.

- All non-required roads and culverts will be decommissioned, and surfaces scarified and graded to achieve surface drainage consistent with the overall surface drainage plan.

During demolition activities, dust conditions will be monitored and controlled. On-site dust suppression measures (including the use of water and dust suppressants) will be used to control and reduce the generation of dust. Air monitoring will be completed to confirm air monitoring objectives identified in Dust Management and Monitoring Plan are not being exceeded.

These activities will produce non-hazardous wastes. There is no requirements to containerize this waste. It will be stockpiled, if required, prior to disposal.

5.9.5.4 Waste Disposal

Based on audits completed of the buildings and site infrastructure, the following waste streams and volumes are expected to be recovered during the abatement and deconstruction processes.

Table 5.9-2 presents the estimated volumes of wastes from the program and proposed disposal method for the recovered waste stream. Future engineering studies will be completed to refine and verify the estimated waste volumes prior to construction.

Table 5.9-2: Proposed Method of Waste Disposal

Waste Stream	Examples of Waste Materials	Estimated Quantity (m^3)	Proposed Disposal Method
Arsenic-impacted materials	Arsenic trioxide dusts and waste containing leachable arsenic currently located in Mill and stored in the TRP, MSA and Northwest Pond Hazardous Waste Area	16,000 (Golder 2018)	Recovered and disposed of underground for freezing as described in Section 5.1
Hazardous waste – other	Waste oils, petroleum products, mill process chemicals, mercury and polychlorinated biphenyl (PCB)-containing products, leachable lead amended painted materials	427 (AECOM 2018b)	Hauled off site for disposal at licensed facility according to federal and territorial regulations
Mill process waste	Semi-processed ores and residual materials located in process tanks	2,558 (AECOM 2018b)	Managed with contaminated soils (see Section 5.4)
Non-hazardous waste	Building demolition debris (wood, steel, glass, brick, paper, used equipment, etc.) and surface debris (tires, used equipment), including double-bagged asbestos-containing materials	76,300 (AECOM 2018a)	Disposed of in a new on-site engineered landfill, constructed specifically for this project (see Section 5.10)

Notes: Estimated quantities do not include waste generated by care and maintenance contractor, construction manager or remediation contractors.

The proposed disposal methods for the recovered wastes are disposed as summarized below:

- Arsenic wastes containerized during reclamation works, as well as the arsenic waste that is currently stored in the MSA and the Northwest Pond hazardous waste area, will be transported underground for disposal in a freeze zone. For additional information, refer to Section 5.1.
- Hazardous wastes containerized during reclamation works will be transported off site for disposal at an approved/licensed hazardous waste disposal facility in accordance with the *Transportation of Dangerous Goods Act* (Government of Canada 1992), the *Canadian Environmental Protection Act, 1999* (Government of Canada 1999), Inter-provincial Movement of Hazardous Waste Regulations, other applicable regulations

to licensed hazardous waste disposal facilities. All shipments will be manifested as required. Hazardous wastes are defined in the *Guideline for Hazardous Waste Management* (GNWT 2017a) in the NWT. Hazardous wastes include items containing polychlorinated biphenyl (PCB), mercury/mercury-containing equipment, metallic lead, cyanide wastes, ozone-depleting substances, items coated with paint containing leachable levels of lead, waste process chemicals, and petroleum products. All hazardous materials underground will also be brought to surface and disposed of off-site as described in Section 5.1.

- Non-hazardous waste will be disposed of in the on-site landfill (Section 5.10). Bagged asbestos wastes is classified as non-hazardous; therefore, it will be disposed of in the on-site landfill. Non-hazardous wastes consist of solid waste that, when disposed of in a landfill or reused, is not expected to undergo physical, chemical, or biological changes to an extent as to produce substances that may cause an adverse effect on the environment. This includes inert wastes such as demolition rubble and surface debris including wood, plastic, steel, glass, paper, drywall, and concrete, as well as similar wastes generated by on-site contractors. Materials containing asbestos greater than 1% by weight are considered asbestos-containing materials; for disposal purposes, asbestos is considered non-hazardous waste.
- Residual amounts of non-hazardous semi-processed ores located in process equipment, tanks, and process piping in the ore process buildings (mill and TRP) will be managed with contaminated soils (Section 5.4), and disposed of in tailings ponds (Section 5.6).

5.9.5.5 Closure of Existing Waste Areas

Closure of the Northwest Pond Non-hazardous Waste Disposal Site

The current non-hazardous waste disposal site will be closed. All waste materials will be left in place and the disposal site will be included within the cover being placed on the Northwest Pond (Section 5.6).

Closure of the Northwest Pond Hazardous Waste Area

The arsenic wastes currently stored in the Northwest Pond hazardous waste area will be removed and placed in a freeze zone as described in Section 5.9.5.5. The perimeter fence will be removed and the area will be included within the cover being placed on the Northwest Pond (Section 5.6).

Closure of the Material Storage Area

The arsenic wastes currently stored in shipping containers at the MSA located in the Central Pond will be re-located from the storage compounds to a freeze zone as described in Section 5.9.5.5. Wastes are to be removed from the shipping containers prior to placement in a freeze zone. All emptied shipping containers are classified as non-hazardous waste, therefore they will be dismantled and placed in the landfill. The perimeter fence at the MSA will be removed and the area will be included within the cover being placed on the Central Pond (Section 5.6).

5.9.5.6 Temporary Construction Facilities

There may a requirement to construct temporary facilities or supply common site services to support construction activities, such as electrical power, water/sewer service management, freshwater intake, office space, explosive/fuel storage. Future planning and engineering design will identify requirements for temporary

facilities as well as regulatory requirements that the temporary facilities need to follow e.g., explosives storage will be in accordance with the Explosives Act and Regulation.

5.9.5.7 Remaining Infrastructure

To complete the remedial works, some infrastructure will remain in place, be constructed, or modified to meet future requirements. Key remaining infrastructure pieces are described below:

- Fencing, signage, and security, including the fencing around Core Industrial Area, signage and security features, security infrastructure (guard house, fencing, signage).
- Transport network—A network of site access roads, bridges, and culverts to inspect and maintain remaining infrastructure. There is currently an extensive road network at the Site that provides access to the developed areas of the Site, majority of the identified borrow locations, and other areas requiring remediation.

  During the remedial program, all roads that are identified to be constructed with arsenic contaminated granular fill will be remediated to applicable standards as previously discussed in Section 5.4. To complete the remedial activities, some areas (such as Townsite Shoreline, Dam 3 Spill area) may require the construction of a temporary access road. All temporary roads will be removed following the completion of the remedial work activities. To meet post remediation inspection, maintenance and security monitoring requirements some areas of the site will require road access in the future; therefore the construction of replacement roads will be required. The network is subject to future design work but the location of the potential major roads that will be required to stay in place are shown in Figure 3.4-1.

  The future road network will provide access to areas including freeze pads, ETP, covered tailings ponds, borrow pits, pumping infrastructure, dock dams, and the landfill. Roads that are no longer required will be removed and the area regraded to be consistent with the surface drainage plan. Details of the future transport routes is still outstanding and will be refined during future design works.
- Utilities to support ongoing operations, maintenance, and monitoring such as electrical power distribution.
- Small building structures to protect groundwater monitoring wells.
- A commemorative plaque, monument or educational memorial for the project will be installed as supported by affected parties during the SDE process.
- Other buildings and site infrastructure, as described in this chapter, will also be present on Site as follows:
- New long-term underground access portal, covers to mine openings (Section 5.1).
- Freeze infrastructure (thermosyphons and instrumentation) and gravel pads and infrastructure to support freeze activities (Section 5.2).
- TCA spillways (Section 5.6).
- New WTP, office facility and outfall, utilities to support WTP, infrastructure to support mine dewatering activities (Section 5.8).
- Landfill with a cell for non-hazardous wastes as well as a cell for WTP waste process residuals (Section 5.10).

- Two existing buildings —the former recreation hall and exploration shop— have been requested by the Yellowknife Historical Society for preservation due to their historical value. The management of the former recreation hall will be transferred to the Yellowknife Historical Society. Due to planned closure activities in the area of the exploration shop, additional structural assessment is required and CIRNAC will continue to work with the Yellowknife Historical Society to enable this to the extent practicable.

5.9.6 Final Site Conditions

At completion of the remediation activities, buildings and site infrastructure with no future use will be removed and new infrastructure required post-closure will be constructed. Some floor slabs will be left in place within the core infrastructure area, and areas will be regraded to match the surface drainage plan.

All site wastes generated will be appropriately disposed of as follows:

- Hazardous and arsenic wastes will be appropriately abated and removed. Hazardous wastes will be disposed of off-site, and arsenic wastes will be disposed of in a freeze zone (Section 5.2).
- All non-hazardous waste will be recycled or disposed of in the on-site landfill (Section 5.10).
- Using best practices presented in “Guidelines for the Planning, Design, Operations, and Maintenance of Modified Solid Waste Sites in the NWT (The Department Municipal and Community Affairs Government of the Northwest Territories 2003)”.

- New infrastructure will be installed, including infrastructure described within this section and in previous sections. This infrastructure will include, but is not limited to:
- a network of site access roads, bridges, culverts, fencing around the Core Industrial Area; signage and security features will be maintained from the current condition and new infrastructure implemented
    - new long-term underground access portal (Section 5.1), freeze infrastructure (Section 5.2), TCA spillways (Section 5.6), new WTP facility and outfall (Section 5.8), and landfill (Section 5.10).

5.9.7 Uncertainties

Engineering designs for the CRP are currently at a conceptual level. In terms of the ability of the proposed design to meet the closure objectives and criteria, no significant uncertainties have been identified. There are several practical uncertainties related to the conceptual level of design, which will be addressed through future stages of detailed design and project execution. For example, current estimates of waste volumes have a degree of uncertainty that will be reduced as the design is advanced.

SECTION 5.10
Landfill

5.10 Non-Hazardous Waste Landfill

5.10.1 Description

This section describes the new non-hazardous waste landfill (the landfill) which will be constructed for the disposal of non-hazardous wastes. The requirement for an on-site non-hazardous landfill was identified to dispose of demolition and debris wastes generated from the various building and infrastructure reclamation projects, as well as WTP process residuals.

A series of options assessments were undertaken to assess potential landfill locations on the Site. From evaluations and studies, an area located east of the C Shaft area was selected (Figure 3.4-1), and preliminary design for the landfill has been undertaken (Appendix 5.10A). The facility will include two disposal cells as follows:

- A non-hazardous waste (NHW) cell, which will operate during the active remediation—The cell will be closed and covered once active remediation activities are complete.
- A WTP process residuals cell, which will remain open through the long-term operation and maintenance phase—The cell will remain open to dispose of non-hazardous process residuals waste generated from the operation of the new WTP.

5.10.2 Pre-disturbance and Existing Site Conditions

Pre-disturbance conditions for the terrain in the landfill area are not known but are presumed to be bedrock outcrops with wetland vegetation (see Chapter 2 and Section 5.4 for the description of terrain). Currently the north and south ends of the proposed landfill site are previously developed and are used as a boneyard / used equipment laydown yards. Located between the two laydown yards is a bedrock / forest / wetland area with a small body of water. The area is also bounded by bedrock outcrops further to the east and to the south. The electrical shop / boiler house is within the footprint of the landfill. Access roads which connect the C Shaft area to the former Townsite run through the proposed landfill site.

5.10.3 Closure Objectives and Criteria

Based on the goals and principles for the GMRP, closure objectives were identified specifically for the on-site disposal of demolition wastes and site debris, as well as WTP process residuals, in a landfill. The objectives and criteria of the GMRP relating specifically to the landfill are presented in Table 5.10-1.

Table 5.10-1: Landfill Closure Objectives and Criteria

Closure Objectives	Closure Activity	Closure Criteria	Monitoring/Maintenance and Inspection

L1. Inadvertent access to landfill by humans and wildlife has been prevented	• Fence the Core Industrial Area to restrict access to the landfill
	• Site presence and on-site security will discourage unauthorized entry to restricted areas.
	• Close and contain the non-hazardous waste cell with perimeter berms.
	• Cover the surface of this cell with a granular layer including a low permeability cover, graded to promote surface runoff.
	• Contain the WTP process residual cell with perimeter berms. During operation, use a temporary cover over the active portion of the cell to cover the wastes.
	• Close the cell by covering with a granular surface layer that includes a low permeability cover, graded to promote surface runoff. Progress the permanent cover as sections of the cell can be closed.
		• **L1-1**. Landfill is installed within the fence perimeter area (see SI3) to prevent inadvertent access.
		Refer to CS1 for fence criterion
		• **L1-2.** Design engineering drawings are signed and sealed by a Qualified Professional and the specifications outlined therein are met
		
		Refer to criterion in development **SI-3** Security log records reduction in number of trespasser sightings in restricted areas (including the landfill)
		
		Criteria in Development with engineering work
		• **L1-3:** Cover is installed over landfill to mitigate mammal or bird access; Specification for design of the cover to mitigate small mammal burrows TBD
			Active Remediation, Adaptive Management and Post-Closure Phases:
			• Waste Management and Monitoring Plan used to monitor, and report volume of waste disposed, and cover soil used.
			• As-built engineering record drawings signed and sealed by Qualified Professional and submitted to the MVLWB.
			• Operational Monitoring Program
			  • Annual Inspections of cell caps and containment berms for erosion and stability, evidence of wildlife or human activity
			  • Fence inspections, e.g., evidence of wildlife or human activity
			  • Periodic inspections of access control
			  • Ongoing site security
			• Wildlife and Wildlife Habitat Management and Monitoring Plan – wildlife observations

L2. Landfill is not, and will not become, a source of contamination to the environment	• Dispose only non-hazardous waste in the landfill.
	• Non-hazardous wastes are contained within berms.
	• Install internal sump within each cell to collect contact water for treatment
	• Grade the base of the landfill cells to promote water drainage within the cells to an internal collection sump during landfill operations
	• Close the cells with low permeability cover and grade the cover to minimize surface water infiltration.
	• Grade surface water to external sumps, collect and treat water from external sumps, as required, until surface runoff quality criteria are met, and water can be released to the environment.
		• **L2-1** Follow the applicable guidelines for waste management*
		• **L2-2** Perimeter berm slopes designed to achieve a minimum Factor of Safety of 1.3.
		• **L2-3** Design base of cell to minimum 0.75% grade to facilitate contact water collection during operations.
		• **L2-4** Design of landfill cover to minimum 1% grade to shed surface water from the cover.
		• **L2-5** Low permeability landfill cover to achieve a hydraulic conductivity equivalent to 10^{-7}m/s.
		• **L2-6** Design engineering drawings are signed and sealed by a Qualified Professional and the specifications have been met
		• **L2-7** Surface water quality from landfill cover meets surface runoff criteria as per the approved Water Management and Monitoring Plan
			Active Remediation, Adaptive Management and Post-Closure Phases:
			• Waste Management and Monitoring Plan used to monitor, and report volume of waste disposed, and cover soil used.
			• As-built engineering record drawings signed and sealed by Qualified Professional and submitted to the MVLWB.
			• Operational Monitoring Program with repairs as required
			  • Annual Inspections of cover and containment berms for erosion and stability
			  • Surface and groundwater quality
			• Surveillance Network Program: water quality monitoring

WTP = water treatment plant; NWT = Northwest Territories; GMRP = Giant Mine Remediation Project; TBD = to be developed; * Guidelines for the Planning, Design, Operations and Maintenance of Modified Solid Waste Sites in the Northwest Territories (Government of Northwest Territories, 2003); Solid Waste Management for Northern and Remote Communities – Planning and Technical Guidance Document (Environment and Climate Change Canada, 2017); Guideline for Hazardous Waste Management (GNWT, 2017)

5.10.4 Consideration of Closure Options and Selection of Closure Activities

There are a variety of design, construction, and operation alternatives that could be applied to the management of non-hazardous wastes produced at the Site. The evaluation of potential disposal locations and methods was documented in a number of previous studies. Key reports, and study outcomes, are as follows:

Preliminary Design Report for Surface Demolition and Debris Removal (Appendix 5.9A)

The preliminary design report evaluated five potential areas for the landfill on the Site. The potential locations were further evaluated in later studies against the following factors:

- existing developed area
- distance to waterbodies
- area available to provide sufficient capacity
- waste haul distance

The preliminary design report included a recommendation and a conceptual design for a landfill on the Central Pond.

Recycling options for wastes which will be generated during the demolition phase of the GMRP were examined in the preliminary surface demolition and debris report. Facilities and buildings were noted to contain large amounts of building materials and debris (structural steel, metal cladding, plate steel, wood timbers, copper wire, and rubber tires) that could potentially be salvaged and recycled. However, due to the costs to decontaminate materials to a level that will allow recycling and the cost to transport these materials to a market, recycling was identified as being potentially uneconomical when compared to on-site disposal. This report recommended that recycling be encouraged and that it be left up to contractors to identify potential recycling opportunities and to incorporate potential cost savings due to recycling into their bids. In the event that contractors do not include any recycling programs, it was recommended the landfill be appropriately sized for the disposal of all non-hazardous wastes.

Feasibility Review of Metal Salvage (AECOM 2014)

In 2014, a study was completed to determine the feasibility of salvaging scrap metal that will be generated during the demolition of the on-site buildings and infrastructure and diverting this waste stream from the proposed on-site landfill. This study evaluated potential recyclable metal products, as well as requirements for sorting and cleaning. Cost estimates were also developed for transporting recyclable steel materials to a waste recycler. This desktop study identified that there was interest in the metal recycling industry in western Canada for the steel waste at Giant mine and that if all the steel materials on the Site were sorted out of the non-hazardous waste stream it could be financially economical to salvage the steel waste materials.

Giant Mine Remediation Program Site Location Study for Non-Hazardous Waste Landfill (Appendix 5.10B)

In 2017, an updated siting assessment was completed that included an evaluation of regulatory requirements, setback distances from key features such as Baker Creek, land use restrictions (before and after development of the landfill), constructability, fill and cover requirements, drainage (hydrology/hydrological) requirements, management and operations, cost implications, geotechnical conditions, and topographical considerations.

Eight alternative on-site locations were identified. A decision matrix, consisting of pros and cons, was used for evaluating the potential locations and assist with the selection of a preferred location. Main factors for evaluating the suitability of each identified disposal site included:

- central location close to mine infrastructure to minimize disposal haul distances
- preferably an eastern site location to minimize haul roads crossing Highway No. 4
- single location with enough area to accommodate the volume of waste requiring disposal
- ability to blend the landfill into the natural topography and provide adequate drainage pathways
- locating the landfill in previously developed area, consistent with the land use concepts presented in the DAR (INAC and GNWT 2010).

Following the evaluation, both the Central Pond and Area 3 near C Shaft were assessed as suitable locations for the landfill. Due to the requirement to have access to the tailings in the Central Pond, for paste backfilling for the underground stabilization program, the Central Pond was discounted and Area 3 was selected as the preferred location of the landfill facility. The location of the proposed landfill is presented in Figure 3.4-1 of Chapter 3.

Giant Mine Remediation Project Non-Hazardous Waste Landfill Preliminary Design Report (Appendix 5.10A)

To further advance the design of the proposed landfill, an evaluation of design parameters was completed. The evaluation included the following:

- **Waste diversion**—completed an evaluation of waste streams that could be diverted from landfill disposal. Items that were assessed included wood, rubber tires, steel and concrete. Due to the limited opportunities to reuse these waste materials (noted above), the evaluation considered the disposal of these waste items in an off-site landfill. Except for the steel wastes, the diversion of the wastes will only minimally reduce the volume of waste destined for the landfill. Therefore, due to the small waste volume reduction and the expected cost to divert and dispose of the waste materials at an off-site location, these waste diversion methods may not be economically viable.
- **Evaluating the suitability of using contaminated soil as intermediate fill**—This evaluation included a review of applicable regulatory standards for the disposal of wastes, practices in other jurisdictions as well as past waste disposal practices in other northern landfills. This evaluation concluded that the use of contaminated soils as fill in the landfill would not be consistent with the design approach for an inert waste landfill and may require the inclusion of a base liner and leachate collection system in the landfill design.
- **Evaluating the suitability of disposing of lead and asbestos containing materials in the on-site landfill**—Based on the evaluation completed, it was identified that the disposal of asbestos containing items as well as the disposal of waste containing lead in the on-site landfill (provided it contained lead at concentrations less than 5 mg/L) was consistent with regulatory standards and should be considered as a disposal method option for these waste streams.
- **Evaluating the need for a liner/leachate collection system in the on-site landfill**—This evaluation concluded that the on-site landfill will be used for the disposal of inert construction and demolition waste, and there is no regulatory requirement to include a liner or leachate collection system.

Based on the evaluation, the recommended design parameters for the proposed landfill facility include:

- The proposed landfill would be limited to waste defined as non-hazardous materials by the GNWT *Guideline for Hazardous Waste Management* (GNWT 2017).
- Asbestos containing waste to be disposed in the landfill according to the requirements of the GNWT *Guideline for the Management of Asbestos Waste* (GNWT 2004) and the GNWT *General Guidelines for Asbestos Removal and Disposal* (GNWT 2010).
- The landfill would not include a liner or leachate collection system.
- Due to the identified challenges with recycling, the landfill would be designed to accommodate all of the identified non-hazardous wastes (inert construction and demolition wastes as well as waste that will be generated by the WTP).

Based on the recommended design parameters identified in the above evaluations, a preliminary design was completed for the selected landfill site located east of the C Shaft area (Area 3). The preliminary design included two adjoining disposal cells as follows:

- A non-hazardous waste (NHW) cell, which will operate during active remediation. The cell will be closed and covered once active remediation activities are complete.
- A WTP process residuals cell, which will remain open through the long-term operation and maintenance phase. The cell will remain open to dispose of non-hazardous process residuals waste generated from the operation of the new WTP.

The preliminary design items included cell configuration, containment berm construction, landfill subgrade, contact water drainage, and cover design (Appendix 5.10A).

The key drivers behind the selection of the closure activities for the disposal of non-hazardous waste are shown in Figure 5.10-1.

Landfill – Key Drivers for Closure Decisions

Higher ↑ Priority ↓ Lower

Drivers	Design Considerations	Selected Options
Align with other remediation activities	➢ **Buildings and infrastructure demolition waste disposal area needed** ➢ **WTP residual disposal area needed**	**On-site non-hazardous waste landfill with two waste cells:** - **1) Non-hazardous waste** - **2) WTP Process Residuals** **Cover landfill at closure**
Input from Surface Design Engagement & affected parties	➢ **Blend with local topography** ➢ **Utilize disturbed areas** ➢ **Follow guidelines**	

PROPONENT

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2018-12-19
DESIGNED	H. Machtans
PREPARED	D. Pahl
REVIEWED	J. Amphlett
APPROVED	J. Amphlett

PROJECT

Giant Mine Remediation Project

TITLE

KEY CONSIDERATIONS DRIVING THE SELECTION OF CLOSURE ACTIVITIES FOR NON-HAZARDOUS WASTE

REV. 0

FIGURE 5.10-1

5.10.5 Engineering Work

Waste Volume

The estimated volumes of non-hazardous waste streams were calculated in 2017 and 2018. Based on the waste audits, the volume of non-hazardous waste requiring disposal in the on-site landfill facility was estimated (Table 5.10-2).

Table 5.10-2: Non-hazardous Waste Volumes

Waste Description	Estimated Quantity (m^3)
Inert Demolition Debris (wood, steel, glass, brick, asbestos, used equipment, surface debris, etc.)	76,300 (Appendix 5.10A)
Water treatment process residuals	Estimated at 275 m^3/yr. (27,500 m^3 for 100 years) (Appendix 5.10A)

Note: Estimated quantities do not include waste generated by care and maintenance contractor, construction manager, or remediation contractors.

The landfill will be designed to accommodate the volume of waste identified in the above table, plus an additional 25% of the volume for intermediate fill, and a contingency to account for contractor generated wastes, additional unidentified wastes, and waste bulking.

Landfill – Preparation of Site

Prior to the construction of the landfill, there will be a requirement to prepare the landfill site, including:

- Temporarily relocating the equipment and waste currently stored at the proposed landfill site.
- Demolition of the electrical shop / boiler house and a portion of the existing road infrastructure that is currently located within the footprint of the landfill.
- Regrading a portion of the road leading to the former Townsite to the south will need to be rerouted around the landfill. Contaminated soils in the area of the landfill site will be disposed of as per Section 5.4.
- In areas within the waste disposal cells, grading the area to promote surface runoff to a collection sump which will operate during waste placement.
- Construction of containment berms to contain the waste.

The following sections provide further details on the two disposal cells that could be constructed to dispose of both the inert construction and demolition waste as well as the WTP process residuals.

Non-hazardous Waste Cell

Inert non-hazardous demolition wastes generated by the remediation program that cannot be recycled will be disposed of in the on-site NHW cell. The NHW cell is designed to utilize existing bedrock outcrops on the east and west sides as containment berms, while berms constructed with granular fill will be built on the north, west, and south ends of the cell. Waste will be placed inside the bermed area in lifts not exceeding 2 m and will be compacted between lifts. Intermediate layers of fill, consisting of uncontaminated granular material, will be used to stabilize the waste layers to minimize future settlement. The landfill will be appropriately sized with sufficient airspace to contain the non-hazardous waste materials and intermediate fill, as well as account for volume contingency.

Although the non-hazardous waste being deposited in the landfill will be dry, contact water within the NHW cell will still be generated from snow melt and precipitation during landfill operations. The NHW cell is designed to promote contact water drainage towards the low end of the cell into an internal collection sump. During operation of the NHW cell, the collection sump will be emptied via a side slope withdrawal pipe, and the recovered water will be treated as required. Grading the landfill base towards a central swale and sump, and providing infrastructure for removing contact water, will help mitigate the potential for seepage through the surrounding containment berms and assist in keeping the landfilled wastes dry. The internal landfill sump will continue to be monitored after the cover is constructed, and emptied if there are recoverable amounts.

Once the wastes have been placed in the landfill, the wastes will be covered with intermediate fill and the landfill cover will be installed. The cover will be constructed with a minimum 0.7 m thick granular material over a low-permeability geosynthetic. The cover will be graded to promote positive drainage away from the cover. The landfill cover grades will be constructed to blend in with the surrounding topography, with maximum elevations lower than the bedrock outcrop to the east of the NHW cell location. Perimeter ditching will divert surface runoff water away from the landfill. The site will be graded in accordance with the overall surface water design (Section 5.5) and to match existing topography. The inclusion of a geosynthetic in the cover will help reduce the potential for surface water infiltration into the waste. The geosynthetic will be covered with a 0.7 m thick cover layer to protect the geosynthetic from UV degradation, wind uplift, and potential burrowing by animals. Details of the cover will be refined during future design works.

Water Treatment Plant Process Residuals Cell

A new WTP will be constructed to treat water (Section 5.8) and the plant will produce a continual waste stream of process residuals, sludge, and filter media requiring disposal. Since the WTP wastes will be generated beyond the time period that the NHW cell will be open and operated, a separate WTP process residuals cell will be constructed. The WTP process residuals cell is proposed to be located adjacent to the NHW cell, with a shared berm between the cells. The WTP process residuals cell is designed to promote contact water drainage from precipitation and snowmelt towards the low end of the cell into an internal collection sump.

As presented in the *Preliminary Design Report for Giant Mine Water Treatment Plant* (AECOM 2012a), testing to date has indicated that the existing ETP waste stream is non-hazardous. As the proposed treatment process in the new WTP is similar in nature to the current process used in the existing ETP, the process residuals for the new WTP are predicted to also be non-hazardous. Testing is underway to confirm assumptions, and further testing is planned into the future. Therefore, this cell will be designed and operated as a non-hazardous waste landfill, similar to the NHW cell. New WTP process residuals will be dewatered sufficiently to allow for the disposal of solids in a separate cell of the landfill facility. Additional testing of the WTP waste residuals is planned, as recommended in the preliminary design report (AECOM 2012a). Future testing will be completed to determine leachability (Toxicity Characteristic Leaching Procedure, TCLP) of the waste materials and suitability for landfill disposal. If the material is determined to be not suitable for disposal in a non-hazardous waste landfill an alternative disposal location (potentially off site) will be considered.

The WTP process residuals cell will be located west of the NHW cell and will be contained by granular berms constructed similar to the NHW cell. A common berm will be located between the NHW cell and the process residuals cell. Similar to the NHW cell design, the base of the cell will be graded to promote drainage of contact water to a sump to accommodate contact water removal as required.

Waste will be placed inside the bermed area in lifts not exceeding 2 m and will be compacted between lifts. Intermediate layers of fill, consisting of uncontaminated granular material, will be used to cover and stabilize the waste layers to minimize future settlement. Future studies will be completed to evaluate characteristics of WTP residuals and to determine if the residual should be containerized to facilitate transportation, placement and covering in landfill. It is proposed that the cell will be progressively covered in a manner consistent with the cover design for the adjacent NHW cell. The cover will be graded to promote drainage off the cover and away from the WTP process residuals cell.

Monitoring Wells

A groundwater monitoring well will be installed at the perimeter of the landfill to monitor for any contaminants of concern. Table 5.10-2 shows the typical design details for proposed groundwater monitoring wells, but details will be determined in conjunction with other monitoring well requirements on Site (Section 5.12).

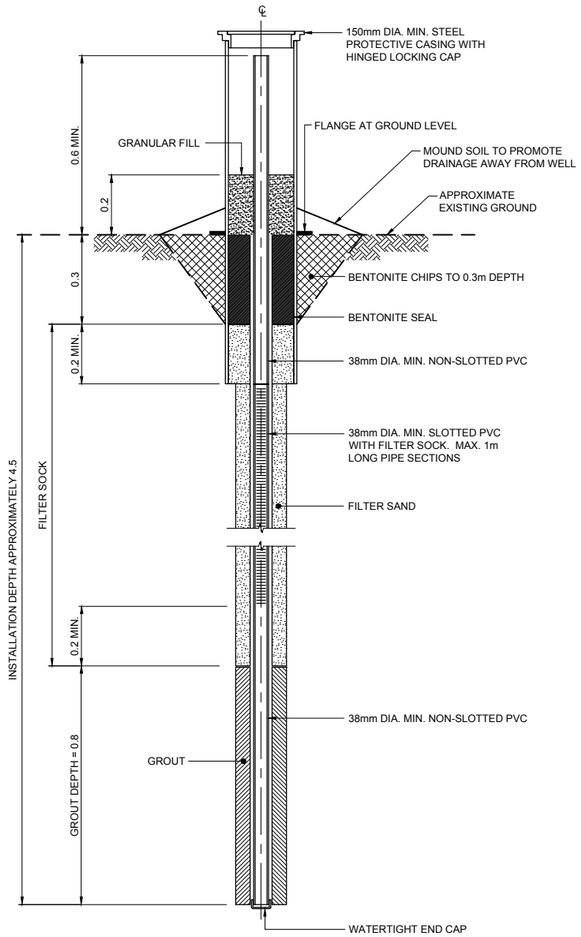
Surface Water Management Post-closure

Collected runoff will be analyzed and treated as required until surface water runoff criteria are met and water can be released to the environment. Final decommissioning of the sumps will not take place until surface water quality objectives have been demonstrated to meet runoff criteria.

Future Engineering Work for the Landfill

Ongoing and future design activities required to support the design of the landfill include:

- Finalize landfill design criteria including berm construction and final cover grading and design.
- Conduct slope stability analysis to confirm maximum acceptable berm slopes.
- Determine suitable gradations for granular fill materials.
- Complete hydraulic evaluation of landfill performance modelling to determine capacities for the internal landfill collection sumps and the surface water retention sumps.
- Determine surface water runoff volume estimates and minimum pond sizing.
- Determine road surfacing design for landfill access ramps.
- Determine requirement for a contact water drainage media, such as a geocomposite or central drainage trench.
- Confirm quality and quantity of wastes generated from new WTP.
- Determine requirement for management of surface water run-on from the adjacent bedrock outcrops.
- Complete detailed design and prepare drawings.

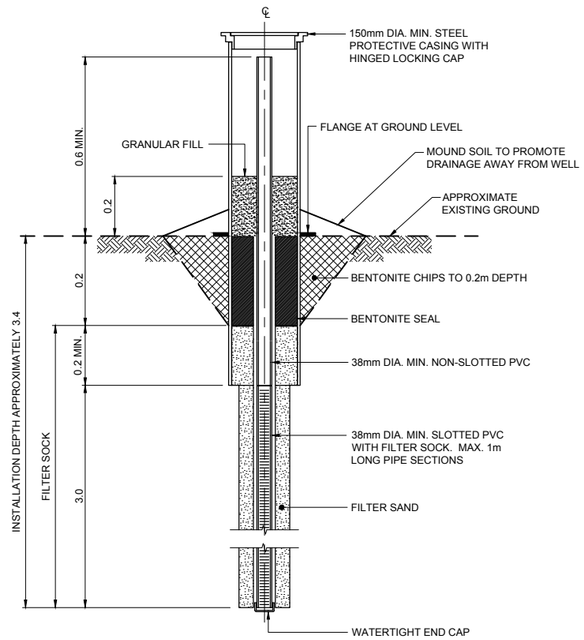


TYPICAL MONITORING WELL

SCALE: NTS

(FOR BEDROCK DEPTH > 0.7m)

NOTE:
MINIMUM 2.5m OF SCREEN AND 0.5m EMBEDMENT INTO SOUND BEDROCK IF SOUND BEDROCK IS ENCOUNTERED.



TYPICAL MONITORING WELL

SCALE: NTS

(FOR BEDROCK DEPTH < 0.7m)

PROJECT

Giant Mine Remediation Project

TITLE

TYPICAL MONITORING WELL DETAILS

PROPONENT

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

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-23
DESIGNED	J. MacKenzie
PREPARED	C. Eros
REVIEWED	G. Woollett
APPROVED	R. Schmidtke

REV. 0

FIGURE 5.10-2

P:\60541267\900-CAD_GIS\910-CAD\30-FIGURES\G\00\60541267-FIG-00-0000-G-5102.dwg

5.10.6 Final Site Conditions

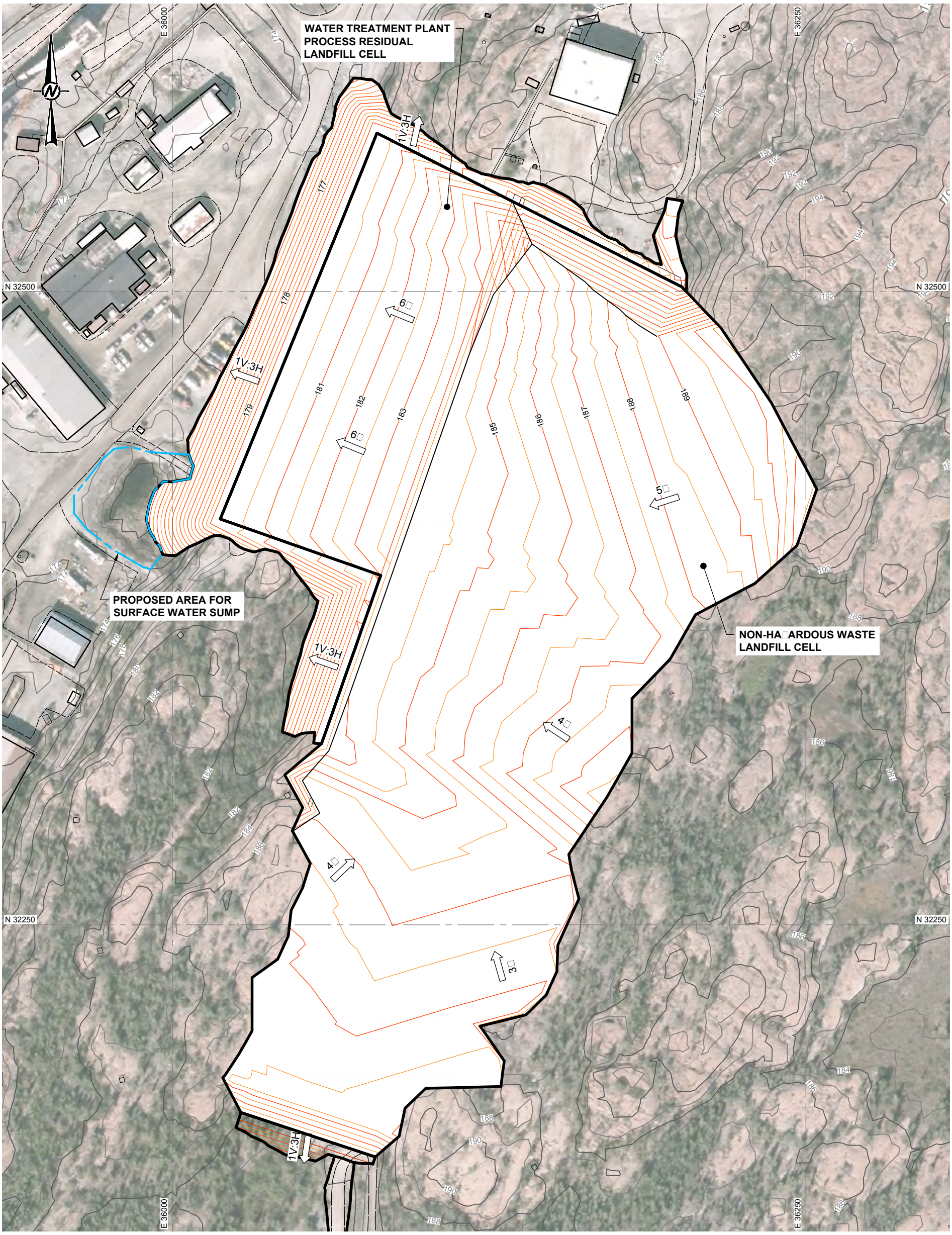
A new landfill is proposed to be constructed east of the C Shaft area and is shown in Figure 3.4-1. The landfill will be composed of two separate waste disposal cells, with a shared berm between the cells, as follows:

NHW cell—The demolition waste cell will be designed, constructed, and filled as an inert construction and demolition waste landfill. Wastes placed in the landfill will consist of dry non-hazardous waste and double-bagged asbestos waste. This cell will be covered once inert demolition, debris, and construction wastes from remediation activities have been deposited, prior to completion of remediation activities. At the completion of landfilling activities, the waste will be contoured and a permanent cover will be installed over the waste cell. The cover will be blended in to the surrounding topography and graded to promote drainage way from the landfill. It is proposed that the highest elevation of the landfill cover will be lower than the elevation of the adjacent bedrock outcrop.

WTP process residuals cell—As discussed in Section 5.8, a WTP will be constructed to continue to treat minewater, producing a waste stream. To dispose of the waste, a separate cell at the landfill will be constructed for the disposal of residual wastes that will be generated during the operation of the WTP. This cell will be located on the west side of the non-hazardous waste disposal cell and will be surrounded with containment berms which will be constructed in the same fashion as the non-hazardous waste cell. As the WTP will remain in operation, there will be an ongoing requirement to dispose of waste residuals from the WTP. This cell will be progressively covered in a manner consistent with the NHW cell cover will be graded to promote drainage off the cover and away from the landfill.

The layout of the proposed landfill is presented in Figure 5.10-3 and cross-sections presenting typical details are presented in Figure 5.10-4.

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LEGEND:

- CONTOUR DEPICTING ORIGINAL GROUND (CONTOUR INTERVAL OF 1.0 m)
- CONTOUR DEPICTING LANDFILL TOP OF WASTE (CONTOUR INTERVAL OF 0.5 m)
- 6 SLOPE DIRECTION AND GRADE
- AREA FOR SURFACE WATER SUMP

0 37.5 75 m

1:1500

PROPONENT

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

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-23
DESIGNED	J. MacKen□ie
PREPARED	C. Eros
REVIEWED	G. Woollett
APPROVED	R. Schmidtke

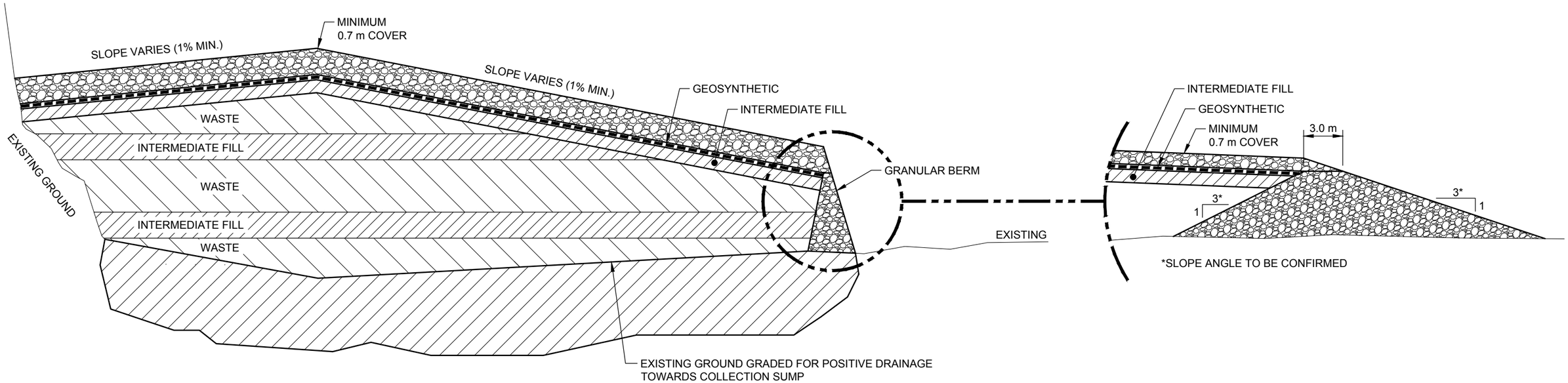
PROJECT

Giant Mine Remediation Project

TITLE

LANDFILL PLAN
TOP OF WASTE CONTOURS

REV.	FIGURE
0	5.10-3



DETAIL 1

SCALE: NTS

TYPICAL LANDFILL SECTION

PROJECT

Giant Mine Remediation Project

TITLE

TYPICAL LANDFILL CONSTRUCTION AND DRAINAGE DETAILS

PROPONENT

Crown-Indigenous Relations and Northern Affairs Canada

Relations Couronne-Autochtones et Affaires du Nord Canada

Government of Northwest Territories

Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-23
DESIGNED	J. MacKenzie
PREPARED	C. Eros
REVIEWED	G. Woollett
APPROVED	R. Schmidtke

REV. 0

FIGURE 5.10-4

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5.10.7 Uncertainties

Engineering designs for the closure plan are currently at a conceptual level. As such, the basis for estimates and analyses include engineering judgement. Additional design works are planned to address key assumptions and reduce relevant uncertainties. The key uncertainties that affect the landfill are summarized in Table 5.10-3, together with the engineering studies and other activities planned to address these uncertainties.

Table 5.10-3: Uncertainties for the Landfill

Uncertainty	Potential Impact of Uncertainty	Plan to Address Uncertainty
Confirmation of the suitability of the ion exchange / adsorption media to be disposed of in the landfill is uncertain. Specifically, if the leachable arsenic concentrations are more than 2.5 mg/L, the limit for classifying the material as non-hazardous waste and can be deposited in a landfill. Preliminary tests suggest this is suitable.	If the studies determine the waste residuals need to be treated as hazardous waste (e.g., the residuals contain leachable levels of arsenic above the 2.5 mg/L limit), an alternative disposal method for the WTP process residuals will be required such as disposing off site at an approved facility.	Pilot testing of candidate adsorption media is planned during the summer of 2018. Part of the testing program is to confirm that the exhausted media complies with the EPA's SW-846 Test Method 1311: Toxicity Characteristic Leaching Procedure. Only adsorptive media that complies will be selected for the full-scale WTP so the exhausted media can be disposed of in the landfill.
Potential poor market for reuse or recycling of salvaged or demolished materials.	Could increase volumes directed to the landfill.	If no recycling is completed, the landfill is sized to dispose of all non-hazardous waste. Additionally, these variations are unlikely to have material impacts on the general nature and scope of the proposed closure and reclamation activity.
Waste volume estimates may be inaccurate, potential for additional waste to be identified or waste volume to increase due to bulking and handling.	Increased waste volume may require additional landfill airspace.	Design landfill facility with contingency to handle additional waste volumes, and have ability to increase landfill footprint if needed.

WTP = water treatment plant; EPA = Environmental Protection Agency.

SECTION 5.11
Residual Effects

5.11 Residual Effects

The CRP has been designed to reduce environmental effects and increase socio-economic and environmental benefits. Despite this, some residual effects will remain after the completion of the reclamation and mitigation is complete. For this CRP, the assessment of residual effects was based primarily on environmental and risk assessments completed for the Site, most of which have included public and affected party engagement (Chapter 1).

The GMRP is in a unique position to assess residual effects given the completion of an Environmental Assessment with MVEIRB on proposed closure activities, not on a new industrial activity, as is more typical. This allows more confidence in the assessment of residual effects because a direct assessment of effects due to reclamation was made in the DAR (INAC and GNWT 2010). The residual effects assessment for the CRP is outlined in Table 5.11-1; this used terminology and effects categories consistent with the DAR wherever possible.

To supplement and update the DAR's effects assessment, additional residual effects were identified through Multiple Accounts Analysis (e.g., pits, Baker Creek Alignment, outfall location) or Failure Modes Effects Assessment for selected components (e.g., Freeze). The predicted long-term effects outlined in the HHERA (Chapter 2; CanNorth 2018) were also reviewed. Residual effects were further considered in light of results from long-term monitoring of the Site during care and maintenance and site stabilization (e.g., EEM, SNP, *Fisheries Act* Authorization Monitoring of Reach 4 for return of fish to Baker Creek).

Forthcoming in 2019, a QRA will be used to more formally update residual risks and identify potential design improvements and/or support contingency planning. The QRA is expected to provide information that will refine the assessment of residual effects, as well as the design of monitoring programs to monitor and possibly further mitigate effects to the environment.

It is noted that closure activities will provide containment of the arsenic trioxide dust and isolate it from contact with the water table; however, the dust will remain underground in place on the Site.

Table 5.11-1: Summary of Residual Effects for Giant Mine Remediation Components

Site Component	Predicted Residual Effects
Underground	• **Water quality effect**— Leaching of contaminants from existing stope fill, new paste backfill made from tailings, and contaminated open pit fill into the underground mine pool may occur, causing elevated concentrations reporting to the WTP. This was accounted for in water quality modelling. • **Water quantity effect**—The minewater level will be managed to maintain such that it forms a groundwater sink relative to Yellowknife Bay; this will create a residual effect of the need for continual pumping and water treatment to maintain this water level. • **Aesthetic effect**—Visible concrete caps will remain on openings to surface, and visible steel borehole casing collars on surface are required for monitoring. • **Surface expression of underground instability**—The possibility of failure of existing mine infrastructure which is below the current water level or otherwise inaccessible will always exist as the mine continues to age. The effect of this is possible surface expression of underground instability.
Freeze Program	• **Aesthetic effect**—A permanent aesthetic change to the landscape above the freeze areas will be left due to the necessary visible portions of the thermosyphons, temperature monitoring equipment, access roads, and any site security fences.
Open Pits	• **Water quality effect**—Possible leaching of contaminants into the underground mine pool may occur, which will report to the WTP. • **Aesthetic effect**— A permanent aesthetic change to the landscape will exist because fill in covers on pits will remain visible. • **Stability effect**—Potential failure of existing mine infrastructure which is below the current water level or otherwise inaccessible will always exist as the mine continues to age. The effect of this is possible surface expression of underground instability. Local fencing and signage may be required to limit access and warn the public of hazards in limited pit areas.
Contaminated Soils and Sediments	• **Water quality effect**—Residual impacts to surface runoff from soils remaining in place within the bedrock/forest/wetland terrain. • **Soil/sediment quality effect**—Tailings will be removed from historical Jo-Jo Lake. Soils will be removed from numerous areas and capped in four areas. It will not be possible to remove 100% of the material; some residual material may remain in cracks and crevasses of the reclaimed area. Coarse material will be placed as required to prevent contact with residual material. • **Human health effect**—Bedrock/forest/wetland terrain impacted by aerial dispersion of arsenic-rich roaster stack emissions will remain. The HHERA concluded that the installation of a physical barrier (i.e., fence) along with administrative controls will result in low to very low risks to human health. • **Aquatic effect**—Removal of sediment from Baker Creek will result in a temporary loss of fish habitat, staggered throughout the reaches of the creek over time. The time for full recolonization of aquatic life of all reaches is expected to be one to five years after removal of sediment from the final reach. The time for full revegetation of the reaches may be more than five years and is thus noted as a potential residual effect due to the time lag for restoration (refer to Section 5.5 for more details). • **Terrestrial effect** – The HHERA concluded that contaminated soils that remain in situ may affect small mammals who can burrow under fences and covers and have access to soils. Monitoring will be done to evaluate this possible effect.
Baker Creek and Surface Water Drainage	• **Stability effect**—Once Baker Creek is realigned, the channel is expected to be physically stable. However, permafrost conditions are likely to be found under the channel, as was found in the realignment of Reach 4 of Baker Creek (see Section 4). Limited subsidence in areas of permafrost melt may occur, though the detailed design will include measures to mitigate this. Channel bed and bank erosion may occur during infrequent flood events (e.g., greater than 1:100-year event). However, this should be limited to lateral channel migration within the active channel area. • **Aesthetic and terrestrial habitat effect**—Modification of the site topography and a permanent loss of habitat in a small area along Baker Creek in reaches 1, 3 and 5 is required for widening of Baker Creek to accommodate the probable maximum flood. • **Water quantity effect**—Post-closure, Baker Creek and its tributary drainage network at the Site is expected to be physically stable, with drainage patterns approximating pre-development patterns. The geomorphic channel will lend itself to development of fish habitat features, though design and construction of specific features will depend on future discussions with regulatory agencies and affected parties. Summer flows will decrease from existing flows because the existing ETP will no longer discharge to Baker Pond (i.e., discharge will occur from the new WTP into Yellowknife Bay); reduced fall water level in Baker Creek will be a residual effect of changing the discharge location. However, this will result in a flow regime similar to that existing prior to development in Baker Creek. Given that the dominant fish habitat use in Baker Creek on the Site is for spring spawning, this habitat use will be maintained, despite the reduction in flows in July through September. Most adult and young-of-year fish out-migrate from the creek by early July (Golder 2010). • **Water quantity effect**—Baker Creek and its tributary drainage network at the Site is expected to balance the desire to have drainage patterns approximating pre-development pattern against the need to have a limited number of site runoff points to Baker Creek. • **Water quality effect**—Possible contaminantation from site runoff may enter Baker Creek. • **Water quality effect**—After remediation activities are complete and the WTP is operational, concentrations of contaminants in Baker Creek are expected to decrease to meet site-specific water quality objectives in the vicinity of Baker Creek outlet (Measure 12 and 13) and not negatively affect aquatic life diversity or abundance, drinking water sources, or water uses of the receiving environment. However, concentrations in Baker Creek will continue to be influenced by loadings originating in upstream areas. Baker Creek originates at Duckfish Lake, then flows from Lower Martin Lake through reaches above the Site, joins with combined outflow from Gar and Trapper lakes via Trapper Creek, and travels through Baker Creek to Yellowknife Bay (see Chapter 2 and Appendix 2B). Many of the upstream areas have been impacted by historical deposition of arsenic. While water quality in Baker Creek is expected to substantially improve, concentrations are expected to be similar to those measured in upstream watersheds (CIRNAC and GNWT 2019a; CanNorth 2018); thus, water quality characteristics may not return to pre-development conditions. Arsenic loading from Trapper Creek and Upper Baker Creek into the reaches of Baker Creek on site will continue at post-closure (CIRNAC and GNWT 2019a), and some recontamination of sediment is possible. Viable alternative technologies (e.g., wetlands) are being evaluated as passive treatment systems to further reduce concentrations in Baker Creek to address this. • **Aquatic effect**—Aquatic life is expected to return to Baker Creek after construction, once the creek is physically stable, with fish habitat features and clean sediment in place and the cessation of treated effluent discharge to the creek. There may, however, be a delay between completion of remediation works and when full biological conditions are restored. Prior to the implementation of effluent treatment in the 1980s, benthic invertebrates were virtually absent from Baker Creek, presumably due to elevated contaminant concentrations from mine effluent (Chapter 2; Golder 2014b, 2017g). Overall, since the implementation of better mining practices in the late 1990s and with the Site beginning closure and reclamation, improvements in the Baker Creek aquatic ecosystem have been documented (Golder 2014b). Because Baker Creek has upstream and downstream connections to fish and benthic drift communities, the time lag for the recolonization of aquatic life in all reaches is expected to be relatively short (one to five years after removal of sediment from the final reach). The time for full revegetation of the reaches may be more than five years and is thus noted as a potential residual effect due to the time lag for restoration.

Table 5.11-1: Summary of Residual Effects for Giant Mine Remediation Components

Site Component	Predicted Residual Effects
Tailings Containment Areas	• **Aesthetic effect and terrestrial habitat effect**—Covered TCAs will remain over 95 ha (8.5% of the total 1,115 ha project area) of the site. • **Soil quality/water quality effect**—Tailings will be removed from the former South Pond area. It will not be possible to remove 100% of the tailings, and some residual material may remain in cracks and crevasses of the reclaimed area. Control and treatment of surface runoff from these areas is planned to address short-term impacts on water quality, with either residual material removed or limited amounts of coarse material placed as required to prevent contact. • **Water quality/sediment quality effect in Foreshore Area**— Tailings will be covered in the Foreshore Tailings Area. After the placement of the designed cover, tailings will continue to exist deeper in the bay, further out from the shoreline; benthos habitat in this area will not improve. As well, some residual metals may leach from uncovered tailings to Yellowknife Bay, in very small quantities. The HHERA estimated that the conditions in Yellowknife Bay would improve over time, albeit slowly (CanNorth 2018). • **Stability effect**—Permanent dams will remain on site containing tailings. Dams will be monitored and maintained in the long term to confirm they continue to meet CDA criteria; however, as dams are engineered structures, some residual risk will remain.
Borrow Material	• **Aesthetic and terrestrial habitat effect**—Modification of the site topography will be required, including removal of high walls at Baker Creek and hills and high points near existing mine components in the area of the borrow development. Creation of limited new vegetated areas may attract wildlife to the site. • **Water quantity effect**—There will be local modifications of surface runoff patterns in the area of the borrow developments. • **Water quality/Stability effect—**Limited areas of permafrost will be disturbed and if the area thawed could result in some ground instability or changes in local water quality (see Chapter 2). •
Water Treatment Plant and Outfall Systems	• **Water quality effect** — In the mixing zone, there will be some localized effects on some species of aquatic life such a small plankton; this will be allowable through approved site specific water quality objectives. • **Aesthetic effect**—Portions of the outfall will be visible on shore and a long-term access road to the conveyance pipe and outfall is needed for inspections and maintenance. • **Aesthetic/public safety effect**—There is a possible residual effect of ice scour in the outfall area. Treated effluent will be discharged at the outfall at a depth of 6 m, with the pipe facing at an angle to prevent scour but not so steeply as to encourage ice erosion. Continued monitoring will be required to confirm ice scour is not occurring and that ice-safety for local users is maintained. Signage will be used to mark any areas of risk, and mitigation will be investigated. The choice of the location and type of discharge (pipe outfall versus deep water diffuser) is in accordance with affected party input and Measure 14. • **Unknown effect**—Water velocities in the area of the outfall are predicted to be low, and as such, velocity-related effects on swimming fish are not anticipated.
Site Infrastructure	• **Aesthetic and terrestrial habitat effect**—Concrete foundation slabs will be left in place within the core area. • **Aesthetic and terrestrial habitat effect**—Modification of the site topography will be required for remaining infrastructure: the new freeze program, WTP, landfill, and supporting infrastructure such as roads and utilities, and fencing required for security. • **Water quantity effect**—With removal of all site infrastructure and installation of limited new infrastructure, the surface will be graded to support the surface water drainage design, which will alter existing drainage patterns; surface water drainage designs will reflect natural site drainage patterns as is practical (see Section 5.5 for further discussion).
Landfill	• **Aesthetic and terrestrial habitat effect**—Modification of the site topography and a permanent loss of potential habitat in a small area is required for the construction/operation/closure of the landfill.

WTP = water treatment plant; HHERA = Human Health and Ecological Risk Assessment; TCA = Tailings Containment Area.

SECTION 5.12
Monitoring and Management

5.12 Monitoring and Management

As committed to in the DAR (INAC and GNWT 2010), the GMRP has developed an Environmental, Health, Safety and Community Management System, which is an integrated system that includes aspects of both environmental management (ISO 14001) and health and safety (OHSAS 18001). Within the Environmental, Health, Safety and Community Management System is the Long-Term Monitoring Program (LTMP); it is the framework around the design and implementation of all monitoring programs on Site (Figure 5.12-1). This includes all environmental, structural and remediation specific monitoring, provisions for quality assurance and quality control, legal compliance, audits and inspections, reporting, etc. In the DAR, the environmental components of the LTMP were noted (see DAR Table 14.2.1); since then, LTMP has been expanded to track monitoring of additional environmental components as well as structural components.

Table 5.12-1 outlines the major components of LTMP; Figure 5.12-1 identifies the linkages of each monitoring category to the LTMP Environmental Review Committee and the Technical Review Committee and how this ultimately ties back to the Environmental, Health, Safety and Community Management System, resulting in continuous review and improvement.

Environmental monitoring will be implemented under the MCM contract through an Environmental Coordinator. The Technical Review Committee is an internal GMRP group who will work with the Environmental Coordinator to identify appropriate technical review (which could be internal or external) of monitoring results and reports.

Table 5.12-1: Long-Term Monitoring Program Components

Environmental Monitoring	Structural Monitoring	Additional

• Aquatic Monitoring incl:
  • Surveillance Network Program (SNP)
  • Operational Monitoring Program (OMP)
  • Aquatic Effects Monitoring Program (AEMP)
  • Metal and Diamond Mining Effluent Regulations (MDMER) including Environmental Effects Monitoring (EEM)
  • Hydrology in Baker Creek
• Wildlife and Wildlife Habitat Monitoring
• Air Quality
• Noise
• Hydrology
	• Freeze
	• Dams and Seeps
	• Landfill
	• Pit stability
	• Tailings cover (incl. TCAs and foreshore tailings)
	• Underground structures (e.g., bulkheads/stopes and pillars)
	• Above-ground structures including roads, bridges
	• Baker Creek (icing, flow, beavers)
	• Minewater
		• Additional monitoring associated with specific activities related to the GMRP to ensure ongoing regulatory compliance (e.g., construction monitoring, drilling program) incl:
		  • Soil and sediment monitoring
		  • Erosion and sedimentation monitoring
		  • Dust monitoring
		• Tracking of other external studies and monitoring programs, incl.
		  • Research Programs (e.g., Cumulative Impact Monitoring Program)
		  • Community Monitoring (e.g., community-based water monitoring program).
		• Linkages to other internal studies and monitoring programs, incl:
		  • Occupational Health and Safety
		  • Human Health

TCA = Tailings Containment Area; GMRP = Giant Mine Remediation Project.

As described in Section 5.0, the GMRP has been divided in three project phases (Figures 5.0-1 and 5.0-2):

- Phase 1: Existing Condition
- Phase 2: Active Remediation and Adaptive Management
- Phase 3: Post-closure Monitoring and Maintenance[1]

The LTMP is a living program with multiple monitoring components. Current monitoring programs at the Site under the LTMP (Phase 1) are comprehensive and include several components and programs (Table 5.12-2). These monitoring programs will continue to function for the remainder of Phase 1 (pre-remediation) as well as through Phase 2 (Active Remediation and Adaptive Management), and into Phase 3 (Post-closure Monitoring and Maintenance). However, the monitoring details associated with each component may be modified to reflect site conditions as the GMRP moves through each phase. Some components are more applicable in certain phases of the GMRP than in others. For example, structural monitoring components will change as remediation work progresses; pit stability monitoring will change from pit wall stability to settlement of fill once they have been backfilled. Some dams and seeps will disappear when tailings are consolidated, and covers will require structural monitoring once in place. Updates to monitoring programs associated with remediation components will also be required. Any changes will be submitted for review and approval prior to implementation. A description of each of these environmental and structural monitoring programs is provided in Section 5.12.2.

Detailed monitoring plans and programs will be submitted for many of the environmental components as part of the Post-EA Information Package. Additional monitoring programs and remediation component-specific details will be provided for review and approval throughout the life of the GMRP (see Section 5.0.3 for more information).

[1] Post-closure maintenance of this site includes on-going operation of the Water Treatment Plant and the active cell in the non-hazardous waste landfill where treatment residuals will be disposed and managed

Giant Mine Remediation Project
Long-term Monitoring Program Overview

Environment, Health and Safety, and Community Management System (EHSC MS)

TRC works with LTMP representative to identify appropriate technical review (i.e., internal vs. external) for Environmental Monitoring Component documents.

Continual review and improvement process.

Technical Review Committee (TRC)

Long-term Monitoring Program (LTMP) Representative

Environmental Monitoring documents and associated data are provided to the TRC for technical review.

Environmental monitoring to be implemented under the MCM contract through an Environmental Coordinator (through separate sub-contracts).

Structural Monitoring documents and associated data are provided to the TRC for technical review.

Structural monitoring to be implemented under the MCM contract (through separate sub-contracts).

Results of activity specific monitoring are provided to the LTMP Representative and are circulated to the Environmental and Structural Monitoring Components for information purposes; some results may be used to inform on-going monitoring.

ACTIVITY SPECIFIC MONITORING
Additional monitoring associated with specific project activities
(e.g., construction monitoring, drilling program)

LTMP - ENVIRONMENTAL MONITORING COMPONENT

- Surveillance Network Program (SNP)[1, 2, 3]
- Operational Monitoring Program (OMP)[1, 2, 3]
- Metal and Diamond Mining Effluent Regulations (MDMER) including Environmental Effects Monitoring (EEM)[2, 4]
- Aquatic Effects Monitoring Program[4]
- Wildlife & Birds[2]
- Air Quality Monitoring Program (AQMP)[2, 5]
- Noise[6]
- Hydrology

Final documents and data for Environmental and Structural Monitoring Components are maintained within the LTMP.

Information will be made available between components to inform on-going monitoring, as appropriate.

LTMP - STRUCTURAL MONITORING COMPONENT

- Freeze
- Dams and Seeps[2]
- Landfill
- Pit Stability[2]
- Tailings Covers
- Underground Structures[2]
- Above-ground Structures (includes material storage areas)[2]
- Baker Creek (icing, flow, beavers)[2]
- Minewater[2, 3]

ADDITIONAL FUNCTIONS OF LTMP

1. Contributing to on-going tracking of regulatory compliance

2. Tracking of other external studies and monitoring programs
   - Research Programs (e.g., CIMP)
   - Community Monitoring (e.g., community-based water monitoring program)

3. Linkages to other internal studies and monitoring programs
   - Research Programs (e.g., CIMP)
   - Community Monitoring (e.g., community-based water monitoring program)

Notes:
(1) SNP and OMP include surface water, groundwater and underground minewater aspects.
(2) Indicates an existing monitoring program that is considered active; however, modifications to the existing program may be required in the future.
(3) It is assumed all underground minewater chemistry samples will be completed under the OMP, except for new submersible pumps in Akaitcho area (and eventual new C-shaft pumps), which will be SNP stations. Bulkhead water balance monitoring is completed under the Structural Monitoring Component.
(4) AEMP is anticipated to include water quality, sediment quality, benthos, fish health and possibly plankton. Water quality, sediment quality, benthos and fish health are also included in the MDMER/EEM program. It is anticipated that AEMP and MDMER/EEM will be harmonized.
(5) AQMP under LTMP includes Site perimeter and community stations; additional activity-specific monitoring is completed as required.
(6) A formal noise monitoring program is not anticipated to be required long term, but may be necessary during implementation of specific remediation activities.

PROJECT: Giant Mine Remediation Project

TITLE: LONG-TERM MONITORING PROGRAM OVERVIEW

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

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2019-01-31
DESIGNED	KH
PREPARED	HP
REVIEWED	K. Harris
APPROVED	J. Amphlett

REV. 0

FIGURE 5.12-1

Table 5.12-2: Long-Term Monitoring Program – Conceptual Monitoring Component Overview for Project Phases 1 through 3

Stage of Remediation		Monitoring Component[a]	Site Components																	
			Minerals					Site Infrastructure				Underground			Control Structures			Constructed Covers		
			Borrow Sources	Soils in Situ	Baker Creek Sediment	Pit Fill	Remediated Soils/ Tailings Areas	ETP/WTP	Discharge Pipe and Outfall	Landfill	Site Buildings & Fence	Under-ground Stopes	Openings to surface	Freeze	Baker Creek Alignment	Tailings Ponds	Dams/ Dykes	Soil Covers	Tailings Covers	Pit Covers
Phase 1 Existing Condition (pre-remediation)		Water		X		n/a	n/a	X	n/a	n/a		X		X		X	X	n/a	n/a	n/a
		Dust	X	X							X					X				
		Air quality	X								X					X				
		Erosion	X									X	X		X	X	X			
		Wildlife	X								X		X			X				
		Structural	X					X			X		X				X			
		Operational						X						X						
		Noise	X																	
		Soil/Sediment chemistry	X	X	X															
		Freeze										X		X						
Phase 2	Active Remediation	Water	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
		Dust	X	X	X		X		X	X	X			X	X	X	X	X	X	X
		Air quality	X	X	X		X	X	X	X	X			X	X	X	X	X	X	X
		Erosion	X	X	X		X		X	X		X	X	X	X	X	X	X	X	X
		Wildlife	X	X	X		X		X	X	X		X		X	X	X	X	X	X
		Structural	X		X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
		Operational						X	X	X				X						
		Noise	X		X		X	X	X	X	X			X	X		X	X	X	X
		Soil/Sediment chemistry	X	X		X	X			X										
		Freeze										X		X						
	Adaptive Management[b]	Water	X	X	X	X	X	X	X	X		X		X	X	n/a	X	X	X	X
		Dust	X		X		X		X	X								X	X	X
		Air quality	X				X		X									X	X	X
		Erosion	X		X		X		X	X		X	X		X		X	X	X	X
		Wildlife			X		X		X	X								X	X	X
		Structural	X		X	X		X	X	X	X	X	X	X	X		X	X	X	X
		Operational						X	X	X				X						
		Noise																		
		Soil/Sediment chemistry		X			X				X									
		Freeze												X						
Phase 3 Post-closure Monitoring and Maintenance[b]		Water		X		X	X	X	X	X		X	X	X	X	n/a	X	X	X	X
		Dust	X				X			X								X	X	X
		Air quality																		
		Erosion	X				X		X	X		X	X		X		X	X	X	X
		Wildlife					X			X	X									
		Structural	X			X		X	X	X	X	X	X	X	X		X	X	X	X
		Operational						X	X	X				X						
		Noise																		
		Soil/Sediment chemistry																		
		Freeze												X						

a) Site-wide monitoring and monitoring of the receiving environment is in addition to these component-specific monitoring activities and is discussed in more detail in Section 5.12.2 and corresponding management and monitoring plans.

b) Adaptive management and post-closure monitoring are anticipated to be similar, especially at commencement of post-closure; frequencies and level of monitoring are anticipated to reduce or be discontinued as specific component performance confirmed.

ETP = effluent treatment plant; WTP = water treatment plant; n/a = not applicable.

The monitoring completed prior to licensing has been used to inform monitoring requirements for Phase 1 and the early stages of Phase 2, as well as the selection of closure activities (e.g., as baseline). Similarly, monitoring during Phase 2 will be used to inform the scope, duration, and frequency of a final detailed post-closure monitoring program, largely based on monitoring as part of adaptive management. Therefore, the post-closure monitoring presented as part of this CRP should be considered conceptual. A Post-closure Monitoring and Maintenance Plan (PCMMP) will be submitted at the end of Phase 2, prior to completion of remediation activities and as a transition of the GMRP into Phase 3.

Monitoring prior to post-closure is focused on ensuring additional impacts to the environment from remediation activities are mitigated, both on an activity level and a site-wide level; it will consist of the following:

- Regulatory compliance monitoring (quality and quantity) at the surface water and groundwater stations identified in the SNP, an annex to the Water Licence, and the surface water stations required under the MDMER (Section 5.12.2.1). The stations and frequency of sampling are outlined in the Water Management and Monitoring Plan (2019a), SNP (2019b), and Aquatic Effects Monitoring Program (AEMP) Design Plan for Baker Creek (2019c); and future stations will be prescribed by the MVLWB and ECCC.
- Extensive environmental monitoring including water quality and quantity (i.e., groundwater, surface water, runoff water, minewater), sediment quality (AEMP and EEM), air quality, wildlife and wildlife habitat, and aquatic effects (AEMP and EEM), as outlined in Sections 5.12.2.1 to 5.12.2.8. Site-wide monitoring details and best management practices are included in the management and monitoring plans submitted with the Post-EA Information Package.
- Structural (Section 5.12.2.7) and operational (Section 5.12.2.8) monitoring of site infrastructure.

Monitoring of the advancement of the frozen rock shell surrounding the arsenic stopes and chambers will begin in the Active Remediation phase and continue in Post-closure Monitoring, for the life of the project (Section 5.12.2.9).

Remediation options selected for the Site have been identified and designed to eliminate the need for future maintenance where possible; monitoring during the adaptive management sub-phase of Phase 2 will help to identify concerns and address issues to minimize maintenance needs prior to entering post-closure. However, it is anticipated that some maintenance will likely be required for some components during Phase 3.

Phase 3, Post-closure Monitoring and Maintenance, begins once each component of the CRP is considered completed. At this point, monitoring is required to confirm closure criteria are met long term. It is expected that a subset of the existing environmental monitoring programs including groundwater, surface water, runoff water, minewater, wildlife habitat, and aquatic effects (AEMP, MDMER/EEM) will continue into post-closure. Over time, as the GMRP progresses into the long-term future, the types, frequency, and level of detail in the monitoring programs are expected to decrease.

An overview of all monitoring components (i.e., current and anticipated) that will be implemented for the different components of the CRP as the GMRP progresses, is provided in Table 5.12-2. Some monitoring programs take both a component-specific and site-wide approach to monitoring (e.g., dust, water, and erosion). Section 5.12.2 provides an overview of each monitoring program and how it has been, and is expected to continue to be,

implemented throughout Phases 1, 2 and into Phase 3. References to existing management and monitoring plans are included, where applicable.

5.12.1 Regulatory Processes for Monitoring and Maintenance Updates and Reporting

Each project phase and monitoring program is governed by a defined regulatory process, which includes implementation of MVLWB-approved activities and reporting on monitoring results. It is fully expected that the MVLWB and its reviewers, or other relevant agencies (e.g., DFO, ECCC) as applicable, will govern and provide input on relevant management and monitoring plans throughout the three phases of the project. An overview of the anticipated standard reporting requirements is provided in Table 5.12-3.

The management and monitoring plans submitted separately as part of the Post-EA Information Package and those planned for development include detailed information regarding site monitoring and management by monitoring component. These are living documents that will be updated annually and as the GMRP progress. All updates will be submitted to the MVLWB for approval.

Appropriate monitoring specific to closure activity implementation and adaptive management will be included in the Design and Construction Plans, and Construction Completion Reports (as needed). All monitoring and management details approved through Design and Construction Plans will be incorporated into management and monitoring plans for a conformity check.

Specific monitoring requirements for the three Reclamation Research Plans will be outlined with Reclamation Research Plan updates. These Reclamation Research Plans include the Minewater Level Reclamation Research Plan (Appendix 5.1B), Metals Downgradient of Dam 3 Reclamation Research Plan (Appendix 5.4B), and Reclamation Research Plan for Alternative Technologies to Reduce Arsenic Loading to the Aquatic Environment (Appendix 5.5B).

Table 5.12-3: Standard Reporting Requirements

Reporting Requirement	Monitoring Program	Reporting Agency	Reporting Frequency
Surveillance Network Program (SNP) Report	SNP	MVLWB	Monthly
Water Licence Report[(a)]	• Water Management • SNP • Waste and Spills Management • Fugitive dust • Erosion and sedimentation • Freeze • Soil and sediment[(d)] • Operational monitoring[(e)] including TCAs • Any additional monitoring requirements from construction or adaptive management • CRP progress updated including summary of additional approved activity-specific monitoring • Reclamation research completed	MVLWB	Annual
Wildlife and Wildlife Habitat Report	• Wildlife Habitat and Protection	MVLWB/GNWT/ECCC	Monthly/Annual/Every three years (comprehensive report)

Table 5.12-3: Standard Reporting Requirements

Reporting Requirement	Monitoring Program	Reporting Agency	Reporting Frequency
Geotechnical Inspection Report	• Dam Safety (OMS) • Stability monitoring (OMP)	MVLWB	Annually for geotechnical inspections/ as per the Dam Safety Guidelines for dam inspections
Aquatic Effects Monitoring Program (AEMP) Annual Report	• AEMP	MVLWB	Annual
AEMP Design Plan and AEMP Re-evaluation	• AEMP	MVLWB	Every three years or as required by the Water Licence
Effluent and Water Quality Monitoring Report	• Metal and Diamond Mining Effluent Regulations / Environmental Effects Monitoring (MDMER/EEM)	ECCC	Quarterly (electronic submission of data) Annual Report
Biological Monitoring Study (EEM)	• EEM Biological Monitoring (on-going based on a three-year cycle)	ECCC	Year 1: Study Design, submitted six months prior to field work in Year 2. Year 3: Final Interpretative Report for period
Fisheries Act Authorization	• Near/in-water work monitoring • Habitat offsetting monitoring	DFO	As stated in the Authorization
GMOB Annual Report	• Environmental Agreement	GMOB	Annual
State of the Environment Report	• Environmental Agreement	Parties to the Agreement	First report 7 years after effective date of Agreement 9 June 2022; every three years after that for 15 years (2022-2037); after 15 years, every 5 years (2037 onward)
Direct Data Upload to GNWT Air Quality Website	• Air Quality	Project commitment during the EA; results submitted to GNWT	Weekly and annual

Notes:

(a) Additional monitoring may be required by the MVLWB during the life of the project. Any additional MVLWB required monitoring will be reported on in the annual Water Licence report.

(b) Air quality monitoring on site is likely to decrease or be discontinued post-closure once activities and dust sources are minimized.

(c) Includes a summary of updates or changes to the process or facilities required for the management of water and wastewater, monthly elevations of water in the Polishing Pond and TCAs, and monthly and annual cubic metres of minewater pumped from the underground.

(d) Soil and sediment monitoring will be completed as activity-specific monitoring components, as required. Results of this monitoring will be reported as part of the Construction Completion Report and summarized annually in the annual Water Licence Report.

(e) The OMP, currently incorporated in the Standard Operating Procedures for Effluent and Water Monitoring (CIRNAC and GNWT 2019d) will be modified into a separate monitoring plan and expanded to encompass structural monitoring aspects (e.g., pit walls and caps/covers) that are not captured elsewhere (e.g., Tailings Management and Monitoring Plan).

AEMP = Aquatic Effects Monitoring Program; EEM = Environmental Effects Monitoring; MVLWB = Mackenzie Valley Land and Water Board; ECCC = Environment and Climate Change Canada; DFO = Fisheries and Oceans Canada; GMOB = Giant Mine Oversight Board; CRP = Closure and Reclamation Plan; EA = environmental assessment; GNWT = Government of the Northwest Territories; TCA = Tailings Containment Area; SNP – Surveillance Network Program; OMP = Operational Monitoring Program; OMS = Operational, Maintenance and Surveillance.

5.12.2 Overview of Monitoring Programs

An overview of specific monitoring components and programs and how they address different aspects of each mine component throughout the three project phases is presented below. Table 5.12-4 outlines the key monitoring programs and monitoring components currently implemented and anticipated during the project life. More details regarding each component can be found in the applicable management and monitoring plans documents submitted as part of the Post-EA Information Package.

Table 5.12-4: Current and Anticipated Aquatic Monitoring Program Components

SNP	OMP	AEMP	MDMER/EEM	Activity-Specific /Other
• ETP/WTP discharge • Seeps, sumps (minewater) • Groundwater • Surface water • Minewater	• Groundwater • Surface water • Minewater • Surface runoff • Bulkhead seepage (underground) • Flood risks (e.g. beaver dams, icing) • Structural[c]	• Water quality in Baker Creek, Yellowknife River, Yellowknife Bay and lake reference area (TBD)[a] • Sediment quality in Baker Creek, Yellowknife Bay, Yellowknife River and lake reference area (TBD)[a] • Toxicity testing (sublethal) in receiving environment • Benthos • Fish health • Baker Creek flow (hydrologgers)	• Treated effluent (ETP/WTP) • Surface water quality in Baker Creek, Yellowknife River, Yellowknife Bay, and lake reference area (TBD)[a] • Sediment quality in Baker Creek, Yellowknife Bay, Yellowknife River and lake reference area (TBD)[a] • Toxicity testing (acute and sublethal) of treated effluent • Benthos • Fish health	• Baseline data collection in Yellowknife Bay • Hydrometric Station 07SB013 on outlet of Lower Martin Lake[b] • Components and locations of additional water quality monitoring for specific closure activities will be defined in Design and Construction Plans • Alternative Technologies to Reduce Arsenic Loading to the Aquatic Environment Reclamation Research Plan; components TBD • Other studies as requested by the MVLWB; components, as specified

(a) For existing ETP, receiving environment is Baker Creek downstream of the discharge and Yellowknife Bay at the mouth of the creek, reference areas are Baker Creek upstream of the discharge and Yellowknife River. For new WTP, receiving environment will be Yellowknife Bay and a lake reference area will need to be defined.

(b) Funding is provided by CIRNAC-GMRP to ECCC for operation of this hydrometric station through an Inter-departmental Letter of Agreement.

(c) The OMP, currently incorporated in the Standard Operating Procedures for Effluent and Water Monitoring (CIRNAC and GNWT 2019d) will be modified into a separate monitoring plan and expanded to encompass structural monitoring aspects (e.g., pit walls and caps/covers) that are not captured elsewhere (e.g., Tailings Management and Monitoring Plan).

SNP = Surveillance Network Program; OMP = Operational Monitoring Program; AEMP = Aquatic Effects Monitoring Program; MDMER = Metal and Diamond Mining Effluent Regulations; EEM = Environmental Effects Monitoring; ETP = effluent treatment plant; WTP = water treatment plant; TBD = to be determined; MVLWB = Mackenzie Valley Land and Water Board; CIRNAC = Crown-Indigenous Relations and Northern Affairs Canada; ECCC = Environment and Climate Change Canada.

5.12.2.1 Aquatic Monitoring

Water Quality and Quantity Monitoring

Water monitoring is the most extensive monitoring program implemented by the GMRP. The purpose of the water monitoring program is to assess whether water quality meets regulated standards and minimize additional impacts to the aquatic receiving environment. Regulatory requirements and the large volume of water collected, stored, and treated on the Site annually have resulted in the development of a robust water monitoring system. These data have also been used to characterize the Site from a water quality perspective, helping inform the selection of closure activities.

Water monitoring on the Site encompasses the following components: treated minewater prior to discharge, site surface contact and runoff water, groundwater (shallow and deep), minewater in the underground mine pool, seepage from dams and dykes, and water monitoring in Baker Creek and Yellowknife Bay. Water monitoring programs currently ongoing include:

- **Surveillance Network Program (SNP)**—The SNP requires water sampling at specific stations to confirm management activities are effective and acting as anticipated. The SNP was originally developed based on requirements of the former Water Licence N1L2-0043 (MVLWB 1998) and only included surface water stations. However, a revised SNP program has been proposed and submitted as part of the Post-EA Water Licence Package and includes surface and groundwater stations. Stations are situated around the Site and are designed to monitor for potential effects from mine components (e.g., TCAs, treated effluent).
- **MDMER/EEM effluent and surface water monitoring**—This monitoring is required by ECCC in relation to the discharge of treated effluent. Monitoring in relation to the existing ETP is focused on Baker Creek as the receiving environment as well as the upstream reference area. Future monitoring will move to Yellowknife Bay when the new WTP and outfall become operational.
- **Operational Monitoring Program (OMP)**—This is an internal monitoring program that is separate from compliance monitoring, but complements the SNP, providing additional data from surface water, groundwater (shallow and deep), seepage, underground minewater, and surface runoff from the Site. It is anticipated that the OMP will evolve to include other, non-aquatic, components (e.g. structural aspects) over time.

Collection of additional baseline data in Yellowknife Bay is required prior to commencement of discharge from the new WTP outfall; this work characterizes the receiving environment for the GMRP once the new WTP is commissioned and the outfall is placed in Yellowknife Bay. Additional baseline data is also being collected in Baker Creek to support the development of the new WTP EQC and site-specific water quality objectives. Baseline data collection is ongoing and will continue to be collected into Phase 1 and 2, prior to commissioning of the WTP.

Water monitoring during Phase 2 will build upon the existing monitoring programs already implemented at the site, as outlined in Table 5.12-4, and incorporate additional regulatory requirements (e.g., AEMP) and knowledge gained prior to licensing. Key updates and additions to water monitoring during Phase 2 are as follows:

- An updated SNP—Modifications to the current SNP stations will be required based on proposed CRP activities; additional surface and groundwater stations are anticipated at the new WTP and downstream from points of discharge from tailings and pit covers. Other SNP stations within the Site are anticipated to no

longer be required as all water will be directed underground. Exact locations for future stations will be provided through SNP amendments during Phase 2 as detailed design progresses.

- The OMP will maintain the same monitoring components in Phase 1, as have been implemented prior to licensing, and will be updated as Phase 2 progresses to reflect changing site conditions. Surface water, groundwater, and surface runoff stations may be added or modified. The specific details of these modifications will be determined through revised modelling of the underground, and may be updated in the future.
- Water quality monitoring programs specific to closure activities will be implemented during Phase 2. Some of the water monitoring required in support of construction or remediation may already be captured under existing programs (e.g., bulkhead monitoring for freeze as part of the OMP), but additional monitoring will need to be undertaken to confirm impacts to water quality are minimized for specific closure activities, including:
    - minewater level monitoring in the underground to identify any movement or settlement of backfill from minewater fluctuations (Section 5.1)
    - underground monitoring around bulkheads during implementation of freeze program (Section 5.2)
    - monitoring of pore pressure in pit fill to confirm water near former openings to surface within pits is properly flowing to the underground (Section 5.4)
    - monitoring of runoff from pit covers and tailings covers (Section 5.3 and 5.6)
    - sediment remediation (Section 5.4) and realignment of Baker Creek (Section 5.5).
    - confirmatory monitoring of treated minewater in the new WTP prior to discharge and at the outfall (Section 5.9)
    - visual monitoring at the outfall pipe for sheen on the water (Section 5.9)
    - seepage and groundwater monitoring around the non-hazardous waste cell and new WTP cell (Section 5.10)
    - all activities where erosion and sedimentation are of potential concern during construction or remediation activities due to excavation, transport, and placement of tailings, contaminated soils, or borrow materials; see Section 5.12.2.4 for a list of activities that require erosion and sedimentation monitoring and management.

It is likely that many of the closure activity-specific monitoring details will eventually become part of routine monitoring programs during the adaptive management part of Phase 2 and possibly be maintained into Phase 3.

The outfall will continue to treat and discharge minewater over the life of the GMRP (100 years), and therefore ongoing monitoring in Yellowknife Bay will be required throughout Phase 3. However, the extent of the monitoring program in the receiving environment is expected to reduce over time should monitoring results show anticipated trends in water quality. Water monitoring across the site is expected to decrease in frequency and robustness over time. For example, OMP monitoring programs will decrease once adaptive management indicates closure activities are working as anticipated. Additional Phase 3 monitoring details will be proposed in the PCMMP and updates to other water monitoring programs prior to completion of Phase 2 activities.

Aquatic Effects Monitoring

Since 2004, biological monitoring studies have been completed to meet the requirements of the MDMER/EEM program. The EEM program has included monitoring of fish health, benthic invertebrate community, and supporting water and sediment quality in the lower reaches of Baker Creek and adjacent area of Yellowknife Bay. The EEM program is completed on a three-year cycle that includes submission of a study design in Year 1, completion of a field program (or other study as required) in Year 2, and submission of the final report in Year 3.

The MVLWB requires an AEMP for all Type A Water Licences to monitor impacts to the aquatic receiving environment. The AEMP is a comprehensive monitoring program that includes water, sediment, and biological components. The EEM biological program will still be required for the Site, which has some overlap in scope with the AEMP. Harmonization of monitoring programs is encouraged by the MVLWB to address overlap in requirements (MVLWB et al. 2017). Harmonization allows for consistency in monitoring and reduces duplication of monitoring efforts. The GMRP has developed its AEMP to align with its EEM requirements to the extent practicable while still meeting the objectives of the AEMP and Water Licence requirements.

The receiving environment for the GMRP will change because of selected closure activities. At the commencement of Phase 1, the approved AEMP for Baker Creek will be implemented. Once the new WTP and outfall are installed and commissioned, the new discharge location for treated minewater will be in Yellowknife Bay near the mouth of Baker Creek. Yellowknife Bay will become the immediate receiving environment and the baseline information collected in Yellowknife Bay will be incorporated into the AEMP design. Project requirements for monitoring stay the same for the future.

A detailed AEMP for existing conditions and a conceptual AEMP for Yellowknife Bay have been submitted together in the Post-EA Information Package. A final design plan for the AEMP in Yellowknife Bay will be submitted to the MVLWB for review and approval prior to discharge into Yellowknife Bay commencing.

5.12.2.2 Soil and Sediment Chemistry Monitoring

Extensive soil chemistry characterization was completed to gain an understanding of the soil concentrations on the Site, identify contaminant hotspots, and develop proposed closure activities for soil remediation (Section 5.4). This work also contributes to pre-soil sampling for EA Measure 21, which requires the GMRP to "collect dust and contaminant level data from soil and vegetation in the vicinity of major reclamation activities before and after major demolition or construction activities to serve as baseline for any related adaptive management activities that may follow."

During Phase 2, after soil remediation is complete, confirmatory monitoring will be completed to verify remediation activities have been successful, remobilization of concentrations from deeper depths is not occurring, and to satisfy EA Measure 21. Confirmatory soil sampling is anticipated to occur during the adaptive management period after active remediation, prior to post-closure. Results of confirmatory sampling will determine whether longer-term soil monitoring is needed in post-closure; if so, then monitoring will be proposed in the PCMMP prior to completion of Phase 2 activities.

Sediment monitoring in Baker Creek and Yellowknife Bay is ongoing as part of the current MDMER/EEM biological program. Additional characterization of sediments in Baker Creek, along the townsite shoreline and foreshore tailings areas has also been completed. These results have been used to help develop remediation

plans for Baker Creek sediments (Section 5.5), the townsite nearshore sediments (Section 5.4), and the foreshore tailings area (Section 5.6).

During Phase 2, after remediation of Baker Creek and the nearshore area is complete (i.e., dredging and capping), confirmatory monitoring will be completed to verify remediation activities have been successful. Sediment sampling in Baker Creek and Yellowknife Bay will continue as part of the AEMP and EEM program. It is anticipated that DFO may require additional monitoring in relation to the *Fisheries Act* Authorization, but specific details are unknown at this time.

5.12.2.3 Dust and Air Quality Monitoring

Dust and air quality monitoring are important components of Site monitoring and management due to the large areas of exposed tailings and planned remediation activities.

Prior to remediation, there are several Site features which may be subject to wind erosion; of greatest concern are the areas of the TCAs where there is no ponded water and exposed tailings dry out. General mitigation for dust generation on roads and tailings have been completed using treated water from the Polishing Pond and a calcium chloride solution. Application of an improved co-polymer dust suppressant on tailings ponds was implemented in 2013 following a large dust event at the Site, which caused significant concern that airborne tailings dust may enter the surrounding communities.

An AQMP was developed in 2013 as part of the management and monitoring plans for site stabilization components that were soon to be implemented (e.g., stope backfilling and roaster deconstruction; Section 4.1). Air quality monitoring will continue for the duration of active remediation and will be reassessed after remediation is completed. The AQMP includes three levels of air quality monitoring which monitor fugitive dust for arsenic concentrations and other metals, asbestos fibres, and particulate size:

- **Activity-specific**—Air quality monitors are placed in the vicinity of an activity at the Site which has potential to generate dust (e.g., building demolition).
- **Fence line**—Air quality monitors are placed around the Site perimeter at designated locations.
- **Community**—Three community monitors are managed by the GMRP to assess whether fugitive dust from the Site reaches the community and whether a trigger of the community monitor is reflective of a dust event at the Site (triggers of activity-specific and fence line monitors).

In addition to the AQMP, visual dust monitoring and wind speed monitoring programs have been developed. Visual and wind speed monitoring is undertaken daily and will be continued throughout remediation activities. Precautionary action levels are set for visual dust and wind speeds to allow for the possible mitigation of a dust event. These include preventative actions, such as wetting mineral materials, roads, and tailings, as well as stop-work actions if wind speeds exceed a threshold likely to result in a dust event. Site-wide dust and air quality monitoring are included in the Dust Management and Monitoring Plan submitted to the MVLWB with the Post-EA Information Package.

Several of the proposed remediation activities may become sources of dust without the application of mitigation measures. Therefore, mitigation measures for fugitive dust will be implemented during Phases 1 and 2 to minimize dust events and maintain air quality. Closure activities where dust mitigation measures will be required include:

- digging up tailings to develop backfill paste for filling underground stopes (Section 5.1)
- installing thermosyphons and monitoring boreholes for the freeze program (Section 5.2)
- excavation and relocation of contaminated soils (Section 5.4) and relocation of South Pond tailings to consolidate mineral wastes in the TCAs (section 5.6)
- blasting for borrow material (Section 5.7) and in support of remediation activities (e.g., Baker Creek realignment [Section 5.5] and the North Pond spillway [Section 5.6])
- filling of pits (Section 5.3)
- construction of the WTP and installation of the outfall pipe (Section 5.8)
- demolition of buildings and site infrastructure (Section 5.9)
- construction of the landfill (Section 5.10), pit, tailings, and contaminated soil covers (Sections 5.3, 5.4, and 5.6) designed to address and withstand wind erosion (e.g., the top layer of rock on pit and tailings covers will be coarse fill material, with a grain size that can withstand wind erosion)

Although some dust generation is anticipated during some closure activities, once implementation of closure activities is complete, dust levels at the Site are expected to return to comparable air quality to the surrounding region. Existing sources of contaminated mineral materials that may have resulted in dust (i.e., tailings) will now be covered and, therefore, eliminated as a potential source of fugitive dust. Adaptive management for dust and air quality will be structured to confirm the implemented closure activities (e.g., covers or borrow source areas) are not a susceptible to wind erosion. See Section 5.12.2.4 and the Erosion and Sediment Management and Monitoring Plan for more information on erosion control measures that will assist with mitigating dust sources (e.g., revegetation of fine grained borrow sources).

Should Phase 3 air quality monitoring demonstrate air quality at the Site to be similar to background levels, and dust monitoring confirms no significant dust sources remain at the Site, the air quality monitoring program may be discontinued. Dust monitoring will continue as a part of ongoing Phase 3 monitoring to determine whether dust from roads and laydown areas used to support long-term monitoring and maintenance at the Site requires mitigation. Additional Phase 3 monitoring details will be proposed in the PCMMP prior to completion of Phase 2 activities.

5.12.2.4 Erosion and Sediment Monitoring

During Phase 1, routine monitoring for erosion has been completed regularly, consisting of visual inspections of the Site to identify any areas of water, ice, and wind erosion or erosion potential and visual inspections of existing erosion control structures to maintain proper performance. Erosion control measures implemented prior to licensing included installation of several runoff diversion systems to help control surface flows and use of silt curtains when working near water. Regular erosion monitoring has proven effective in identifying maintenance needs to reduce scour.

Activity-specific erosion and sedimentation monitoring and mitigation will be required during Phase 2, both during closure activity implementation and adaptive management phases. Closure activities that require working in or adjacent to Baker Creek and Yellowknife Bay will require application of erosion control best management practices and increased monitoring frequency. Ongoing site-wide monitoring erosion will also continue.

Several of the proposed remediation activities have the potential to cause erosion without the application of mitigation measures and best management practices for erosion. Erosion of newly disturbed soils or disturbance of tailings could result in increased erosion, especially if combined with spring melt, a large precipitation event, or high winds (see Section 5.12.2.3 for dust management). Activities and features that may cause erosion and sedimentation without proper monitoring and management include:

- removal and handling of mineral wastes, including contaminated soils and sediment (Section 5.4), tailings relocation (Section 5.6), and borrow recovery (Section 5.7)
- installation and long-term performance of pit and tailings covers and contaminated soil caps (Sections 5.3, 5.4, and 5.6)
- surface water management including discharging treated water, surface water runoff and diversion, and surface water storage (Sections 5.5 and 5.8)
- minewater level fluctuations underground, including impact on backfill in and around critical stopes, bulkheads, and crown pillars (Sections 5.1 and 5.2)
- near or in-water engineering works including Baker Creek channel realignments (Section 5.5), A1 and A2 high wall recontouring (Sections 5.4 and 5.7), placement of residential shoreline cover and foreshore tailings cover (Sections 5.4 and 5.6), and installation and operation of WTP near-shore outfall (Section 5.8)
- use of site roads and laydown areas (Section 5.9)
- removal of any vegetation surrounding areas being remediated or components being constructed
- former South Pond (Section 5.6) and former contaminated soils areas (Section 5.4), after relocation of contaminated material

The Transportation Association of Canada, the Ontario Department of Transportation, and the Yukon Government have developed valuable guidance with specific and adaptive methods for erosion and sedimentation control. The GMRP has developed an Erosion and Sediment Management and Monitoring Plan which amalgamates guidance and best management practices that are applicable to Site conditions and selected closure activities.

To avoid erosion during Phase 2 activities, erosion controls are to be incorporated into all phases of planning and implementation of selected closure activities, including:

- development and selection of engineered designs and procedures for implementation of closure activities
- selection and implementation of water management and soil erosion best management practices prior to, during, and after remediation work
- developing erosion monitoring details specific to each closure activity and adaptive management phase to be included in corresponding Design and Construction Plans

- prioritizing maintenance on constructed or remediated site features, should monitoring identify signs of water, ice, or wind erosion

Once closure activities are completed and adaptive management has addressed any initial erosion control issues, erosion monitoring in Phase 3 is anticipated to continue but decrease in frequency. Maintenance to address erosion control issues will be completed during Phase 3 as needed (refer to Section 5.13 for contingency management). Additional Phase 3 monitoring details will be proposed in the PCMMP prior to completion of Phase 2 activities.

5.12.2.5 Noise Monitoring

Noise monitoring is applicable during implementation of closure activities to uphold worker safety and address anticipated noise disturbance to wildlife or the community. With the likelihood that multiple remediation activities will be occurring simultaneously at the Site, implementation of applicable noise monitoring and mitigation will be required. Remediation activities anticipated to require noise monitoring and potentially noise mitigation include:

- drilling during installation of freeze program (Section 5.2)
- blasting A1 and A2 high wall recontouring (Sections 5.4 and 5.7)
- blasting during Baker Creek realignment (Section 5.5)
- blasting and recovery of borrow materials (Section 5.7)
- demolition of remaining buildings on site (Section 5.9)

Higher noise levels from use of vehicles and equipment on Site in support of remediation activities is also anticipated. Specific noise monitoring and mitigations will be identified in Design and Construction Plans.

In addition to remediation activities, monitoring and mitigation of workplace noise in the new WTP may be required so that volumes continue to meet worker health and safety requirements (Section 5.8). It is anticipated that the diesel generator room will require hearing protection, but other areas are not expected to exceed the requirements. Noise monitoring is not expected to be required elsewhere at the Site during post-closure. Any monitoring activities outside the WTP will be focused on confirmatory monitoring. Should a contingency scenario occur (Section 5.13) where maintenance or additional activities are required that may result in higher than appropriate noise levels, noise mitigation and monitoring will be implemented with methods similar to those outlined for Phase 2 activities, as applicable.

Applicable regulations and noise bylaws will be implemented and adhered to, including:

- Part 8 “Noise Control and Hearing Conservation” in the Occupational Health and Safety Regulations R-039-2015
- City of Yellowknife Noise Bylaw for Construction Noise

Noise monitoring and mitigation will be proposed in Design and Construction Plans. and standard operating procedures, appended to the Borrow Materials and Explosives Management and Monitoring Plan, once developed.

5.12.2.6 Wildlife and Wildlife Habitat Monitoring

Wildlife monitoring and management to reduce wildlife attractants at the Site has been ongoing prior to licensing. Bear sightings are common and have been documented and communicated diligently. Migratory birds use structures on site for roosting and nesting; therefore, surveys of site infrastructure have been completed each spring to identify and monitor nests. No work is completed in nesting areas until chicks have fledged. A wildlife sightings log has been kept, though inconsistently; it provides means for staff to track wildlife activity at the Site. The data is not systematically collected and contains repeated observations, but provides an indication of potential wildlife incidents or problem wildlife at the Site.

Monitoring moving forward into Phases 1 and 2 will implement an improved wildlife and wildlife habitat monitoring program at the Site. Monitoring will be completed to identify both potential harm to wildlife and potential benefits of remediation to wildlife. Monitoring program components include wildlife sightings log, site surveillance, bird nest surveys, denning surveys (as required), pre-blast surveys, and wildlife incident reporting. All monitoring components are discussed in detail in the Wildlife and Wildlife Habitat Management and Monitoring Plan submitted together with the Post-EA Information Package. This monitoring plan is a living document and will be updated and evaluated in response to monitoring results throughout Phase 2.

One of the major impacts to wildlife identified in the DAR from the existing Site are effects to terrestrial environments through contamination present in surface water, groundwater, and soils. Air quality from dust events may also pose concern. Closure objectives and activities that are anticipated to improve these impacts include:

- Reduced availability of contaminants—Activities such as the excavation of contaminated soils and capping of tailings areas will reduce the influence of historical contamination, most notably the isolation of arsenic (Sections 5.4 and 5.6)
- Removal of physical hazards—Buildings will be demolished, unstable landforms will be contoured, derelict equipment will be removed, and open pits and underground openings will be filled (Sections 5.3, 5.7, and 5.9)
- Termination of on-site disposal of domestic wastes (lunchtime wastes).
- Habitat creation—Natural revegetation of remediated areas (not pit and tailings covers) and the naturalization of Baker Creek will provide new habitat (Sections 5.4, 5.5, and 5.7); off-setting activities to compensate for impacts in Baker Creek will also result in improved habitat.

The GMRP is not actively creating habitat on site, other than to satisfy offsetting requirements in the *Fisheries Act* Authorization, nor has it selected its closure activities to specifically promote wildlife use of the area. The Site is located within a developed area, surrounded by many other contaminant sources and hazards to wildlife including the Yellowknife Landfill, quarries, highway, secondary roads, and trails. The Core Industrial Area will be fenced and WTP operations will continue, which will likely deter wildlife from the Core Industrial Area of the Site.

Any potentially adverse effects on the terrestrial environment resulting from project activities should be evaluated within the context of the positive effects noted above as site remediation activities are anticipated to result in a net benefit to wildlife and wildlife habitat at the Site. Remediation activities likely to impact and/or deter wildlife while being implemented are included in Table 5.12-5.

Table 5.12-5: Potential Impact Pathways and Mitigation of Impacts to Wildlife and Wildlife Habitat

Potential Impact Pathways	Remediation Activities	Monitoring and Mitigation to Reduce Impacts
Direct habitat loss	• Earthwork activities resulting in surface disturbances • Site access and preparation, borrow and backfill, contouring and capping of tailings and tailings ponds, Baker Creek rehabilitation • Demolition of surface infrastructure • Vegetation clearing	• Bird nest surveys • Denning surveys • Blast surveys • Wildlife incident investigations
Indirect habitat loss or alteration	• Demolition of surface infrastructure • Lights • Noise • Dust • Odours • Human activity • Fencing of Core Industrial Area	• Bird nest surveys • Blast surveys • Site surveillance • Mitigation and monitoring for dust • Mitigation and monitoring for noise • Mitigation and monitoring of waste, including odours
Wildlife injury and mortality	• Vehicle-wildlife collisions • Harm to wildlife during human-wildlife or project-wildlife encounters • Damage or harm to active bird nests on infrastructure or quarries/pits • Presence of sharp objects and unstable structures or landforms	• Wildlife sightings log • Bird nest surveys • Denning surveys • Blast surveys • Site surveillance • Wildlife incident investigations • Monitoring as per the Waste Management and Monitoring Plan • Mitigation and monitoring as per the Traffic Management Plan
Exposure to contaminants	• Spills • Mobilization of arsenic-contaminated materials • Storage of non-hazardous waste • water management sumps until closed, through use by staging and nesting water birds	• Wildlife sightings log • Site surveillance • Wildlife incident investigations • Management and monitoring of spills as per the Spill Contingency Plan • Management and monitoring as per the Waste Management and Monitoring Plan • Closure activities selected work to minimize wildlife exposure to arsenic • Closure of water management sumps will eliminate ability for water birds to use ponds for staging and nesting

Based on recommendations from the HHERA (CanNorth 2018), monitoring tissue chemistry of small mammals and vegetation will be included as part of environmental monitoring at the Site. The purpose of this monitoring is to determine if contaminant uptake into the vegetation and small mammals is occurring in areas where soil removal is not anticipated.

Once there is less site activity and fewer on-site staff, the robustness and frequency of the wildlife monitoring program is anticipated to decrease. Additional Phase 3 monitoring details for wildlife and wildlife habitat will be proposed in the PCMMP prior to completion of Phase 2 activities.

5.12.2.7 Structural Monitoring

Structural monitoring at the Site has been ongoing since mine closure and has been of increasing concern as the mine infrastructure ages. In 2012, concerns related to the stability of the underground stopes and the Roaster Complex were identified. In response to this, the GMRP applied for and was granted Water Licence MV2012L8-0010, which allowed specific site stabilization and deconstruction activities to proceed. Other site

infrastructure that structural monitoring deemed a risk to worker health and safety as well as posed a risk to the environment was also deconstructed (e.g., headframes at C Shaft and A Shaft, assay lab and curling rink; see Chapter 4 for details). Structural monitoring has also resulted in water management changes, such as using pipes to move water from Central to North Pond, instead of allowing seepage through dam infrastructure.

Closure activities planned for Phase 2 will address many of the existing stability issues on site. Some concerns will be eliminated as a result of closure activities; i.e., buildings will be demolished; therefore, stability concerns with aging infrastructure will no longer exist. Other mine components will be stabilized but remain on site (e.g., underground stopes and dam infrastructure) and structural monitoring after closure activities is anticipated to continue into Phase 3.

Anticipated adaptive management and post-closure structural monitoring requirements, once closure activities are complete, are outlined in Table 5.12-6. Detailed structural monitoring information will be provided with Design and Construction Plans. Geotechnical inspections will be completed annually throughout the life of the project; structural monitoring will be tracked through LTMP. The Tailings Management and Monitoring Plan includes required structural monitoring for tailings covers and dams and dykes post-closure. Additional details on Phase 3 stability monitoring will be provided prior to transitioning to post-closure.

Table 5.12-6: Structural Monitoring after Closure Activity Implementation

Component	Closure Activity	Structural Monitoring
Dams	Some removed; most maintained as part of TCA	• Visual inspection to detect signs of instability or seepage • Water level monitoring to evaluate piezometric levels in selected dams • Movement monitoring of slope indicators and survey monuments
Stopes and crown pillars	Backfill stopes with tailings paste	• Stability of backfill in stopes, including for changes after minewater fluctuations. • Site surface surveys for subsidence • Remote sensing for subsidence • Borehole camera inspections of backfill • Borehole extensometers and/or time domain reflectometry
Pits	Fill pits	• Visual inspection for settlement/ signs of instability, erosion, vegetation growth • Elevation monitoring to track settlement of the pit surface • Slope indicators and survey monuments to detect movement • Monitoring of stopes under pits of stopes (see stopes and crown pillars)
TCAs	Cover tailings	• Elevation monitoring to track settlement of the cover to verify that positive drainage is maintained and that differential settlement does not excessively stress the cover • Visual inspection to evaluate cover condition • Monitoring of moisture conditions to provide supplemental information on changes in tailings moisture following cover placement • Thermal monitoring to track the development of frost conditions under the cover, providing supplementary understanding of the tailings evolution over time and aid in the interpretation of measured moisture conditions
	Construct spillways to Baker Creek	• Visual inspection for erosion, settlement, and blockages.

Table 5.12-6: Structural Monitoring after Closure Activity Implementation

Component	Closure Activity	Structural Monitoring
Foreshore Tailings	Improved cover	• Visual inspection for settlement, erosion (requiring additional materials), vegetation growth (requiring removal), or deposition of sediment from wave action, which may influence effectiveness of cover
Contaminated soils	Cover some contaminated soils in Core Industrial Area	• Visual inspection for settlement/ erosion/vegetation growth (requiring removal)
Nearshore sediment	Cover sediments	• Visual inspection for settlement, erosion (requiring additional materials), vegetation growth (requiring removal), or deposition of sediment from wave action, which may influence effectiveness of cover.
Baker Creek	Realign and widen flood plain to reduce flood risk	• Visual inspections for settlement, erosion, and blockages, as well as sediment deposition. Slopes may be inspected and instrumented in selected areas for stability monitoring
Landfill	Construct and cover non-hazardous waste landfill	• Routine inspections of the containment berms, landfill cap, and the surrounding drainage ditching for signs of erosion, settlement, cracking or slumping, and for migration of the underlying waste material to surface. If deficiencies are noted, repairs or improvements will be completed
Site buildings and other supporting infrastructure	Construct WTP, pipeline, outfall and other supporting infrastructure (incl. freeze system)	• Periodic inspections of new buildings and infrastructure to confirm compliance with codes (e.g., above-ground structural monitoring, foundation monitoring including inspections for signs of thaw settlement, slope failure, erosion, slumping, or collapse)
	Install fence line, barriers, signage, covers over openings to underground	• Periodic inspections of fences, barriers, signage
	Demolish buildings	• Inspection of cap materials placed over concrete slabs for signs of erosion, or settlement.

TCA = Tailings Containment Area; WTP = water treatment plant

5.12.2.8 Operational Monitoring

Water Treatment Plant

The new WTP will be fully automated based on process control logic developed from the pilot test results and engineering requirements developed during detailed design. The correct function of the WTP will be monitored with on-line analytical instrumentation and grab samples tested at an off-site laboratory.

The effluent will be monitored by on-line analytical instrumentation for feedback to the plant operators on the system performance, with monitoring the following as part of the system:

- pH monitoring throughout the treatment process
- turbidity to measure clarity of the water and particle counters to measure the count and dimensions of particulates; used to measure suspended solids in the water

- conductivity; indicator of dissolved ions in the water such as dissolved metals

If measurements are recorded that do not meet the targeted pre-determined limits for these parameters, the control system will generate alarms to initiate operator intervention. Depending on the alarm category the flow through the WTP may be stopped until the operator has remediated the concern. Grab samples will be used to calibrate and confirm the alarm set points used on the instruments above.

If water quality does not meet EQC, water will not be discharged into Yellowknife Bay, instead the water will be recirculated back to the underground. Non-compliant water will be retained on site for further treatment. The WTP processes can be adjusted such that it is back in compliance prior to discharge.

Additionally, the monitoring by on-line analytical instruments will be supplemented with monitoring via routine periodic grab samples. These samples will be used to verify the on-line results and alarm points. The samples will be tested at an off-site certified laboratory, with parameters evaluated to include metals and arsenic. These samples will provide QA data to confirm that the instrumentation and automation within the WTP is functioning as designed and providing appropriate control that the plant is meeting the design objectives for the treated water quality.

Additional testing will be carried out on spent ion exchange media, sludge, and other process residuals to confirm that they are non-hazardous and suitable for disposal in the on-site landfill.

All the treatment processes require a high level of process understanding and chemistry knowledge; therefore, skilled and experienced operational staff will be employed and trained to operate and maintain the WTP as designed and to meet the specifications.

Outfall

Operations and maintenance of the conveyance pipe and outfall will be undertaken and will include:

- periodic inspections and maintenance of the pipeline and in-lake outfall for any signs of leaks or blockages and to confirm that the treated water is discharging properly with no scour
- periodic testing of the freeze protection system, to prevent freezing of the water within the conveyance pipe
- inspections of the pipeline right-of-way to maintain access and control traffic
- inspections of the signage and barriers around the outfall
- inspections of the in-lake outfall to confirm the pipe does not float
- monitoring of the outfall area for potential ice-thinning via inspections of the ice thickness in the vicinity of the outfall, and adjacent lake ice, for comparison. Comparative measurements are required to determine if ice thickness at the outfall that has significant variability to the surrounding ice thickness.

5.12.2.9 Freeze Monitoring

Freeze monitoring is exclusive to the freeze program for arsenic trioxide dust in the chambers and stopes underground at the Site (Section 5.2). As explained in Section 5.2.4, the passive cooling system selected to freeze the arsenic trioxide dust-filled stopes, B1 Pit, and Chamber 15 uses thermosyphons to freeze the ground.

Freeze monitoring will be split into two main stages once installation of the freeze system is complete:

1. The first stage will monitor the development of the frozen shell until the short-term containment criteria has been met. Data will be collected regularly to help calibrate the thermal models. Temperature monitoring sensors will be installed in locations which are anticipated to be the last to satisfy the short-term criteria.
2. The second stage will confirm ongoing frozen conditions and proper operation of the thermosyphons. Comparison of ground temperature data to predicted temperatures can be done less frequently during this stage if there is correlation between measured and predicted values. Ultimately, a thermal model that has matched historical data can be used to predict performance based on updated climate change parameters as they are made available. The location of the sensors will correlate with the locations identified during advanced design to be most susceptible to climate change impacts as per the long-term freeze monitoring criteria.

The first stage of the freeze monitoring program will begin during Phase 2, after installation of thermosyphons and the supporting freeze infrastructure; the adaptive management period will be used to confirm the freeze program is trending towards a fully frozen state (Stage 1). The second stage of the freeze monitoring program will occur during Phase 3, though there may be some overlap of the first stage into the post-closure monitoring phase, if a frozen state takes longer than predicted, the GMRP may enter Phase 3 before fully achieving the closure criteria.

Prior to licensing, the GMRP completed the FOS on Chamber 10; this study helped develop an understanding of how the freeze system will work and the development of key monitoring requirements that will be used to assess the effectiveness of the full-scale freeze monitoring program. In order to monitor the ongoing effectiveness of the freeze program, the following monitoring components will be implemented:

- **Thermosyphon temperature monitors**—Temperature instrumentation will be included on a selected number of thermosyphons. The sensors will be installed on the thermosyphons' radiator fins above ground and on pipe surfaces underground. The radiator temperatures will be compared to climate station reported air temperatures during winter to confirm that the radiator temperatures are greater than air temperatures. This temperature disparity indicates that the thermosyphon is transferring heat from the ground into the atmosphere. The in-ground pipe temperatures will be monitored at various depths to confirm that the CO_2 is being properly circulated through the entire length of the pipe. A minimum of four thermosyphons will be instrumented per chamber or stope.
- **Infrared thermosyphon monitors**—A secondary measure used to confirm proper thermosyphon operation will be conducted by infrared thermometer camera. The camera can be used as necessary to check the operating status of a particular thermosyphon. In winter, the thermosyphon radiators will appear warmer (i.e., red on the camera) than the surrounding air. These infrared inspections could be done in conjunction with the regular maintenance program, which will include visual inspections of the thermosyphons and checks for leaking or damaged thermosyphons. The most likely cause of a malfunctioning thermosyphon would be a CO_2 leak at the filling port. Thermosyphons found to be malfunctioning will be repaired or replaced as necessary. Replacing a thermosyphon radiator section does not involve the downhole piping.
- **Ground temperature sensors**—Temperature sensors will be installed in strategically located drill holes to monitor bedrock temperatures. The bedrock instrumentation will allow temperature measurements to be collected at various depths to monitor freeze performance and to calibrate thermal models. Bedrock

temperature monitoring instrumentation will be strategically placed based on modelling results that will identify critical locations such as those that are last to freeze and first to detect warming trends. It is estimated that a typical chamber/stope will have up to 14 bedrock instrumentation holes with multiple sensor locations in each hole. These temperature sensors, in co-ordination with the thermal models, will allow monitoring of the freeze-containment criterion. Temperature monitoring strings will not be grouted in and can be retrieved/repaired or replaced as necessary.

- **Defined thermal modelling thresholds and action level**—Ground temperature monitoring and a regularly calibrated thermal model will be used in conjunction with appropriate action trigger levels, to plan when intervention, investigation, and maintenance/replacement will need to be done. Thresholds and corresponding actions will be defined as part of the final design and proposed in the Arsenic Trioxide Frozen Shell Design and Construction Plan and corresponding management and monitoring plan.
- **Data management system**—Temperature data from all locations will be automatically collected and stored using a data acquisition, management, and storage system. Data will always be accessible remotely. Automatic reports can also be developed and distributed to summarize the status of the freeze. Monitoring of a passive system is not onerous and reporting will be completed annually as part of annual reporting requirements.
- **Technology reviews**—As part of the reversibility closure objective (F2, Section 5.2.3 and EA Measure 3), a review of emergent technologies and alternative remediation options for the arsenic trioxide dust will occur periodically following the full implementation of the dry frozen shell method and the results will be reported in the Status of the Environment Report required under the Environmental Agreement.

Additional monitoring and mitigation will be implemented in Phase 2 during installation of the freeze system, including construction of the laydown pads and drilling for thermosyphons and monitoring boreholes, to address dust, noise, and potential erosion and sedimentation concerns.

An Arsenic Trioxide Frozen Shell Management and Monitoring Plan will be developed and submitted together with the Design and Construction Plan. This monitoring and maintenance plan will incorporate detailed information about the key monitoring program components outlined above, including contingencies and action levels, as well as operational inspection information. It will address both stages of the freeze monitoring program.

5.12.3 Cumulative Effects Monitoring

The cumulative effects assessment in the DAR (INAC and GNWT 2010, Chapter 11) did not identify that the GMRP was contributing to significant cumulative effects in the downstream receiving environment. However, increased activity in the Yellowknife area, and new research of the areal extent of deposition from historical mining in the Yellowknife area suggests cumulative effects monitoring in the area should be considered. Further, the GMRP committed to participation and reporting on such monitoring in the Environmental Agreement (Government of Canada 2015). To this end, the GMRP has completed the following:

- established an air quality monitoring program that included regional locations and proposes to continue this until the end of the Active Remediation Phase to verify closure criteria are met and parties are satisfied moving to reduced post-closure monitoring is appropriate;
- conducted the HHERA including samples collected from the Yellowknife area (Table 2.5-3); and,

- participates and shares data with GNWT Cumulative Impacts Monitoring Program, Natural Resources Canada, ECCC, and various universities.

In the future, the GMRP plans to continue monitoring water in Yellowknife Bay and air quality in the Yellowknife area at locations determined in consultation with the YKDFN, NSMA, the City of Yellowknife, and appropriate regulatory agencies. The GMRP also plans to continue and expand work with Indigenous groups and other parties for community-based monitoring such as large-bodied fish and water quality monitoring.

SECTION 5.13
Contingencies

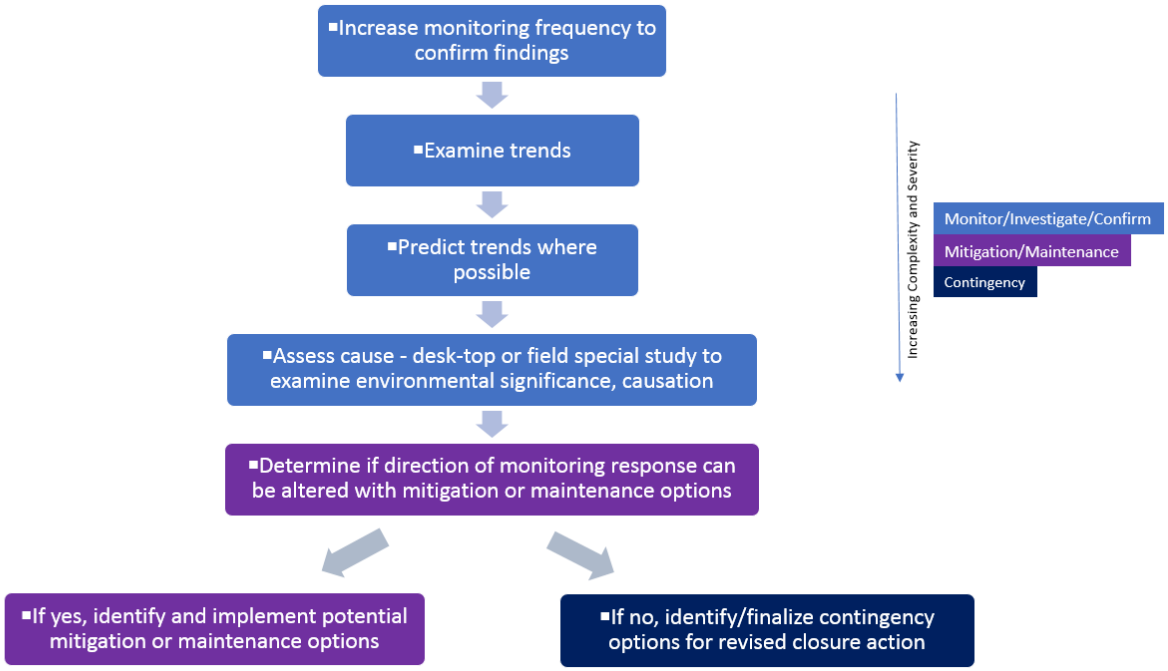
5.13 Contingencies

Contingencies are required should the selected closure activity appear to be unsuccessful in meeting closure criteria and/or objectives. It is anticipated that adaptive management will be included in most monitoring programs.

In general, should monitoring or inspection indicate the closure criteria may not be met, a series of actions would be initiated. An example of the generic types of actions that would be taken is outlined in Figure 5.13-1. The actions outlined in Figure 5.13-1 may not occur in sequential order. For example, observations of a more serious nature (e.g., a sinkhole appears near a designed site feature versus a spike in total suspended solids in runoff at freshet) may require the activation of a contingency for immediate mitigation rather than additional monitoring and study.

It is expected that the types of monitoring, mitigation, and maintenance actions will be outlined in various construction, management and monitoring plans (Figure 5.12-1). This will require affected party input and regulatory approval. Further, standard mitigations were also outlined in the DAR (INAC and GNWT 2010). A number of draft management and monitoring plans were submitted with the Post-EA Information Package to the MVLWB (Table 1.1-1), and specifics on monitoring and maintenance are not repeated herein; this section focuses on contingencies for closure activities.

Figure 5.13-1: Sequence of Actions That Could Be Taken if Monitoring Suggests Closure Objectives Will Not Be Met



As noted above, adaptive management and maintenance actions are distinguished from specific closure contingencies, where the selected closure option is not achieving the closure objectives. Some general contingencies for Site components are outlined in Table 5.13-1.

Table 5.13-1: General Contingences for Selected Components of the Giant Mine

Item	Relevant Contingency
Underground stability maintenance	• Add more material to void[(a)] • Change paste backfill type (e.g., concrete or large waste rock)[(a)] • Fill sinkholes if found after pit fill in place[(a, b)]
Underground minewater level maintenance	• Continue to pump and treat using the two treatment trains instead of deferring to a duty-standby configuration, therefore maintaining the higher pumping and treatment capacity to keep minewater at the approved level. Post-closure there is additional capacity at the WTP as post closure only 1 train is required to meet water treatment requirements. The plant has been designed with capacity to undertake maintenance / repairs for 30% of the time, regular maintenance has been anticipated and accommodated in the design. In the long term, low inflow rates for treatment. • Allow the minewater level to rise.[(b)] Confirmation of the depth and storage volume relationship in the mine will provide estimates of the allowable downtime of the treatment facility, and in turn allowable minewater level rise, in the event of catastrophic failure e.g., fire, earthquake. This provides time frames to implement a repair. • North shaft wells will be capped, and available as backup if required. Adaptive management option for water quality and quantity (not an emergency backup, an adaptive management approach). Additionally, a third intake identified in the C Shaft area, a new well could be developed in case of loss of one well. During this period, one well would still operation. • If unable to meet EQC and WQO, the water can be recirculated within the system until targets are achieved. If required, can run at a reduced treatment capacity (e.g., double treat the water before discharge); in the long-term minewater equalization storage can be used whilst upgrades to the plant are implemented to overcome this issue.
Creation of frozen shell	• Use hybrid approach to improve on fully passive process and/or install additional thermosyphons where required to maintain frozen shell.
Pit cover stability (differential settlement)	• Fence areas around pits if excessive settlement occurs, sinkholes develop or if underground stabilization does not achieve desired stability[(a)].
Flooding to underground (via pits or Baker Creek)	• Install additional dykes or other in-stream measures to direct flow away from the pits[(a)]. • Alter grading on pit fill to direct water to a sump and/or underground
Surface runoff/seepage quality from TCAs/pits/soil covers	• Collect and treat seepage/runoff water for a longer period, until quality/quantity is adequate for release[(a)]. • Install or enhance passive treatment processes in drainage networks[(b)].
Contaminated soil/sediment removal to target concentrations and reduction in water quality concentrations	• Deepen/widen soil excavations to remove additional material[(a)]. • Install cover or change cover type (thickness or material)[(a)]. • Install/use liner in affected area[(a)]. • Install sumps downstream of covers and collect water until runoff water quality improves[(b)].
Dam stability	• Reinforce or buttress dams, and address seepage losses if observed[(a(b)]

Table 5.13-1: General Contingences for Selected Components of the Giant Mine

Item	Relevant Contingency
Achievability of WTP effluent quality criteria	• Implement alternative operations strategy, e.g., replace ion exchange media more frequently[(a)]. • Change treatment process, e.g., use different ion exchange media[(a)]. • Change outfall design to improve mixing[(a, b)].
Foreshore Tailings Area cover stability	• Revise cover design with alternative rock type and thickness[(a)].
Availability of borrow/quarry material	• Obtain off-site material[(a)]. • Revise final landform geometry to reduce fine-grained soil needs and use more coarse material[(a)].
Capacity of landfill	• Room for landfill expansion has been allowed. A higher elevation of the landfill can be considered if during construction it is determined that capacity is insufficient[(a)]. • Use of off-site disposal locations for disposal of WTP process residuals.

a) Contingencies proposed for closure period 2020 to 2030.
b) Contingencies proposed for long-term closure maintenance beyond 2030.

TCA = Tailings Containment Area; WTP = water treatment plant; EQC = effluent quality criteria; WQO = water quality objective.

CHAPTER 6
Schedule

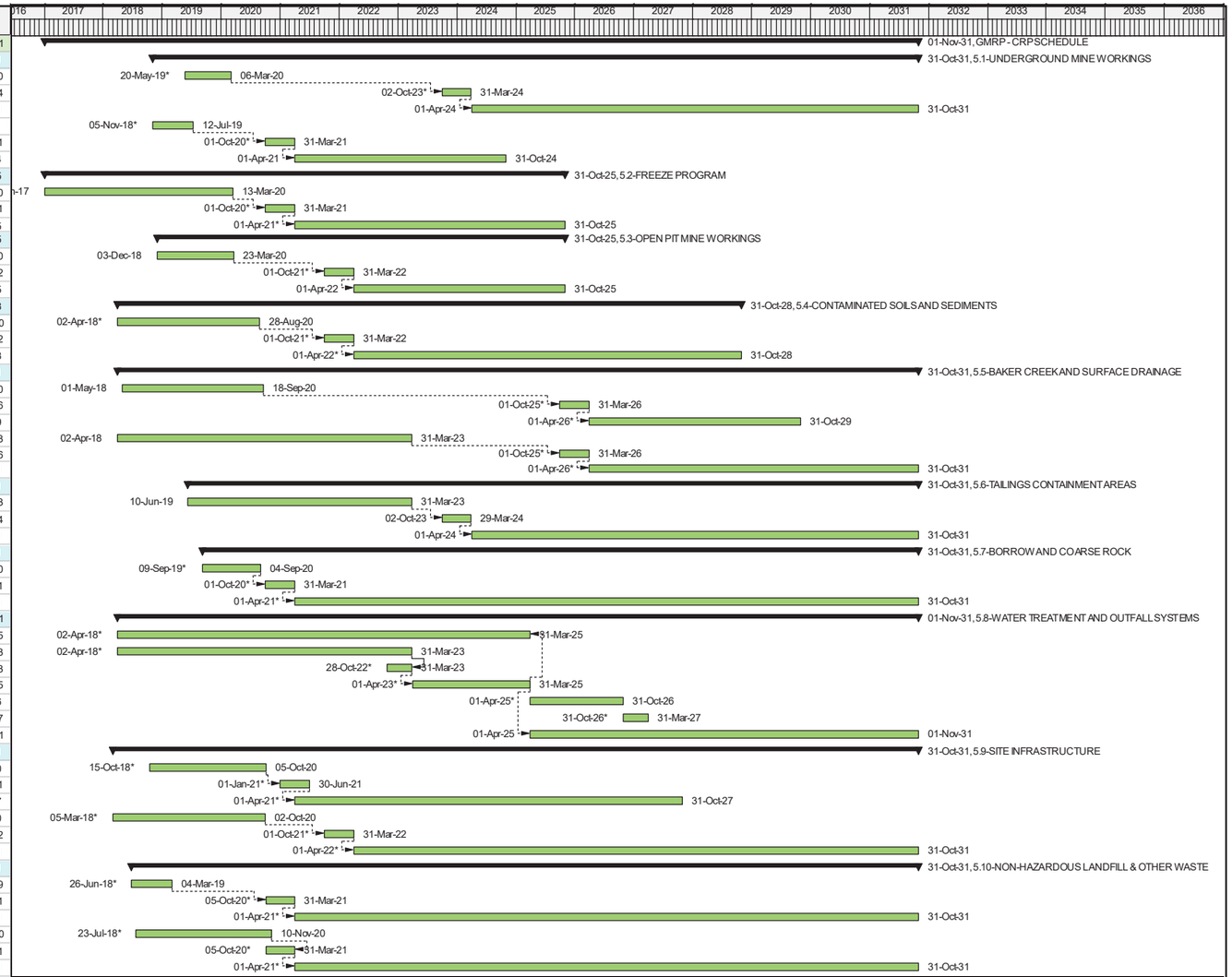
6 SCHEDULE

The implementation schedule was developed based on current information that supports this CRP. Chapter 5 describes the closure plan and activities for the proposed individual project components.

The schedule shown in Figure 6.0-1 assumes a ten-year construction duration with a start date of 1 April 2021 and a completion date of 31 October 2031. Design, regulatory, procurement, engagement, and implementation durations are identified in Figure 6.0-1. The 1 April 2021 start date is based on an assumption that the issuance of a Water Licence will occur by June 2020 and that a one-year period prior to construction is required to allow for the completion of management plans, detailed design submissions, other Water Licence submittal requirements, and establishment of sub-contractor contracts by the Main Construction Manager. The schedule presented in this chapter may change as a result of other regulatory approval dates, different sequencing of work by the Main Construction Manager to manage the available local workforce, or unexpected site conditions that may impact the duration of the work.

The schedules for the individual components have been developed based on the required design and construction activities and current scope of work following durations from similar work at the Giant Mine and other similar projects in the Yellowknife area. Start and end dates are assumed and sequenced based on known dependencies in the work.

Activity ID	Activity Name	Start	Finish
GMRP - CRP SCHEDULE		02-Jan-17	01-Nov-31
5.1-UNDERGROUND MINE WORKINGS		05-Nov-18	31-Oct-31
5.1-100	Openings to Surface Final Design	20-May-19*	06-Mar-20
5.1-105	Openings to Surface Regulatory, Procurement, Engagement	02-Oct-23*	31-Mar-24
5.1-110	Openings to Surface Implementation	01-Apr-24	31-Oct-31
5.1-115	UG Mine Workings Final Design	05-Nov-18*	12-Jul-19
5.1-120	UG Mine Workings Regulatory, Procurement, Engagement	01-Oct-20*	31-Mar-21
5.1-125	UG Mine Workings Implementation	01-Apr-21	31-Oct-24
5.2-FREEZE PROGRAM		02-Jan-17	31-Oct-25
5.2-100	Final Design	02-Jan-17	13-Mar-20
5.2-105	Regulatory, Procurement, Engagement	01-Oct-20*	31-Mar-21
5.2-110	Implementation	01-Apr-21*	31-Oct-25
5.3-OPEN PIT MINE WORKINGS		03-Dec-18	31-Oct-25
5.3-100	Final Design	03-Dec-18	23-Mar-20
5.3-105	Regulatory, Procurement, Engagement	01-Oct-21*	31-Mar-22
5.3-110	Implementation	01-Apr-22	31-Oct-25
5.4-CONTAMINATED SOILS AND SEDIMENTS		02-Apr-18	31-Oct-28
5.4-100	Final Design	02-Apr-18*	28-Aug-20
5.4-105	Regulatory, Procurement, Engagement	01-Oct-21*	31-Mar-22
5.4-110	Implementation	01-Apr-22*	31-Oct-28
5.5-BAKER CREEK AND SURFACE DRAINAGE		02-Apr-18	31-Oct-31
5.5-100	Baker Creek Final Design	01-May-18	18-Sep-20
5.5-105	Baker Creek Regulatory, Procurement, Engagement	01-Oct-25*	31-Mar-26
5.5-110	Baker Creek Implementation	01-Apr-26*	31-Oct-29
5.5-115	Surface Drainage Final Design	02-Apr-18	31-Mar-23
5.5-120	Surface Drainage Regulatory, Procurement, Engagement	01-Oct-25*	31-Mar-26
5.5-125	Surface Drainage Implementation	01-Apr-26*	31-Oct-31
5.6-TAILINGS CONTAINMENT AREAS		10-Jun-19	31-Oct-31
5.6-100	Final Design	10-Jun-19	31-Mar-23
5.6-105	Regulatory, Procurement, Engagement	02-Oct-23	29-Mar-24
5.6-110	Implementation	01-Apr-24	31-Oct-31
5.7-BORROW AND COARSE ROCK		09-Sep-19	31-Oct-31
5.7-100	Final Design	09-Sep-19*	04-Sep-20
5.7-105	Regulatory, Procurement, Engagement	01-Oct-20*	31-Mar-21
5.7-110	Implementation	01-Apr-21*	31-Oct-31
5.8-WATER TREATMENT AND OUTFALL SYSTEMS		02-Apr-18	01-Nov-31
5.8-100	Operation of Existing ETP	02-Apr-18*	31-Mar-25
5.8-105	Final Design (Including Design under Design/Build Contract)	02-Apr-18*	31-Mar-23
5.8-110	Regulatory, Procurement, Engagement	28-Oct-22*	31-Mar-23
5.8-115	Implementation	01-Apr-23*	31-Mar-25
5.8-120	Back-up Operation (if required) of Existing ETP	01-Apr-25*	31-Oct-26
5.8-125	Decomissioning of Existing ETP	31-Oct-26*	31-Mar-27
5.8-130	Operation (Under MCM Contract)	01-Apr-25	01-Nov-31
5.9-SITE INFRASTRUCTURE		05-Mar-18	31-Oct-31
5.9-100	Surface Demolition Final Design	15-Oct-18*	05-Oct-20
5.9-105	Surface Demolition Regulatory, Procurement, Engagement	01-Jan-21*	30-Jun-21
5.9-110	Surface Demolition Implementation	01-Apr-21*	31-Oct-27
5.9-115	Site Services Final Design	05-Mar-18*	02-Oct-20
5.9-120	Site Services Regulatory, Procurement, Engagement	01-Oct-21*	31-Mar-22
5.9-125	Site Services Implementation	01-Apr-22*	31-Oct-31
5.10-NON-HAZARDOUS LANDFILL & OTHER WASTE		26-Jun-18	31-Oct-31
5.10-100	Non-Hazardous Waste Landfill Final Design	26-Jun-18*	04-Mar-19
5.10-105	Non-Hazardous Waste Landfill Regulatory, Procurement, Engagement	05-Oct-20*	31-Mar-21
5.10-110	Non-Hazardous Waste/ Process Residuals Landfill Implementation	01-Apr-21*	31-Oct-31
5.10-115	Hazardous Waste Final Design	23-Jul-18*	10-Nov-20
5.10-120	Hazardous Waste Regulatory, Procurement, Engagement	05-Oct-20*	31-Mar-21
5.10-125	Hazardous Waste Implementation	01-Apr-21*	31-Oct-31



LEGEND

Remaining Level of Effort

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

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

YYYY-MM-DD	2018-11-22
DESIGNED	R. Schmidtke
PREPARED	D. Pahl
REVIEWED	R. Schmidtke
APPROVED	R. Schmidtke

PROJECT
Giant Mine Remediation Project

TITLE
GIANT MINE REMEDIATION PROJECT SCHEDULE

REV.	FIGURE
0	6.0-1

6.1 Underground Mine Workings

6.1.1 Underground Mine Workings

Underground remediation (Section 5.1) is scheduled to commence in Year 1 and continues for four years on a seasonal basis (April to October).

- **Year 1**: backfilling of voids under B1, C1, and A2 pits if required and backfilling of identified underground openings
- **Year 2**: preparation of Chamber 15 to accept arsenic-impacted waste generated by the roaster demolition; backfilling of identified underground openings continues
- **Year 3**: disposal of arsenic-impacted waste in Chamber 15; backfilling of identified underground openings continues
- **Year 4**: disposal of arsenic-impacted waste in Chamber 15 continues; backfilling of identified underground openings continues

Dependencies: None

6.1.2 Openings to Surface

The activities required for closing the mine openings are scheduled for Years 4 to 10 (Section 5.1 and 5.3).

- **Year 4**: new underground access established
- **Years 5 to 10**: progressive closure of openings at surface

Dependencies: None

6.2 Freeze Program

Freeze program activities are scheduled to commence in Year 1 and continue for five years on a seasonal basis (April to October). Each of the four freeze areas (AR1 to AR4) require site preparation to support the drill rig and passive freeze pipe installation operations at the surface (Section 5.2). The schedule only reflects the installation of the freeze infrastructure and not the time to complete the freeze to meet design objectives.

- **Year 1**:AR1 and AR2 site preparation
- **Year 2**: AR2 drilling and passive freeze pipe installation and AR3 site preparation
- **Year 3**: AR3 drilling and passive freeze pipe installation, AR4 site preparation
- **Year 4**: AR4 drilling and passive freeze pipe installation, AR1 site preparation continues
- **Year 5:** AR1 drilling and passive freeze pipe installation

Dependencies:

Demolition of infrastructure and contaminated soil to be removed prior to freeze pad area development. B1 Pit must be filled prior to site preparation and passive freeze pipe installation in AR4 can occur.

6.3 Open Pit Mine Workings

Open pit closure activities are scheduled for Years 2 to 5. The activities will most likely be seasonal (April to October)

- **Year 2**: B1 Pit infilling
- **Year 3**: A1 Pit infilling
- **Year 4**: C1 Pit infilling
- **Year 5**: A2, B2, B3, and B4 pits infilling

Dependencies:

B1, A1, and C1 pits must have base stabilized prior to infilling

B2 Pit cannot be filled until a new underground access is established. The underground mine is currently accessed through the B2 Pit portal.

Borrow material and contaminated materials (B1 and A2) will be required for pit infilling. The production rate for quarried material and the contaminated soil remediation activities will control the rate at which pits can be filled and pit covers can be placed.

6.4 Contaminated Soils and Sediments

Remediation of contaminated soils and sediments is scheduled for Years 2 to 8 on a seasonal basis (April to October).

- **Year 2**: remediation of Core Industrial Area and heavily impacted soil around former roaster
- **Year 3**: remediation of Developed Areas, Townsite, and Shoreline Lands
- **Year 4**: remediation of Developed and bedrock / forest / wetland areas,
- **Year 5**: remediation of bedrock / forest / wetland areas and Dam 3
- **Year 6**: remediation of bedrock / forest / wetland areas,
- **Year 7**: excavation and covering of Jo Jo Lake tailings and Baker Pond tailings/sediment.
- **Year 8**: excavation and covering of Jo Jo Lake tailings and Baker Pond tailings/sediment.

Dependencies:

B1 Pit must be stabilized before highly impacted soil from the roaster can be placed in the pit.

Mine buildings must be demolished before soil can be excavated in specific areas.

Excavation of tailings/sediment in Baker Pond and Jo-Jo Lake cannot begin until the new WTP is commissioned and treated water is being discharged to Yellowknife Bay and the existing ETP is offline and ceases discharging into Baker Creek.

6.5 Baker Creek and Surface Water Drainage

6.5.1 Baker Creek

Baker Creek construction is scheduled for Years 6 to 8.

- **Year 6**: new channel construction.
- **Year 7**: new channel construction continued
- **Year 8**: new channel construction continued

Dependencies:

Baker Creek channel construction cannot begin until the new WTP is commissioned and treated water is being discharged to Yellowknife Bay and the existing ETP is offline and ceases discharging into Baker Creek.

6.5.2 Surface Water Management

Final site grading and surface water management activities are scheduled for Years 6 to 10 and will mostly be seasonal (April to October).

- **Years 6 to 9**: progressive site regrading
- **Year 10**: final regrading

Dependencies:

The final surface water management plan depends on all remediation work components.

6.6 Tailings Containment Areas

Remediation of the Tailings Containment Areas is scheduled for Years 4 to 10.

- **Year 4**: start of relocation of South Pond tailings into Central and North ponds and concurrent dewatering of the Central and North ponds.
- **Year 5**: continue dewatering of Central and North ponds
- **Year 6**: continue dewatering of Central and North ponds and Settling and Polishing ponds.
- **Year 7**: dewatering of Northwest Pond, placement of cover on the Central and North ponds, Foreshore Tailings Area, and Settling and Polishing ponds, stabilize dams
- **Year 8**: placement of cover on the Northwest Pond and on the Central, North, and Settling and Polishing ponds; dam stabilization
- **Year 9**: placement of cover on the Northwest Pond and on the Central, North, and Settling and Polishing ponds; spillway construction
- **Year 10**: placement of cover on the Northwest Pond, spillway construction

Dependencies

Deposit of materials (including South Pond tailings) into Central Pond and cover placement on Central Pond cannot be completed until the MSA material has been disposed.

Central and North Ponds should be dewatered prior to or concurrently with deposit of relocated materials (including South Pond tailings).

The cover placement cannot be completed until all waste materials that are to be relocated to the TCAs have been placed.

North and Central Ponds cannot be dewatered until the surface water management system has been updated to route collected water underground.

The Polishing Pond, Settling Pond, and Northwest Pond cannot be dewatered until the new WTP meets treatment performance objectives. Cover placement cannot be completed until dewatering is done and sufficient drying has taken place.

Borrow material will be required for cover construction. The production rate for quarried material will control the rate at which cover can be placed.

6.7 Borrow Material

Borrow source activities are scheduled for Years 1 to 10 and include borrow area development in fine-grained unconsolidated deposits, quarry development, and aggregate crushing and screening facilities operating on a continuous basis.

- **Years 1 to 10**: site preparation, borrow excavation and production, progressive rehabilitation and management
- **Years 8 to 10**: progressive and final quarry reclamation

Dependencies

Borrow production will be linked with construction activities on site, with production rates and locations tied to the rate of development for areas where it is needed.

Borrow materials to be acquired from remediation activities will not be available until specific remediation work commences; major sources include A1 and A2 Pit high wall recontouring, and North Pond Spillway construction.

6.8 Water Treatment and Outfall Systems

The new WTP construction is scheduled for Years 1 to 5. These activities will be undertaken on a continuous basis, weather and conditions permitting.

- **Year 1**: 30% design by Government of Canada General Design Engineer, procurement of design/build/operate contractor by the Main Construction Manager
- **Year 2**: detailed design by successful design/build/operate contractor, progressive procurement of long lead delivery modules/equipment

- **Year 3**: progressive procurement of modules/equipment
- **Years 4 to 5**: construction of WTP, including minewater intake and outfall and WTP commissioning
- **Year 6**: operation of WTP (with existing ETP available)
- **Years 7 to 10**: operation of WTP

Dependencies:

The new WTP is planned to operate for one year to confirm treatment performance before the existing ETP can be decommissioned and demolished. Demolition of infrastructure and removal of contaminated soil prior to WTP construction.

Disposal location in the landfill for WTP waste must be commissioned prior to operation of WTP.

6.9 Site Infrastructure

6.9.1 Site Infrastructure

Demolition and debris removal, road and decommissioning activities, on surface and underground are scheduled for Years 1 to 10. Surface work will occur on a seasonal basis (April to October).

- **Year 1**: Townsite demolition
- **Year 2**: TRP demolition and surface debris removal
- **Years 3 to 4**: mill building demolition, disposal of arsenic waste into Chamber 15 and B1 Pit to be frozen
- **Year 5**: C-Dry and machine equipment garage demolition
- **Year 7**: ETP demolition
- **Years 1 to 10**: hazardous waste removal in support of demolition, and progressive road and utility decommissioning.

Dependencies:

Site infrastructure and debris cannot be moved from their current location until the NWHL facility is commissioned

The ETP cannot be demolished until new WTP meets performance objectives.

C-Dry infrastructure may be demolished later in the GMRP (Year 1 to 10) if the Main Construction Manager determines it needs to remain as office space to support the project during implementation.

6.9.2 Site Services

Site service activities are scheduled for Years 1 to 10 and will occur on a seasonal basis (April to October).

- **Years 2 to 3**: power, communications, site office, and maintenance shop established to support Site infrastructure required to support the GMRP

- **Year 10**: site roadway system upgrades, fencing at Core Industrial Area and open pits, construction of new bridge at Baker Creek Reach 0, installation of commemorative plaque, monument, or educational memorial

Dependencies:

Power and communications must be installed prior to completion of the WTP

6.10 Non-hazardous Waste Landfill and Other Waste

The NHWL is scheduled to be constructed in Year 1 to accept site infrastructure demolition debris and general site waste. Non-hazardous waste landfill operation activities are scheduled for Years 1 to 10 and will occur on a continuous basis throughout the construction period.

- **Year 1**: landfill / water treatment process residual waste cell construction
- **Years 1 to 10**: landfill / water treatment process residual waste operation
- **Year 10**: landfill closure

CHAPTER 7
Post-closure Site Assessment

7 POST-CLOSURE SITE ASSESSMENT

The residual environmental impacts of the GMRP as a whole will be assessed through multiple studies once the Active Remediation and Adaptive Management Phase and the Post-closure Phase (see Chapter 1) are complete. This will include multiple types of monitoring and studies brought together into a State of the Environment Report. The types of monitoring and reporting are outlined in brief below.

Risk Register and Quantitative Risk Assessment

The Giant Mine Risk Register is regularly updated to assess the physical and chemical risks on the Site. The QRA, which was prepared to meet Measure 5, will also be reviewed and updated, where required. Any residual environmental risks from these studies will be reviewed and included in environmental effects studies outlined below.

Human Health and Environmental Risk Assessment

An HHERA was completed in 2018. It predicted environmental effects remaining in the Post-closure Phase (Long-Term Monitoring Phase). Monitoring results will be compared with these predictions and any unanticipated stressors and trends toward additional residual environmental effects. These will be added into the aquatic, wildlife, and air quality monitoring to refine those study designs.

Aquatic Effects Monitoring Plan

The AEMP will include provision to review the stressors on the Site after closure and determine the effects of the remaining stressors to the aquatic environment. This plan will be updated regularly for approval by the MVLWB and with input from affected parties. It is expected to serve as the main study documenting aquatic effects once closure is complete.

***Fisheries Act* Authorization Compensation Monitoring**

The GMRP expects to have to compensate for habitat in the outfall and shoreline areas of Yellowknife Bay. Once construction is complete and new habitat is in place in these areas, multiple years of monitoring will be required to determine if the objectives of the compensation were met. Further, it is anticipated that the performance of the newly aligned reaches of Baker Creek and any new habitat features will also require monitoring to confirm the habitat is functioning as designed. It is anticipated that this will include fisheries monitoring outside of that conducted under the AEMP.

Air Quality Monitoring Plan

The Air Quality Monitoring Plan will be updated regularly with input from affected parties. It is expected to serve as the main study documenting residual air quality changes post-closure.

Wildlife and Wildlife Habitat Protection Plan

The Wildlife and Wildlife Habitat Protection Plan will be updated and reported on regularly with input from affected parties. It will document any residual wildlife- or habitat-related issues. As outlined in the DAR, samples for small mammal chemistry and vegetation are expected to be collected in the final years of monitoring to allow a comparison of the current concentrations to post-closure concentrations (INAC and GNWT 2010).

Status of the Environment Report

As required under the Environmental Agreement (Government of Canada 2015), the GMRP is required to report on the environment to affected parties, regulators, and GMOB at a regular frequency. It is anticipated that a Status of the Environment Report will be prepared that documents conditions at post-closure. This report will draw on the results from any of the aquatic, habitat compensation, wildlife, wildlife habitat, and air quality monitoring programs for detailed information for an assessment of residual environmental effects. This report will document positive changes and any adverse residual effects remaining after closure activities are complete and the Site begins to stabilize. It is anticipated that a number of years of monitoring after closure activities are complete will be required to document the recovery of the environment.

CHAPTER 8
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